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Alpeza et al. explore consumer attitudes toward the Traditional terms and the PDO/PGI terms implemented in wine labeling after Croatia's access to the EU. The importance of PDO differs significantly depending on subjective knowledge. The research findings signal the need for consumer education and promoting the PDO's meaning and value.

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Akli et al. analyze the behavior of consumers of agroecological products in Algeria. The main results show that: more than a third of those surveyed online regularly consume agroecological foods; consumption of these foods varied according to age, income level and household structure; the motivations are mainly linked to the expected health benefits and quality of the food; the constraints on consumption are the lack of availability and the high prices of these products on the domestic market.

Sustainability, circular economy and bioeconomy: A conceptual review and integration into the notion of sustainable circular bioeconomy

Fátima Rojas-Serrano*, Guillermo Garcia-Garcia**, Carlos Parra-López***, Samir Sayadi-Gmada***

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Abstract

National legislation and international regulations are pushing societies to become more sustainable while meeting socio-economic demands. People are becoming more aware of their environmental impact and want more sustainable products and processes. However, the terminology around sustainability, circular economy, and bioeconomy can be unclear, and there is confusion about their boundaries and interpretation. This article contributes to the ongoing discourse within the scientific community by providing a clear and widely accepted definition of a sustainable circular bioeconomy, as well as insights and policy recommendations to facilitate its development into practice. The sustainable circular bioeconomy is a combination of circular economy and bioeconomy concepts that can contribute to achieving sustainability. The adoption of this concept can significantly contribute to the achievement of sustainable development goals related to responsible consumption and production, industry, innovation and infrastructure, poverty reduction, social equity, and environmental protection.

Keywords*: Sustainability, Circular economy, Bioeconomy, Circular bioeconomy, Sustainable development.*

1. Introduction

The terms sustainability, circular economy, and bioeconomy have gained momentum in recent years, moving from being restricted to academia to frequently appearing in the media, business action plans, and political strategies (European Commission, 2022). With the model of a society in transition, it is increasingly common to find citizens questioning whether current production systems are sustainable, and many

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of these citizens, generally uninitiated in these issues, are beginning to become familiar with these terms (Venkatesh, 2022). This change in consumer profile is primarily driven by concerns about climate change, global resource scarcity, and economic globalisation (Villarán *et al.*, 2018; Zabaniotou, 2018).

The transition towards more sustainable models requires more research and technology transfer, but this is hampered if the terminology is unclear and the actors involved are not aware of the differences between the concepts. The understanding and interpretation of these concepts varies depending on the actors involved (Näyhä, 2019). Within academia itself, the debate on the meaning of sustainability is still open, which hinders its use as a relevant global objective (Whyte and Lamberton, 2020). Similar issues with unclear and debated definitions of the circular economy (Corvellec *et al.*, 2021) and bioeconomy (Tan and Lamers, 2021) also hinder a more widespread application of the approaches underlying these concepts.

Furthermore, the boundaries between some of the concepts, such as sustainability and the circular economy, remain unclear (Geissdoerfer *et al.*, 2017). Although they have similarities and overlap in some aspects, they do not have the same meaning and are often confused. If we add the bioeconomy variable to the equation, the boundaries become even more blurred, making it necessary to review the origin and evolution of each term to understand its scope and use. In addition, new concepts, such as the circular bioeconomy, continue to emerge regularly, complicating the understanding of the meaning of the concepts and their applicability.

In this context, this article reviews the use of the concepts of sustainability, circular economy, and bioeconomy in the literature and sheds light on their boundaries. The aim is to answer the following research questions:

RQ1: How have the definitions of sustainability, circular economy, and bioeconomy evolved over time?

RQ2: What are the differences and overlaps between these concepts?

RQ3: How can these concepts, or their combinations, support the development of more sustainable systems?

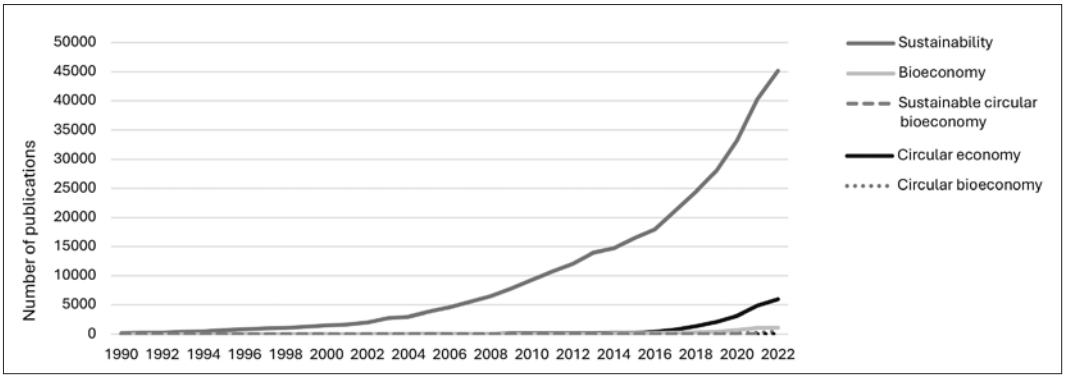
To answer these questions, a comprehensive analysis of each term is provided, highlighting their differences and commonalities. The aim of this study is to provide a theoretical basis for considering the postulates of the circular economy and the bioeconomy as tools for increasing the profitability of companies while minimising environmental impacts, and thus making systems more sustainable. The role that the novel concept of sustainable circular bioeconomy can play in this transition towards more sustainable systems is also discussed.

2. Methodology

The process of selecting references for this literature review was systematic and followed specific criteria. A more detailed breakdown of each step can be found below:

- Literature search: The first step was to conduct a literature search in the Scopus database. The search terms used were "sustainability", "circular economy" and "bioeconomy". The use of the terms "circular bioeconomy", that integrates the circular economy and bioeconomy, and "sustainable circular bioeconomy", that integrates sustainability, circular economy, and bioeconomy, was also explored. The aim was to find academic works in English language that used these terms in their title, abstract, or keywords, thus ensuring that they were central to the research.
- Time frame: The search covered the period from 1970 (earliest available data) to 2022 (latest full year), to capture the evolution of these concepts over time.
- Form of terms: Only noun forms of the terms were searched for, not adjectives. This was done to focus on articles that delve into the meanings and implications of the concepts themselves (such as "sustainability") rather than those that simply describe a process or product as being "sustainable".
- Inclusion of other sources: The literature search focused on journal articles and conference papers, but also included other relevant sources such as national legislation, international standards, and economic strat-

Figure 1 - Number of publications including the terms sustainability, circular economy, bioeconomy, circular bioeconomy, and sustainable circular bioeconomy by year.



egies, providing a broader and more practical context for these concepts.

- Selection criteria: Not all sources that mention the search terms were included in the review. To be selected, a publication had to meet one or more of the following criteria: the concepts were defined, the concepts were compared, or different approaches to the concepts were shown. This ensured that the selected sources contributed to a deeper understanding of the concepts.

Based on this criterion, 98 publications were selected for a thorough study. The next section presents the results obtained from the literature review and discusses the evolution of the concepts of sustainability, circular economy, and bioeconomy.

3. Evolution of the concepts in the literature

Figure 1 shows the number of publications found in Scopus for each concept by year. Although the search was carried out from 1970 onwards, Figure 1 only presents results from 1990 onwards, as until then the number of publications with the term "sustainability" was negligible (0-100 per year), while the number of publications with the terms "circular economy", "bioeconomy", "circular bioeconomy" and "sustainable circular bioeconomy" was nil (except for one publication by Ikeda (1979), who mentioned "bioeconomy", but in a different context to the one dealt with in this article).

Figure 1 clearly shows that "sustainability" is by far the oldest concept found in the literature, followed by "circular economy", "bioeconomy", "circular bioeconomy" and finally "sustainable circular bioeconomy". There has always been a clear predominance of publications on sustainability, while the number of publications focussing on the circular economy and the bioeconomy only started to increase from 2017. There are a negligible number of publications that have addressed the concept of (sustainable) circular bioeconomy so far. Moreover, only very few publications have addressed all or some of these concepts together. In addition, in most of the papers analysed, the concepts were introduced through the presentation of a case study, and only in a small number of them was the relationship between the concepts comprehensively analysed.

The next subsections analyse and discuss the importance, origin and evolution of the definitions, principles and critiques of the concepts of sustainability, circular economy and bioeconomy. Their boundaries, differences, and commonalities are highlighted. Table 1 summarises the elements of analysis for the three concepts.

3.1. *Sustainability*

The concept of sustainability dates back to the forestry treaties of the first half of the 18th century (Geissdoerfer *et al.*, 2017). In particular, it is based on the principle that the amount of timber harvested should never exceed the volume

Table 1 - Summary of the elements of analysis for sustainability, circular economy, and bioeconomy.

	Sustainability	*Circular economy*	*Bioeconomy*
The most common definition	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (sustainable development)	A system where materials never become waste and nature is regenerated	Production of renewable biological resources and their conversion into food, bio-based products, and bioenergy
Origin of the concept	18th century	Second half of the 20th century	Early 20th century
Principles	Three sustainability pillars/dimensions/ domains: environmental, economic, and social	Eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature	Increase the applications of biotechnology, prioritise the use of bioresources, and consider ecological criteria
*Examples of usage in supranational agendas or standard*s	European Green Deal, 2030 Agenda for Sustainable Development	Circular Economy Action Plan (European Commission)	EU bioeconomy strategy
*Criticism and limitation*s	Lack of clearly established time dimension, lack of concrete objectives, and lack of specificity	Could generate outcomes such as those of the linear economy, high-energy consumption of recycling, and technical unfeasibility in certain situations	Use of bio-based resources does not guarantee a more sustainable system

planted. This principle of sustainability unites an economic criterion (i.e., maximum timber production securing the continuing existence of an individual business enterprise or livelihoods) and an ecological one (i.e., preserving a particular ecosystem). Subsequently, the concept of sustainability emerged from the field of ecology, referring to the respect for nature's ability to regenerate itself, giving rise to the modern conception of "sustainable is that which is capable of maintaining itself at a certain speed or level". In the late 18th century and the 19th century, the works of David Ricardo and Thomas Malthus, as well as those of the philosopher John Stuart Mill, are often considered the first systematic studies of the ecological limits on growth in a finite world and are credited with being an early source of critical sustainability. Malthus' *An Essay on the Principle of Population*, published in 1798, has been a very influential study on the relationship between population growth and resource scarcity (Malthus, 1798).

In the 20th century, the United States (US) National Environmental Policy Act of 1969 defined the US commitment to sustainability as the aim "to create and maintain conditions under which man and nature can exist in productive harmony, and fulfil the social, economic and other requirements of present and future generations" (United States Congress, 1969). This policy has been the basis for the national environmental policies of many other countries and has inspired the definition of sustainability most commonly used today.

However, it was not until the 1972 United Nations Conference on the Human Environment, also known as the Stockholm Conference, that the environment began to occupy the global political agenda. This conference led to the creation of the United Nations Environment Programme (UNEP) to protect ecosystems, tackle climate change, and promote green economic development. In the same year, the key report "The Limits to Growth", commissioned by the Club of Rome, was published (Meadows *et al.*, 1972). This report examined the results obtained by a computer simulation of the exponential population and economic growth in the context of a finite resource supply.

More aspects related to the concept of sustainability were studied in the following years. In 1983, the World Commission on Environment and Development was established to pursue

sustainable development. This commission was chaired by the then Prime Minister of Norway, Gro Harlem-Brundtland, hence its common name "the Brundtland Commission". The main outcome of this commission is the document "Our Common Future" published in 1987. This document, known as the Brundtland Report, defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). This was the first time that the concept of sustainability was associated with development. Indeed, both concepts share common synergies but show important differences. UNESCO (2012) defined them as "sustainability is often thought of as a long-term goal (i.e. a more sustainable world), while sustainable development refers to the many processes and pathways to achieve it". Development objectives evolved from purely economic objectives to include social objectives (intragenerational equity) and environmental objectives (intergenerational equity). As a result, from the late 1980s and early 1990s onwards, development models have increasingly sought to move towards sustainability (environmental, economic and social).

The inclusion of these three sustainability pillars was further developed in the 1980s and 1990s. Stahel and Reday (1981) included measures clearly rooted in the three-fold dimension of the sustainability concept in their report on the Potential for Substituting the Manpower for Energy, commissioned by the European Commission. They introduced a purely circular production model, a loop economy based on measures such as waste prevention, regional job creation, and efficient use of natural resources, among others. This idea was further developed in the 1990s, when the idea of the triple bottom line was introduced to reflect the importance of three components (Ps) in any business decision: people, profit and planet (Elkington, 2013). Now, the three dimensions, i.e., social, economic, and environmental, are widely accepted and constitute the three domains of sustainability (Depetris-Chauvin *et al.*, 2023; Kirchherr *et al.*, 2017; Millar *et al.*, 2019; Näyhä, 2019; Zabaniotou, 2018). However, the importance of each dimension, particularly the environmental and economic dimensions, has been highly debated. This has caused the categorisation of sustainability into two types: weak and strong. Weak sustainability focuses on the economic domain and states that the aggregation of human capital and natural resources must be maintained intact over time. On the other hand, strong sustainability gives more importance to the environment and aims to keep only natural capital constant over time (Hediger, 1999). Finally, recent new trends related to sustainability include the concept of planetary boundaries, which aims to define the environmental limits within which humanity can operate safely (Steffen *et al.*, 2015). However, this only looks at the environmental domain of sustainability.

The concept of sustainability is currently part of the political agendas of most countries and the strategies of most large organisations. For instance, the European Green Deal aims to contribute to environmental sustainability by transforming the EU economy to eliminate net greenhouse gas emissions by 2050 and decoupling economic growth from resource use (European Commission, 2019). Similarly, the US proposed a Green New Deal in 2019 to address climate change as well as social challenges such as economic inequality and access to clean water (Friedman, 2019). Although the legislation was rejected by the Senate, it was reintroduced in 2021. The US has already implemented a number of other environmental sustainability policies, such as the Clean Air Act, the Clean Water Act, and the Endangered Species Act. At the global level, the United Nations General Assembly established the 2030 Agenda for Sustainable Development, which defined 17 Sustainable Development Goals (SDGs) and 169 targets to be achieved by 2030. This Agenda was adopted by Heads of State and Government in 2015 (United Nations, 2015) and is shaping sustainability policies designed in all countries of the world. Despite being instrumentalised, the concept of sustainability has become as entrenched as the principles of democracy, justice and freedom (Geissdoerfer *et al.*, 2017; O'Riordan, 1988).

Despite its widespread everyday use, there are criticisms of the concept of sustainability. One of its main weaknesses is that it only indicates that future generations cannot be deprived of

satisfying their own demands, without a clearly established time dimension (Ulhoi and Madsen, 1999). Moreover, its concrete objectives have not been specified either, as these objectives are normative determinations that cannot be derived solely from scientific-descriptive models (Valentin, 2018). Consequently, empirical and quantitative data on their implementation are not abundant (Ritzén and Sandström, 2017). This lack of specificity is the main argument put forward by detractors of the concept of sustainability, who consider it only a buzzword that does not materialise in actions, policies or laws.

Kirchherr *et al.* (2017) also argued that although the concept of sustainability dates back to the 18th century, and despite the popularity of Brundtland's definition of sustainable development, it is still considered too broad a concept, making it difficult to put into practise. Other authors go further and question what should be sustained, for how long, and for whose benefit (Giampietro and Mayumi, 2009). Sustainability claims have also been used by companies for "greenwashing", in order to divert attention to minor issues or to create a "green talk" (Siano *et al.*, 2017).

Some authors, such as Ruggerio (2021), argued that sustainability is not a state that systems can achieve, i.e., systems cannot be labelled as "sustainable", but only as "more sustainable" or "less sustainable" than alternative systems. This means that sustainability is not an end goal but a path towards more sustainable systems. Other authors and institutions, such as UNESCO, distinguish "sustainability" from "sustainable development", and set the former as a long-term goal, while using the latter to refer to pathways to achieve it (UNESCO, 2012). According to this commonly followed view, sustainability can be seen as an idealistic theoretical goal, but the concept itself does not define what concrete practical path should be followed to achieve it.

In conclusion, sustainability is a holistic concept with a clear generic objective: not to overexploit natural resources beyond their recovery capacity, having a positive impact on the three pillars on which it is based (economic, social and environmental). However, if this objective is not translated into time-bound actions and responsibilities, it runs the risk of becoming utopian.

3.2. *Circular economy*

The concept of circular economy was first used in the second half of the 20th century. One of its main promoters was the English economist Kenneth E. Boulding, author of the essay "The economics of the coming spaceship Earth" (Boulding, 1966), in which he drew a parallel between a human being on Earth and an astronaut in his spaceship. According to Boulding, economists in general do not consider the Earth to be a closed system, but on the contrary, matter, energy, and information seem to come from elsewhere, as if natural resources were inexhaustible. Similarly, waste also seems to flow out of the system to some other place of infinite absorptive capacity. Although many economists used to think in this way, as early as in the early 19th century, leading economists such as David Ricardo, Thomas Malthus, and Stuart Mill had already warned about the limits of the planet. In this context, one of the basic ideas of the circular economy is to consider the waste of one process as an input into other production processes, contrary to the prevailing linear economy, also known as the "take-make-waste" economy (Suttie *et al*., 2017). In fact, one of the principles of the "cradle-to-cradle" philosophy, on which the circular economy is based, is that "waste equals food", which encourages designing processes in such a way that their waste can be "food" for other systems (Ellen MacArthur Foundation, 2013).

The concept of the circular economy is based on the idea that natural resources are not infinitely available to humans, nor is nature's capacity to absorb the waste generated by human activity infinite (Boulding, 1966). This is similar to the concept of sustainability. The main novelty introduced by the circular economy is, as its name suggests, the circularity of the production model as opposed to the prevailing linearity. This means that production must be seen as a cycle that cannot be closed without returning to the starting point. Hence, the term "closed-loop economy", is a concept similar to that of the circular economy (Ellen MacArthur Foundation, 2013; (Ellen MacArthur Foundation, 2013; Saidani *et al.*, 2022).

There are many definitions of circular econo-

my, but to date there is no consensus on which one should be accepted by the scientific community (Korhonen *et al.*, 2018b; Yuan and Moriguichi, 2006). Kirchherr *et al.* (2017) and Millar *et al.* (2019) noted the scarcity of studies investigating or contrasting the different definitions of circular economy. This makes it difficult to disseminate and use the concept (Kalmykova *et al.*, 2018). In addition, the foundations of the circular economy are based on many other concepts, such as steady-state economics, industrial ecology, cradle-to-cradle philosophy and others (Kalmykova *et al.*, 2018).

Bastein *et al.* (2013) defined the circular economy as an economic and industrial system based on the reuse of products and raw materials and the resilience of natural resources, in which value destruction is minimised and value creation is maximised throughout the system. Yuan and Moriguichi (2006) proposed a simpler definition: a system in which the flow is circular and raw materials and energy are used in multiple phases. To achieve this goal, the life cycle of products needs to be redesigned (D'Amato *et al.*, 2017).

According to the Ellen MacArthur Foundation (2015), the circular economy is based on three principles: 1) preserving and enhancing natural capital by controlling finite stocks and balancing renewable resource flows; 2) optimising resource use by rotating products, components, and materials with maximum utility at all times, in both technical and biological cycles; and 3) fostering system efficiency by revealing and eliminating negative externalities. These principles perfectly coincide with the concept of sustainability.

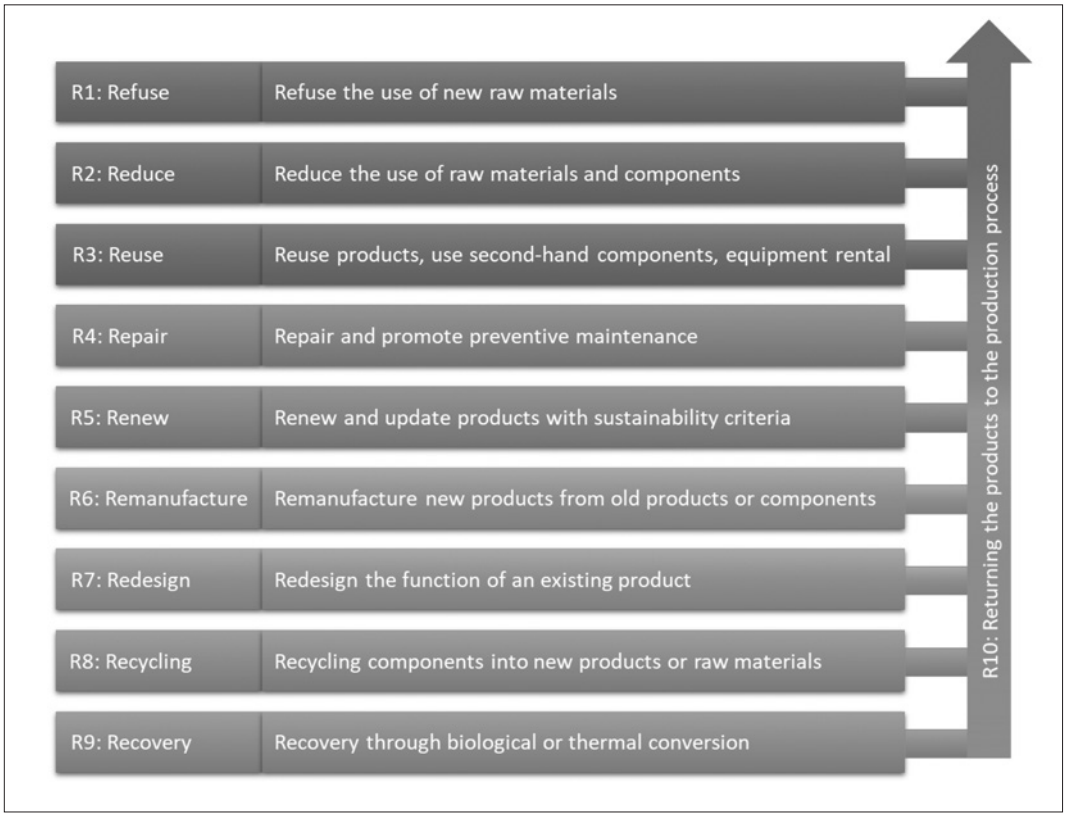
The circular economy not only increases resource efficiency by minimising waste and resource use but also considers the economic, environmental and social domains, as does the concept of sustainability (Ghisellini *et al.*, 2016; D'Amato *et al.*, 2017; Näyhä, 2019). In 2015, the European Commission itself adopted an action plan to help accelerate Europe's transition towards a circular economy that explicitly mentions the use of resources in a sustainable way, with actions that are beneficial for both the economy and the environment (European Commission, 2015).

The circular economy is also often related to the 3Rs principle, which promotes reduce, reuse, and recycle, in this order (Ghisellini *et al.*, 2016; Yuan and Moriguichi, 2006). Ritzén and Sandström (2017) and Kalmykova *et al.* (2018), among others, added a fourth R, recover, to refer to options such as energy recovery, which should always be the last preferred option. Van Buren *et al.* (2016) and Potting *et al.* (2017) included economic, social, and environmental value creation as primary objectives, embodied in a framework of the following 9Rs: 1) refuse the use of new raw materials; 2) reduce the use of raw materials; 3) reuse products; 4) repair and maintain; 5) renew products; 6) remanufacture; 7) redesign; 8) recycle; and 9) recover energy. For Kirchherr *et al.* (2017), the circular economy is also based on this framework, but with an emphasis on prioritising prevention over the other options. We suggest adding the tenth R, which would be "return" (Figure 2), to emphasise that all physical products generated in the system, including by-products and waste, should remain in the same or a different production system. R10 completely closes the circular system.

The circular economy continues to gain momentum and is even seen as a replacement for the linear economy as a production system. This is reflected in the fact that some of the world's most developed nations include it in their policies, such as China, the European Union, and the United States (Circular CoLab, 2018; European Environment Agency, 2018a; World Bank Group, 2009). The private sector has also begun to explore the opportunities offered by the circular economy (Ellen MacArthur Foundation, 2013).

Two factors have driven the development of the circular economy: 1) China's adoption of this concept as a development strategy in 2002 and its implementation in its national policy in 2006 (Yuan and Moriguichi, 2006) and 2) the launch of the Ellen MacArthur Foundation in 2010 by yachtswoman and elite athlete Ellen McArthur in partnership with five major multinationals, with the aim of "accelerating the transition to a circular economy" (Suttie *et al.*, 2017). In fact, one of the most widespread definitions of the circular economy is that of the aforementioned foundation, which defines it as "a system where materials never become waste and nature is regenerated" (Ellen MacArthur Foundation, 2023). The circular econ-

Figure 2 - The 10R principle. Own elaboration partly based on van Buren et al. (2016) and Potting et al. (2017).



omy is "one that is restorative and/or regenerative in intention and design" (Ellen MacArthur Foundation, 2013) and has as principles to eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature (Ellen MacArthur Foundation, 2023).

There are also negative views on the circular economy in academia. Some authors think that the circular economy could generate outcomes similar to those of the linear economy (Millar *et al.*, 2019) if changes do not come from the core of the system, i.e., the business model (Bocken *et al.*, 2014). Others warn of the high-energy consumption of recycling, which is sometimes higher than that of manufacturing/extraction of new materials (Allwood, 2014), which could make the energy efficiency of the recycling process lower than that of the manufacture/extraction of new materials. Giampietro (2019) argued that the circular economy is not thermodynamically feasible, as entropy increases in each closed loop, leading to losses in quantity (materials, by-products, etc.) and quality (mixing, degradation). This is in line with the work of Allwood (2014), who argued that the circular economy would only be technically feasible if global demand for products were stabilised, and of Korhonen *et al.* (2018a) who considered the possibility of circularising the economy to be unfeasible. Furthermore, Korhonen *et al.* (2018a) argued that the definition of circular economy should also refer to a reduction in production to levels that are acceptable to nature.

Few articles have analysed both the circular economy and sustainability at a theoretical level. Among the few exceptions is the work of Geissdoerfer *et al.* (2017), who, based on an in-depth literature review, studied the differences and similarities between the two concepts, as well as the types of relationships that exist between them. In terms of similarities, they pointed out the intergenerational nature of the commit-

ments and the need for greater intervention by institutions as a vehicle for development. Other common aspects are the global approach, the interdisciplinary nature of their object of study, and the necessary cooperation between different actors. Regarding the most notable differences, it is worth highlighting the open and unspecific objectives of sustainability, with a diffuse temporal dimension, as opposed to the objective of a more efficient use of resources promoted by the circular economy. Finally, although sustainability gives importance to its three domains, weak sustainability gives more importance to the economic domain, whereas strong sustainability focuses more on the environmental domain. In the circular economy, the economic system predominates, with environmental and social gains being little more than collateral (Murray *et al*., 2017). There is a broad consensus in the literature on the similarities and differences indicated, except the last point.

In conclusion, the circular economy, in terms of objectives and fundamental principles, fits very well with the concept of sustainability, albeit with some nuances. Indeed, the circular economy is often seen as an indispensable element for achieving sustainable development (Läpple, 2007; Näyhä, 2019; Yuan and Moriguichi, 2006) and could therefore be the instrument to concretise sustainability in a legal framework and align the actors involved.

3.3. *Bioeconomy*

The term "bioeconomy" was first coined in the 1920s by the Russian biologist Baranoff to describe the economics of the fisheries sector. It then became generalised in the 1950s, referring to the need to use renewable resources, and was consolidated in the 1970s and 1980s as an ecological perspective applied to economics (Giampietro, 2019), with the Romanian mathematician and economist Georgescu-Roegen at the forefront. In the last decade, the bioeconomy has gained great popularity and has been studied and disseminated by international organisations such as the Organisation for Economic Co-operation and Development (OECD, 2009). The bioeconomy has been placed at the centre of the political strategies of major powers such as the United States and the European Union (Guo and Song, 2019), in coexistence with circular economy strategies.

For Vivien *et al.* (2019) and Befort (2020), the original concept of bioeconomy has evolved into two new meanings that are very different from the original. The first new meaning emerged between the 1990s and 2000s with the biotechnology revolution and places biotechnology at the centre of the bioeconomy. It is part of the so-called knowledge economy or economy based on scientific knowledge and research. The second new meaning, currently dominant in the European Union, is the so-called biomass bioeconomy, which encompasses sectors as diverse as energy, agriculture, fisheries, forestry, chemistry, as well as biotechnology itself, as suppliers of the raw materials transformed in the so-called biorefineries. This new term refers to industries that process different types of biomass (wood, agricultural products, waste and algae) with the aim of replacing fossil fuels.

The multiple definitions of bioeconomy found in the literature agree with the two new meanings mentioned above. Thus, De Besi and McCormick (2015), McCormick and Kautto (2013), and Suttie *et al*. (2017) defined it as an economy based on the sustainable production and conversion of biomass into bio-based materials or energy. Very similar is the definition of the European Commission (2018), according to which the bioeconomy is the production of renewable biological resources and their conversion into food, bio-based products, and bioenergy, affecting sectors as diverse as agriculture, forestry, fisheries, the food industry, the paper industry, as well as some chemical, biotechnology, and energy industries. The perception of biomass as the basis of the bioeconomy is shared by other authors (Aguilar *et al.*, 2018; Lainez *et al.*, 2018; Lewandowski, 2015; Näyhä, 2019; Villarán *et al.*, 2018; Wohlfahrt *et al.*, 2019). The exact definition of the bioeconomy varies from region to region, from organisation to organisation and even between different stakeholders (McCormick and Kautto, 2013; Näyhä, 2019).

On the other hand, for organisations such as the OECD, the bioeconomy is the result of the application of biotechnology to production, based on

the development and use of biological materials, with potential benefits for the economy and the environment (OECD, 2009). Although this definition straddles the two new meanings outlined by Vivien *et al.* (2019), it gives biotechnology a leading role.

Bugge *et al.* (2016) also distinguished three conceptions of the bioeconomy, albeit from a different perspective. The first conception is framed within a scientific vision, which emphasises the need to deepen research to increase the applications of biotechnology and, therefore, the commercialisation of its results. The second, more along the lines of De Besi and McCormick (2015), prioritises the use of so-called bio-resources and promotes research into new raw materials of biological origin and the establishment of new value chains. In contrast to the first conception, which prioritises further biotechnology transfer, the second focuses on the potential for adaptation and conversion of new bio-based materials to existing industrial processes. Finally, a third vision focuses on bioecology, i.e., the importance of taking ecological criteria into account in industrial processes, optimising energy and nutrient use, and promoting biodiversity while avoiding monocultures and soil degradation. Although this third vision does not fully correspond to the initial concept of bioeconomy promoted by Georgescu-Roegen, it is the closest and the only one that explicitly includes ecology.

Although there is some overlap between the bio-based and biotechnology-based streams, they are completely independent of the original ecological stream. This has led some authors (e.g. Giampietro, 2019; Plumecocq, 2014; Vivien *et al*., 2019) to call for a return to the concept put forward by Georgescu-Roegen and to argue that the transition of the current economic system must involve a change based on ecological principles. These three streams that make up the concept of the "bioeconomy" are described in more detail below, and their relationship to sustainability and the circular economy is discussed.

In terms of biomass use, the potential for new functions and properties of biological versus non-biological resources represents an open door for innovation, which should be implemented in the economic context (Aguilar *et al.*, 2018). According to Suttie *et al.* (2017), the preferential use of bio-based materials over fossil-based materials could be considered a subcategory of the circular economy, as it would help achieve waste minimisation. There are many examples of this use of biomass to support the transition to a circular economy, e.g., the substitution of polypropylene by plant fibres such as jute or hemp in the manufacture of raffia and other growing materials (Hitschfeld and Rodríguez, 2015; Marín-Guirao *et al.*, 2022). If the trellis elements were compostable, at the end of their useful life, they could be sent to a composting plant together with the plant waste (Sayadi-Gmada *et al.*, 2019). In this way, they would cease to be waste and would be transformed into a new product, which could also be returned to the farm in the form of compost, thus closing the cycle (Castillo-Díaz *et al.*, 2022).

As for the biotechnology stream of the bioeconomy, one of its objectives is to obtain high value-added products from biomass (Egea *et al.*, 2018 and 2021), which can again be perfectly integrated into the objectives of the circular economy if the biomass used as raw material is a waste (Pinela *et al.*, 2017). For example, biotechnology makes it possible to extract active compounds from plant waste, such as carotenoids, lycopene (Pinela *et al.*, 2017; Villarán *et al.*, 2018), organic acids, enzymes (Irfan *et al.*, 2020), microorganisms, and proteins (Leceta *et al.*, 2014). This means that countries with a high dependence on agriculture and the agri-food industry could find an alternative to their usually costly waste management, bringing an economic benefit that, for example for the Netherlands, is estimated at EUR 3.5 billion per year (Bastein *et al.*, 2013). Another objective of biotechnology is the production of alternative materials that can satisfy specific applications without becoming waste that is difficult to manage, such as biodegradable or compostable plastics for agricultural mulch (Blanc *et al.*, 2019).

As for the ecological stream of the bioeconomy, Georgescu-Roegen's conception is a priori compatible with the circular economy. On the one hand, a circular model is more easily integrated into biogeochemical cycles than the dominant linear model (Leipold and Petit-Boix, 2018). On the other hand, the circular economy is strongly root-

ed in industrial ecology (Mirabella *et al.*, 2014) and economic degrowth (Vivien *et al.*, 2019). In this sense, they share common ideas, such as waste minimisation, which can help optimise the use of energy and materials in the system (Bugge *et al.*, 2016). However, beyond the above, no other similarities have been found between the bioeconomy and the circular economy. On the contrary, the material and energy limits of recyclability are questioned. Indeed, the use of biomass and biotechnology has proven to be compatible with the circular economy. However, for proponents of a more orthodox idea of the bioeconomy, mainly ecological economists, the combination of biotechnology, use of biomass resources, and circular economy is not sufficient to harmonise natural cycles with the current production system.

From the above discussion, we can see the urgency of delving deeper into each of the three coexisting streams in the bioeconomy to unify them not only around the principles of the circular economy but also according to economic, social, and environmental criteria, i.e., from an eminently sustainable perspective. An approximation to the definitive definition of the bioeconomy could be as follows: the bioeconomy is an ecologically based production model based on two pillars: 1) the use of biological resources and 2) the use of biotechnology. The former represents the raw materials, while biotechnology is the instrument to implement it. However, to ensure the sustainability of the system, the central core must be ecology.

It should be noted that the use of bio-based resources in the production process does not guarantee a more sustainable system (Ramcilovic-Suominen and Pülzl, 2018; Tan and Lamers, 2021). For example, it is uncertain that biodegradable plastics can fully degrade under uncontrolled conditions, especially in oceans where temperatures are lower (Tulashie *et al.*, 2019). This creates a major marine pollution problem. On the other hand, when biodegradable materials decompose rapidly, they release greenhouse gases, increasing global warming more than non-biodegradable materials in the short term. Another example is the indiscriminate increase in bio-crops, which leads to deforestation and land-use change, which in turn leads to the loss of carbon sinks (Suttie *et al.*, 2017; Zabaniotou, 2018), threats to natural ecosystems (Aguilar, 2018; Bohlin *et al.*, 2011), increased pollution from agro-industry, impacts on biodiversity from unsustainable soil and water management practices (Kayatz *et al.*, 2019; Santos-Martín *et al.*, 2019), and competition between bioresource production and food production (Baumgarten and Kerckow, 2017; Bobe *et al.*, 2014; Martínez de Arano *et al.*, 2018).

A radical transformation towards biorefineries has several risks, not only for the reasons outlined above, but also because 1) the industry has been in existence for several centuries, so it is not feasible to replace it in such a short time (Mirabella *et al.*, 2014; Nielsen *et al.*, 2020), and 2) the replacement of the facilities would generate such a large amount of waste that it would be difficult to manage it in a sustainable way (Vinyes *et al.*, 2017). On the other hand, the powerful lobbies of the petrochemical industry could simply renew their feedstocks and continue to produce unsustainably (Vivien *et al.*, 2019).

From the above discussion, it can be concluded that the circular economy and the bioeconomy tend to be seen as complementary rather than antagonistic (Beltrán, 2018; D'Amato *et al.*, 2017; EEA, 2018). Their points of convergence include boosting local production and developing rural areas (Aguilar, 2018; Bugge *et al.*, 2016; Näyhä, 2019). The circular economy can boost local production by using the waste generated locally, similar to the bioeconomy, which should prioritise the use of local biological resources over biomass from distant locations. Promoting local production also supports the development of rural areas, where large amounts of biomass, for instance from agricultural activities, are generated. Furthermore, the use of biological resources at the local level, as well as appropriate technologies to valorise them instead of exporting them, creates added value and synergies in innovation and development (Bugge *et al.*, 2016), with implications for job creation and a lower carbon footprint due to the elimination of transport. This has led to the merging of the terms into one that integrates the fundamental principles of both: circular bioeconomy.

4. Towards a sustainable circular bioeconomy

The concept of sustainability, as mentioned above, is broad, holistic, and abstract; therefore, it needs a unanimous definition in order not to become a utopia, as well as tools to materialise it. These tools can be the circular economy and the bioeconomy. The principles of the circular economy and the bioeconomy are synergistic in terms of the goal of achieving socio-economic development by decoupling economic growth from resource depletion and environmental degradation (Lokesh *et al.*, 2018). Moreover, a fully functional bioeconomy is completely compatible with the achievement of a circular economy, both at the micro (local rural development) and macro (national) levels (D'Amato *et al.*, 2017; Tan and Lamers, 2021). Indeed, the bioeconomy, along with the circular economy, has the potential to contribute directly to the UN Sustainable Development Goals, which are today's main targets for sustainable development. However, a broader view should be taken, considering the circular bioeconomy as a type of interaction that belongs to a broader concept than the bioeconomy and the circular economy (Raimondo *et al.*, 2021).

There is little previous work on the implementation of a circular bioeconomy to achieve sustainable systems. At the policy level, examples range from the local level, such as the pilot project on circular bioeconomy for organic waste in Sangüesa (Spain) (Gobierno de Navarra, 2017), the regional level, such as the Andalusian Strategy for the Circular Bioeconomy (Junta de Andalucía, 2017), to the international level, with the European Commission leading the way (European Commission, 2022). The European Commission defines the circular bioeconomy as the production of energy, food, platform chemicals, and other bio-based materials and compounds from biomass in a sustainable and integrated/cascading manner (biorefinery) while generating zero waste. Although the circular bioeconomy is generally conceived as a sustainable alternative, it must be implemented through a legal framework based on environmental, economic, and social principles, so that the attractiveness of new business opportunities resulting from the combination of the circular economy and the bioeconomy remains sustainable.

In fact, neither the bioeconomy nor the circular economy are inherently sustainable, although both concepts can be used as approaches to make a system more sustainable. Moreover, both the bioeconomy and the circular economy complement each other; therefore, the ideal production model would be one that brings together the strengths of both systems. Therefore, in our view, the ultimate strategy should be a sustainable circular bioeconomy, a combination of what should be done (the circular economy) and how it should be done (the bioeconomy) to achieve economic, social, and environmental benefits (sustainability).

In the literature review presented in Section 3, the term "sustainable circular bioeconomy" was found in 48 articles. However, these articles only claimed to use this approach in their work, without providing a precise definition or explanation of the approach. Only five articles provided a partial definition of the concept, focussing on different aspects, such as the use of natural resources (Krüger *et al.*, 2020), biomass utilisation (Sevigné-Itoiz *et al.*, 2021), bio-waste valorisation (Briassoulis *et al.*, 2021), and the use of by-products in biorefineries (Khan *et al.*, 2022). Zabochnicka (2022) integrated the three main concepts (i.e. sustainability, circular economy and bioeconomy) but only provided the following generic definition: "sustainable circular bioeconomy is an element of the circular economy that is connected to all processes, products and technologies that are "bio", and aims at sustainability".

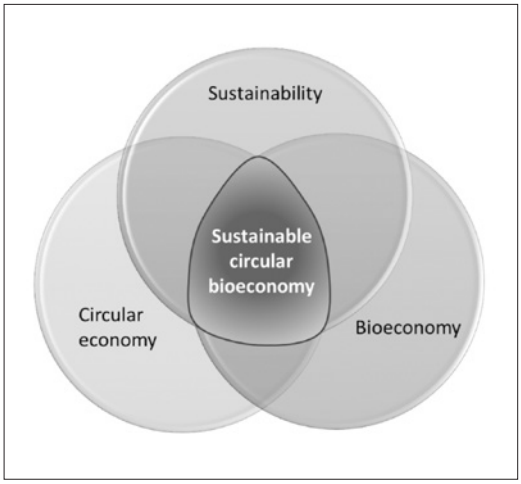
On the basis of the discussion above and the literature review presented in Section 3, we propose the following definition of sustainable circular bioeconomy: "a deeply ecologically based production model that produces social, environmental, and economic benefits by integrating the principles of the circular economy and the bioeconomy". In this context, the three concepts (i.e. sustainability, circular economy and bioeconomy) can be represented with a Venn diagram, with clear overlaps as well as distinct areas for each concept (Figure 3). The ideal strategy corresponds to one that integrates all three concepts: the sustainable circular bioeconomy (darker central area in Figure 3). Therefore, a sustainable circular bioeconomy is an economic system that prioritises sustainable production and consumption practices, while integrating principles from

the circular economy and the bioeconomy. In a sustainable circular bioeconomy, the production and consumption of goods and services are based on principles of environmental and social responsibility. This means that economic activity is designed to support the long-term health of the planet, while also benefiting society through job creation, poverty reduction, and improved access to resources and services. One of the implications of this model is that it requires a significant shift in the way we approach production and consumption. Instead of a linear take-make-dispose model, the sustainable circular bioeconomy emphasises the importance of circularity and waste reduction. This requires a shift towards closed-loop systems that minimise waste and maximise the reuse of resources. Another implication is that the sustainable circular bioeconomy can create new opportunities for innovation and economic growth. For example, it can foster the development of new technologies and business models that prioritise sustainable production and consumption practices. It can also create new employment opportunities in areas such as recycling and resource management. Finally, the sustainable circular bioeconomy has important implications for environmental and social sustainability. Prioritising the long-term health of the planet and supporting equitable access to resources and services has the potential to reduce poverty, promote social justice and protect natural resources and ecosystems.

It should be emphasised that consumers are not only a key factor in setting product prices but also encourage the production of certain products to the detriment of others. The criteria traditionally considered by consumers, such as aesthetics, performance, price, or brand, have started to include the sustainability of the production process and of the product itself. Thus, the shift towards more sustainable systems must start from the citizens, not only because of their power as consumers, but also because of their growing awareness of their own waste generation and its associated impacts on the environment. Due to growing public awareness, citizens are expected to embrace the principles of a sustainable circular bioeconomy.

The proposed definition and concept of a sustainable circular bioeconomy can contribute to the achievement of sustainable development and multiple SDGs in several ways: 1) the sustainable circular bioeconomy prioritises sustainable production and consumption practices, which is in line with SDG 12 'Responsible consumption and production'; by adopting circular economy principles such as waste reduction and resource efficiency, it can contribute to reducing the environmental impact of production and consumption; 2) the sustainable circular bioeconomy can create new opportunities for innovation and economic growth, which is in line with SDG 9 'Industry, innovation and infrastructure'; it can foster the development of new technologies and business models that prioritise sustainable production and consumption practices, which can contribute to job creation and economic growth; 3) the sustainable circular bioeconomy can help reduce poverty and promote social justice, which is in line with SDG 1 'No poverty' and SDG 10 'Reduced inequalities'; by creating new employment opportunities in areas such as recycling and resource management, it can generate income and support livelihoods, especially for disadvantaged communities; and 4) by prioritising the long-term health of the planet and supporting equitable access to resources and services, the sustainable circular bioeconomy can contribute to the protection of natural resources

Figure 3 - Relationships among the concepts of sustainability, circular economy, bioeconomy, and sustainable circular bioeconomy.



and ecosystems, which is in line with SDG 13 'Climate action', SDG 14 'Life below water' and SDG 15 'Life on land'.

Building on the concept of a sustainable circular bioeconomy and the preceding discussion, a number of public policies can be developed to put the concept into practice, including the following:

- Establishing regulatory frameworks: Policies should be developed to establish legal frameworks in line with environmental, economic, and social principles to ensure the sustainability of the circular bioeconomy. This will help to regulate the business opportunities arising from the combination of the circular economy and the bioeconomy.
- Encourage the use of biomass: Policies should be developed to promote the use of biomass in a sustainable manner with the aim of achieving zero waste. This can be achieved by promoting the use of by-products in biorefineries, the valorisation of biowaste, and the use of natural resources.
- Develop pilot projects: Pilot projects on circular bioeconomy should be promoted at the local level. These pilot projects can serve as a blueprint for other regions to follow, leading to the development of sustainable circular bioeconomies at the regional level.
- Create new market opportunities: Marketing strategies should focus on creating new market opportunities based on quality attributes to meet consumer demand for more sustainable products.
- Promote the uptake of new technologies: The adoption of new technologies can enhance the sustainability of systems and products. An example of this is the use of digital technologies to collect and analyse large volumes of data in real time, which allows the optimisation of production processes as well as the use phase of the products.
- Educate citizens: Actions should be taken to communicate and educate citizens about the principles of a sustainable circular bioeconomy. This will enable citizens to make informed choices about their consumption patterns and waste generation. In addition, consumer preference for sustainable products can encourage businesses to adopt sustainable production models.
- Work together at international level: Collaboration at the international level can help promote the sustainable circular bioeconomy. The European Commission has taken the lead in this regard, and more such collaborations can be established to share best practices and ideas.

4. Conclusions

This article has revised the definitions and use of the concepts of sustainability, circular economy, bioeconomy, and circular bioeconomy. The concept of sustainability has been widely accepted for a long time and is based on the principle of not overusing natural resources beyond their capacity for recovery. It has a triple dimension of social, economic, and environmental considerations, but its objectives are not clearly defined and the responsible actors are yet to be identified. The circular economy aims to optimise the use of resources and minimise waste generation by integrating them into a circular production model. It prioritises the economic dimension, but the importance of the social and environmental dimensions remains a subject of debate. The bioeconomy is divided into three streams: the original ecological concept, the biomass-based bioeconomy, and the biotechnology-based bioeconomy. The core of the bioeconomy is ecology, and biotechnology is the instrument for its application.

The integration of these concepts results in the concept of a sustainable circular bioeconomy. The sustainable circular bioeconomy uses waste as input for another or the same process, prioritises the use of biological materials over those of fossil origin, and uses biotechnology to generate social, environmental, and economic benefits. Implementing a sustainable circular bioeconomy requires efforts from multiple actors. The scientific community must reach a consensus on its definition, objectives, and levels of action. The aim of our study is to contribute to the ongoing discourse within the scientific community on the need to establish a clear and widely accepted definition of sustainable circular bioeconomy.

Given the growing global interest in this emerging field, it is imperative that a consensus is reached on the fundamental concepts and principles that underpin this paradigm shift towards a more sustainable, resource-efficient, and regenerative economic model. Our work aims to provide insights and recommendations to facilitate the development of a common understanding of the sustainable circular bioeconomy, enabling stakeholders to work together more effectively to achieve its goals.

In addition to efforts at the theoretical level, public institutions should provide support and credibility to the concept and implement it in practice through regulations at the international and national levels. Governments must rely on scientific knowledge to design and implement strategies, while industry must apply this concept to become more competitive, enter new markets, and increase profitability. The role of citizens is also crucial in spreading environmental values and cultivating a culture of sustainability. They must understand the impact of their daily activities on the environment, particularly from the waste they generate. In conclusion, the sustainable circular bioeconomy is key to increasing sustainability in our societies, and all actors must play their part in achieving it. Adopting the principles of a sustainable circular bioeconomy can significantly contribute to the achievement of sustainable development and several SDGs, particularly those related to responsible consumption and production, industry, innovation and infrastructure, poverty reduction, social equity, and environmental protection.

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Covid-19 crisis: What lessons on the role of the informal economy in the Tunisian date value chain?

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Abstract

The objective of the paper is to analyze the stakes associated with the informality in the Tunisian Dates supply chain. We focus on the interdependencies between the formal and informal sectors, interdependencies which have been particularly revealed during the Covid-19 crisis. This crisis has highlighted the fundamental role of the informal sector in structuring the supply chain, mainly in the marketing intermediation links. Based on its impacts on the Tunisian date sector, we revisit the debates on the informal sector and offer a critical analysis of the strategies generally proposed to fight against this phenomenon. Radical strategies to eliminate the informality would have the effect of paralyzing a certain number of transactions in the supply chain inducing vulnerabilities of formal stakeholders. Conversely, a tolerant policy towards the informal economy could in the long term compromise the sustainability of the supply chain. The lessons learned from the Covid-19 crisis suggest, firstly, the implementation of policies aimed to reduce the dependence of formal actors on the informal sector. Such a policy is likely to facilitate, in a second phase, the success of progressive integration strategies of the informal economy into the formal system.

Keywords: *Covid-19 crisis, Informal economy, Date value chain, Resilience, Tunisia.*

1. Introduction[1]

In Tunisia, the informal economy accounted for 35.2% of GDP in 2022 (UNDP-ILO, 2022) and has a greater impact on the agricultural sector (Hassen *et al.*, 2021). Informal employment is estimated at 26.8% of the working population, with a higher rate of informality for self-employed workers (57.6%) than for employees (16.1%). It is generally acknowledged that the informal economy makes it possible to absorb social insecurity on the one hand, by supporting part of the population and, on the other, by providing another part with additional income (UNDP-ILO, 2022). Based on these observations, a large number of studies (Coşkun, 2022; Leyva

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and Urrutia, 2023) have focused on the role of the informal economy in the labour market, on the impact of this informal workforce on the performance of sectors and on innovation and knowledge transfer (Ibidunni *et al.*, 2020).

Paradoxically, few studies have explored the issues linked to the presence of the informal economy as an operator in the various activities of supply chains (Colovic *et al.*, 2022; Narula, 2019). However, its contribution to the creation of value in agricultural sectors in developing countries, in particular in the Maghreb, and its predominant weight in the sharing of this value is indisputable. The Tunisian date sector can be considered a textbook case in this area.

From this point of view, and to a certain extent, the Covid-19 crisis has acted as a life-size experiment to assess the weight of the informal economy in Maghreb supply chains, and its role in the vulnerability or in resilience of supply chains. As Folke (2006) and Baggio *et al.* (2015) pointed out well before this recent crisis, resilience obviously involves strengthening the ability of stakeholders and systems to respond to economic, environmental and social shocks by anticipating them, absorbing them and reducing fragility. In the face of a possible resurgence of crises in the future, there is therefore an urgent need to draw lessons from this pandemic.

The pandemic has highlighted some of the structural weaknesses of agricultural supply chains in the Global South[2] and its role in the malfunctioning of the supply chains during the crisis (Zimmerer and Haan, 2020, Rukasha *et al.*, 2021). As we shall highlight in the following sections, informal actors have been more affected than the formal economy by the regulations governing the mobility of stakeholders.[3] From this statement, the main objective of the document is to analyze, through a value chain approach, the points of vulnerability of the value chain of Tunisian Dates in a crisis context, focusing mainly on the role of the informal sector and the interdependencies which link to the formal sector. Considering the feedback from operators, experts, and institutional stakeholders involved in the date sector during the Covid-19 crisis,[4] it appears that the informal economy is involved in a process of integration into the overall value chain, through close interaction with the formal economy. Thus, we can legitimately ask the following questions: should the informal economy be considered as a factor of vulnerability that must be eradicated, or as an essential player in the structuring of supply chains, which must be accommodated? Will increasing the skills of stakeholders involved in the formal economy be enough, without considering their dependence on the informal economy, as the health crisis has shown (and we shall highlight later on)?

Another question concerns the difficulties associated with public intervention in this context, due to the fact that a large number of transactions are carried out through relationships between the formal and informal economies. The chances of success of such policies in sectors that include a mix of formal and informal stakeholders is at the heart of recurring debates. Phillips (2011) describes the complexity of the relationship between formal and informal systems, and shows how the implementation of an effective policy for upgrading value chains may have asymmetrical effects on stakeholders, generally to the detriment of the informal economy. Should we support a formal economy knowing that it faces both unfair horizontal competition and vertical dependence on informal stakeholders? In other words, what are the social costs and benefits as-

[2] Regarding the impacts of the Covid-19 pandemic on African food systems see ADB (2021).

[3] Government decree no. 2020-156 of March 22nd 2020, which set out the requirements needed to ensure the continued operation of essential services, as part of the implementation of total containment measures.

[4] Our analysis is largely based on work carried out as part of the European project ValueTEAM, funded by ARIMNET 2 (ERA-NET), and aimed at enhancing the local and international value of the Maghreb date sector. We have drawn on the various contributions and discussions between experts, institutions and professionals from the Maghreb date industry who came together at a forum (FOPRODATTE) which the authors organised on March 18th 2022 in Hammamet, Tunisia (see Appendix 1). The exchanges between the 51 participants were recorded and a summary was shared with all the participants present at the forum.

sociated with the presence of the informal sector in the date value chain that make financial support for the sector economically justifiable? Can the Government with little capacity for structuring and controlling sectors come to tolerate activities that take place outside the formal economy? This is perhaps one of the reasons why the informal economy has grown considerably in a large number of developing countries, in a context where no public policy has been able or willing to properly eradicate it. From this point of view, an ITES report (2023) considers that approaches aimed at including the informal economy are more legitimate and effective than those that seek to eradicate it.

This article follows on from these debates. While drawing on the lessons of the Covid-19 crisis through the risks linked to the presence of the informal economy in the Tunisian date value chain, we highlight certain structuring effects of the presence of the informal sector which hinder public policies. Do informal activities weaken the sector and reduce its resilience in the face of crises? Or on the contrary, do they provide structure, by enabling certain parts of the supply chain to operate with relative efficiency and organisational rationality? In order to response to these questions, we propose a descriptive and factual analysis of the evolution of the characteristics of the sector before and after the Covid-19 crisis and shed light on economic policy. We fill a gap in the literature by adopting a value chain approach which considers the strong interdependencies that exist between the formal sector and the informal sector: vertical supplier/customer interactions and horizontal interactions between collectors-packers belonging to the same link in the chain. The aim is to put forward ideas and recommendations for the rational and effective management of this phenomenon.

The remainder of the article is organized as follows: Firstly, we will present a diagnosis of the state of the sector before and following the health crisis, as well as the vulnerabilities identified. Secondly, we will highlight the interactions between the formal and informal economies. Finally, we will suggest ways forward and strategies for strengthening the resilience of the sector and mitigating the impact of future crises.

2. The Tunisian date sector

Date palm cultivation has developed over more than seven centuries in Tunisia. Traditional production systems have evolved considerably with the modernisation of irrigation techniques and borehole pumping systems. This evolution has benefitted from the development of export activities. New oases have sprung up in the Djerid and Nefzaoua areas, in the governorates of Tozeur and Kebili, respectively. This development has been accompanied by organisational changes in marketing, particularly following the liberalisation of packaging and export activities. This dynamic has resulted in an increase in production, which testifies to the part played by the date sector in the Tunisian economy today. Production, which has been growing steadily since 1975, reached 331,500 thousand tonnes during the 2019-2020 season (ONAGRI, 2022). At an international level, Tunisia ranks third, with exports estimated at US$ 255,900 (ITC, 2022). The sector is also an important source of income, thanks in particular to its high market value in the southern regions of Tunisia (Zouhair *et al.*, 2020). Date production is carried out by small farmers who own small palm groves ranging from 0.5 to 3 hectares (Khamassi, 2015), The oases are concentrated in four governorates: Gabès, Gafsa, Kebili and Tozeur, which are home to 10% of the Tunisian population. Closely affected by climatic factors, these regions face drought, which accentuates the financial precariousness of growers, who also have to contend with a low-skilled workforce.

Farmers usually sell their produce in one of two ways. The first is the sale of standing crops, with a price based on an estimation of the average palm tree yield. Sorting, harvesting and transport are the responsibility of the collector. This type of transaction involves risks for the collector, based on the quality of the dates, the availability of volumes and their compliance with quality standards. The second type of transaction is the wholesale of tonnage. This type of transaction does not involve any risks for collectors, who can select the quality required by exporters and possibly obtain supplies from other collectors sourcing locally.

Packing is an important stage in the process of improving the visual and commercial quality of exported dates, particularly through disinfestation, sorting and packaging. Finally, contracts, which are generally informal and oral, are an important part of transactions in the Tunisian sector.

3. The informal economy in the production and collection stages of the Tunisian date supply chain

From the 1980s onwards, the informal economy became a permanent fixture in the sector, notably through the illegal seizure of new land, which simultaneously generated a substantial increase in potential and an alternative production system that benefited from state subsidies. The public development of hydraulic infrastructures has undoubtedly played a catalytic role in the expansion of palm groves, especially in the Kebili region. As a result, these expansions, which take advantage of illegal and control-free access to water, total an area four times larger than the one legally irrigated in this region (Mekki *et al.*, 2021). These palm groves are tolerated by local authorities because they contribute to a public strategy geared towards an intensive agricultural model.

The literature shows that the incentives for formal producers to subcontract to informal stakeholders, and ultimately the degree of informal infiltration into the sector, depend on the level of specialization in the producer's agricultural activity. In particular, studies (Fusillier *et al.*, 2009; Gendre *et al.*, 2007) show how the choice of harvesting practices and the marketing strategies adopted by growers are largely determined by their specialization. Unlike producers in Kebili who are specialized in the production of dates, in Djerid (Tozeur), date production is generally not the only activity of producers. The latter have other, more stable sources of income from non-agricultural activities. Since they do not work full-time, these farmers are in contact with collectors, most of whom operate within informal channels, which means that informality plays a significant part in the sector.[5]

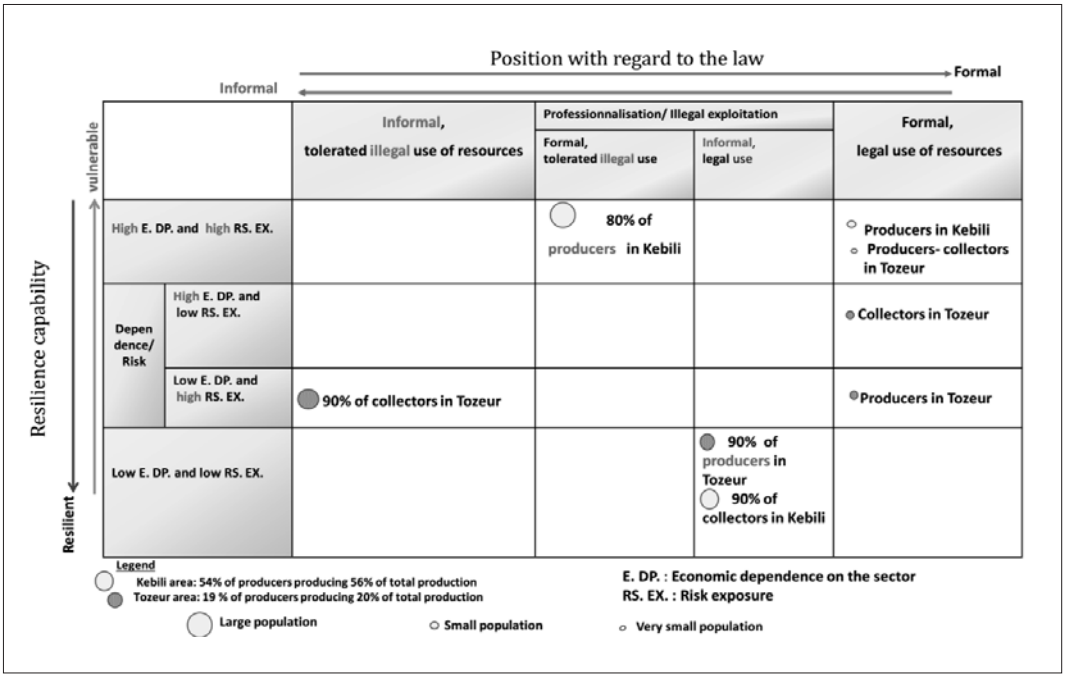
In the date value chain, collection is the activity the most integrated into the informal economy. In the Kebili region, collectors are simple intermediaries remunerated via fixed commissions. The dependence of local producers on collectors is limited to establishing links with exporters and packers through a wholesale price indexed to the export market price. These informal collectors have long-term relationships with some exporters-packers. In the, Djerid, collectors collect, sort, quality control, store and transport the product.

Figure 1 shows a typology of stakeholders based on two dimensions: the relationship between operators and the law, and their resilience capability. The first dimension reflects the lack of professionalization and the degree of informality in the activity of operators (Hugon, 2014). Informality can be defined by the need for lower costs, the low barriers to entry in terms of qualifications, and the funds required (Pesqueux, 2012). The second dimension deals with the resilience capability and reflects the capacity to face disturbance and maintain its controls (Holling, 2001).

The resilience is widely used with the concept of adaptive capacity to characterize the potential of enhancement of the operator's ability to cope with crisis. In Figure 1, we refer to the degree of the operator's vulnerability through its defenselessness (Chambers, 1989) i.e., a lack of means to face a crisis without loss. Two sides characterize vulnerability: an external side relating to the shocks to which a system is exposed and an internal one representing the capacity to recover from external disturbances (Chuku and Okoye, 2009). In examining the vulnerability of operators to shocks and crises (or its opposite, resilience), it is important to include these two sides. In our case, our assessment is based on the degree of specialization, distinguishing specialized versus diversified (based on the dependence of operators on their main activity and on supply chain), and their degree of exposure to risks (market, climate and product). Besides, in the absence of credible and up-to-date informa-

[5] There are both informal and formal collectors, but the proportion of informal collectors is the highest.

Figure 1 - Typology of stakeholders in the upstream phase of the chain.



Source: Authors.

tion, the mapping provides a general overview covering approximately 80-90% of operators in the two main production areas studied. We lack accurate data on the behavior and constraints imposed on other operators to be able to position them on the map, which justifies the blank cells in the matrix. Figure 1 puts the risks revealed by the crisis into perspective. This calls in particular to examine the impact of each criterion defining the operator's resilience capability.

Regarding specialization, it turns out that faced with the same high degree of external uncertainty, the formal producer of Kebili, who is mono-product and is highly dependent on the collector (strong specialization), tends to be more vulnerable to the crisis than an informal collector in Tozeur who has other sources of income and who is weakly dependent on the producer (strong diversification). So that, the crisis highlights a risk linked to the specialization of operators.

Moreover, Figure 1 shows how the crisis has affected all formal operators connected to informal operators, especially formal producers in the Kebili area, particularly vulnerable to external shocks. The informal nature of the partner in the supply chain increases the risk of experiencing opportunistic behavior which accentuate its vulnerability.

A stakeholder's decision to enter the supply chain informally depends on the level of incentives. Table 1 shows the benefit that producers or collectors derive from informal activity and the costs that they can bear. It describes the impact of a stakeholder's decision to engage in informal activity on the other operators within the chain, as well as on the community (the State).

The Table 1 shows that all stakeholders benefit from informality such as lower unit costs, tax avoidance, and greater flexibility in choosing partners in the absence of contractual commitments, but that they also bear costs that may be implicit or latent over the long term (lack of skilled labour, cost of access to water, decline in date quality) or in the event of crises. The public authorities also benefit from informality by reducing poverty, increasing the competitiveness of dates and boosting export volumes. However, they bear the social cost of managing water stress, the loss of income in terms of so-

Table 1 - Cost/benefit analysis of informal participation in the date value chain.*

	Informal stakeholder		*Other stakeholders within the chain*		*State*	
	Private costs	*Private benefits*	*Private costs*	*Private benefits*	*Social costs*	*Social benefits*
Producer Informal use of resources	- Audit penalties - Unsustainable relationships - Risk of opportunism	- Lower costs - Increase in production	- Disruption to irrigation - Overproduction and lower prices - Poorly qualified workforce - Ratchet effect**	- Low downstream dependency	- Water wastage and salinisation - Poor planning of the distribution of agricultural land - Loss of income from social security contributions and poor targeting of assistance programmes	- Increase in exports - Reduced poverty in the short term - Lower production costs and improved competitiveness
Informal collector No official registration or contractual agreement	- Financing the pre-production phase - Risk of speculation	- Subsidised equipment - Tax avoidance - Flexibility and diversification	- Weakening of producers' bargaining power - Disengagement of unregistered collectors - Dependence on exporters	- Pre-production financing - Shared market and climate risk - Stable and regular supply at a competitive price	- Loss of earnings (registration fees) - Inadequate targeting of profiles***	- Marketing and employment without depending on the State

* The Table is based on discussions at Round Table 2 of the FOPRODATTE forum (Loukil and Rouached, 2022).
** The ratchet effect reflects the impossibility for actors to change the rules of informal land or water use, which become a given for informal producers.
*** Informal actors don't pay social security contributions, but at the same time benefit from social assistance programs due to a mistake of inclusion, since in principle they don't belong to the target category.

Source: Authors.

cial security contributions, and the disruption to agricultural production planning which, with the impact of climate change, is likely to pose a real problem for food security.

4. Effects of the informal economy within the supply chain

The existence of the informal economy in the various activities of the sector, and in particular in the collection activity, has consequences for the operation of the chain, as shown in Table 1, in terms of costs incurred, horizontal competition (between collectors), vertical competition (with suppliers and downstream exporters-packers), and the volume and quality of the final offer.

Effects on costs and supply

On the supply side, the presence of speculators in the largely informal collection activity can contribute to a significant gap between overall supply and demand (local and for export) during periods of high production. In this context, collectors who have benefited from public funding for the acquisition of storage equipment, obtain supplies at low prices during the harvest period and resell the product at a much higher price during periods of high demand (Ramadan, end-of-year festivities, etc.).[6] The average production cost of dates in the formal economy, estimated at between € 0.80 and € 1.1 per kg, is now competing with the cost associated with informal production. Similarly, informal stakeholders involved in collection are more competitive than their formal competitors. They ultimately have a relatively comfortable profit margin. This competitive advantage is largely due to the low cost of acquiring informal production factors.

Subcontracting operations are carried out by informal operators who, without paying taxes, have access to input (crates, protective bags and nets) subsidised by up to 50%.[7] These well-financed operators also handle the harvest and high-volume logistics. Formal collectors face unfair competition, which prevents them from implementing the investment strategies they need to adapt to the demands of international markets.

Impact on traceability and product quality

For any approach to promoting products through quality, and in particular for food products, traceability is a central issue. It requires the identification of operators and their commitment to comply with precise requirements. Consequently, when the value chain is infiltrated by informality, the compliance of informal operators and thus traceability are no longer ensured. This is generally the case of the date value chain which, in the absence of providing guarantees of product traceability cannot display a qualitative advantage that could justify a better selling price. More precisely, the incentive to meet the importers requirements, is hampered by the presence of informal collectors. In fact, such incentives rely on the transmission of information about market expectations from downstream to upstream. The only information transmitted concerns volume requirements (and not the quality). The informal collector may therefore have negative effects on the formal producer by making it difficult to adapt to international requirements (Rouached *et al.*, 2023). In addition, the absence of an adequate producer price encouraging quality improvement leads operators to focus their efforts on maximising volumes of a basic quality standard (Fusillier *et al.*, 2009; Gendre *et al.*, 2007). This leads to the commoditisation of exported products. The informality prevalent in the upstream deprives operators of the opportunity to benefit from a negotiated sales price indexed to high certified quality. Thus, upstream prices are

[6] Production is expected to reach 400,000 tonnes by 2025 (ONAGRI, 2022), with a loss rate of 25 to 30%. In the absence of official data on national date consumption, an extrapolation based on per capita consumption, put forward by an international date expert, has made it possible to a wastage rate of around 45%, well above the FAO figure of 25% (Round Table 1, FOPRODATTE Forum, Rouached and Loukil, 2022).

[7] As part of the public policy of extensive agricultural growth and aimed at protecting production against borer attacks, the institutional partner, the *Groupement Interprofessionnel des Fruits*, offers inputs at reduced prices (Gendre *et al.*, 2007). In the absence of an official professional card, these practices are not discriminatory.

Table 2 - Evolution of date exports in Tunisia (2017-2021).

	2017	*2018*	*2019*	*2020*	*2021*
Date exports (US dollar)	229,990	281,792	265,875	261,735	255,900
Date exports (in tonnes)	104,357	124,019	113,987	109,267	118,666

Source: ITC, 2022.

aligned with spot market prices based on criteria other than those required by importers. Furthermore, in the absence of a contract governing exchanges between operators (especially informal ones), the price criterion is favoured over the quality criterion.

Impact on natural resources

Over and above the short-term effects of informality, studies (e.g. Alvarado *et al.*, 2022) have shown how informal activity increases the long-term risks of environmental degradation and the depletion of natural resources. Tunisia, which is in a situation of extreme water stress, is a textbook case of this process. In fact, the existence of an informal economy in the sector exacerbates the already inefficient management of water resources, which is likely to compromise the resilience of the industry in the long term. In Southern Tunisia, according to the national report on the water sector (2020), 96% of the total volume of groundwater is used for agriculture and, 81.5% of water points in deep aquifers are illicit (statics for 2019). This situation not only affects water quality, which results in soil salinization and lower soil productivity, but also the ability of managers to maintain and repair the network. Illicit pumping represents a loss of revenue for the Tunisian state, which does not collect royalties on the irrigation water used. Illicit water use is also reflected in an increase in non-payment of royalties in the formal distribution, a phenomenon that has intensified since the 2011 revolution, as well as in clandestine connections. This in turn leads to the deterioration of irrigation infrastructures and a deterioration in the quality of dates and agricultural produce. In addition, Tunisia's irrigation policy, which sets relatively low-price levels, provides a strong incentive to adopt irrigated farming (National Water Sector Report, 2020). The average price of water for irrigation is estimated at 0.110 TND[8]/m^3, whereas the actual price in southern oases is 0.028 TND/m^3. As this price only partially covers water service costs, it does not allow for the optimal allocation of resources and is an incentive to produce in terms of volume without adjusting supply (in terms of both volume and quality). However, cost-based pricing would run the risk of excluding small farmers.

In the long term, the presence of an informal sector that uses water resources without public control is likely to undermine the sustainability of the date export sector and food safety.

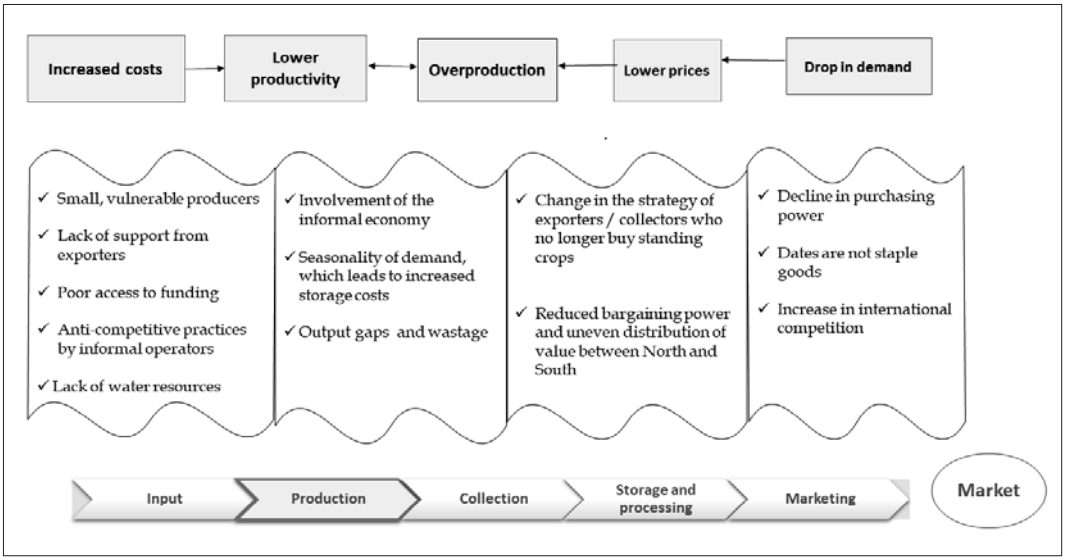
Today, public policies tend to accommodate the current situation by supporting the development of existing operations and to combat all forms of new illegal land expansion. However, the major problem concerns illegal private boreholes, which are responsible for the over-exploitation of water resources. Given the difficulty of monitoring and control by local authorities, and the failure of associations to manage resources, thought should be given to new mechanisms for the collective governance of resources along the lines of "common pool resources" (Ostrom, 1990; Farolfi *et al.*, 2022). The introduction of management rules and approval mechanisms would limit the over-exploitation of water resources.

5. Informal economy during the Covid-19 crisis

The Tunisian date sector was considerably affected by the Covid-19 crisis. Simultaneous

[8] 1 TND (Tunisian dinar) = 0.32 USD

Figure 2 - Impact of the Covid-19 crisis on the Tunisian date sector.



Source: Authors.

shocks to supply and demand have affected the entire supply chain (see Figure 2). Tunisian exports, which represented around 40% of production, fell in value over the 2020-2021 period (see Table 2). From the point of view of local consumption, dates, which are not a staple product, suffered a drop in demand, which generated a stock of unsold products and a fall in prices.

In addition, sanitary containment measures (airport closures, inter-city travel bans, market closures, etc.) have increased packaging and transport costs. They have also caused a distribution problem that has been exacerbated by the heavy involvement of the informal economy in intermediary activities. As a result, the majority of informal transactions could not be maintained. In the absence of buyers, the dates could not be harvested. Small farmers were directly affected, as they were forced to assume the risks of their activity.

Even though formal stakeholders in the intermediation branch were affected and weighed on the sector's performance during the crisis, the disengagement of informal collectors and the loss of informal labour undoubtedly had a greater impact on supply systems. During the confinement period, travels between regions are reserved for workers with official authorization.[9] The inability of distant informal workers to travel (Koussani and Khamassi, 2022), generated additional costs, due to the use of more expensive formal labour. This has automatically pushed up all prices of the supply chain. Excess supply upstream has exacerbated the imbalance of power between stakeholders in the chain, to the detriment of producers, resulting in a drop in quality, a reduction in producers' bargaining power and an even more inequitable sharing of value within the value chain. Finally, in a theoretical study, Aziez *et al.* (2022), show how the disengagement of the informal economy from the marketing intermediation link can have an impact on the intermediate prices ratio between low and high quality dates to the detriment of good quality dates whose extent of the price drop is greater.

It is important to note that some informal collectors who usually buy dates on the vine have given up this activity with the onset of the crisis.

[9] Government decree no. 2020-156 prohibits the circulations of operators without an official registration in the trade register.

This opportunistic behaviour was possible since transactions are generally carried out without a contract. Oral agreements then simply broke down. The disengagement has deprived the sector of usual investments, especially since these collectors usually finance the collection and transport operation by providing the material and equipment for storing the product. Moreover, when it comes to small collectors, the crisis has led the majority to a state of bankruptcy and pushed them to leave the sector. As a result, producers who could not bear the cost of these harvest and post-harvest operations were forced to let the product rot on the vine.

The existence of oversupply and unsold stocks among producers benefits the stakeholders who remain in business, in particular collectors, packers and formal exporters, whose bargaining power has increased compared with the pre-crisis period. A halt in the activity of informal collectors has affected the financial situation of producers in two ways: on the one hand, they have lost income due to the lack of outlets and uncompensated production costs, and on the other, their bargaining power vis-à-vis their customers (collectors or exporters, depending on their marketing channel, see Figure I in Appendix 2) has deteriorated.

6. Lessons and recommendations

The complexity of interactions in the context of transactions between the formal and informal economies reveals the need for an integrated, multidimensional strategy aimed as much at strengthening the capacities of formal stakeholders as at controlling the degree of infiltration of informal stakeholders and the balance of power between stakeholders in the date sector, without upsetting the sector's organisational balance in the short or medium term. We present below a number of options that can satisfy both short- and medium-term as well as long-term objectives: in the short and medium term, to provide a framework without adversely affecting the current organisation of the sector, and in the long term, to reduce to a bare minimum, or even eradicate, the influence of the informal economy on the organisation of the sector.

Increasing the bargaining power of producers

The interviews carried out with professionals in the sector (producers, heads of producer organizations, packers) (see Appendix 1) confirm the disengagement during Covid, of a certain number of informal actors in collecting and packaging activities reducing the competition in the intermediate links and leading to a more power for formal collectors vis-à-vis producers. The presence of the informal sector therefore appears to be a significant factor in the balance of Upstream-Downstream forces.

Thus, formal producers could be the most vulnerable in the event of a crisis, due to the unfavourable bargaining power. The small size of their farms, the limited diversification of their activities and the difficulty of accessing funding accentuate their vulnerability by weakening their resilience capability in the event of a crisis. Public authorities need to strengthen their credibility regarding funders and their negotiating power regarding intermediaries (collectors, packers). One solution would be to encourage the organisation of supply through producer grouping schemes, in order to reduce costs through pooling, and mitigate the impact of external shocks. In addition, these schemes are a way of strengthening producers' bargaining power, which in the event of a crisis ensures better access to the market. Experiments with farmer groups have demonstrated their effectiveness in increasing producers' incomes, by promoting the adoption of new technologies and reducing costs (Tran *et al.*, 2023; Blekking *et al.*, 2021). Today, however, Tunisian farmers' membership of these collective structures is still low. There is an urgent need to improve the attractiveness of professional organisations by strengthening their internal governance capability and raising farmers' awareness of the benefits of grouping together.

Offering producers alternative funding to the informal financing system

Some informal collectors have considerable financial capacity, and are able to carry out crucial functions such as standing crop sales as well as bearing the risks associated with this mode of transaction, packaging and logistics. Despite

the contribution of the informal sector to farmers' funding, it is crucial to reduce the impact of informal collectors by implementing alternative funding mechanisms. The Covid-19 crisis has revealed opportunistic behavior on the part of a large majority of collectors who have withdrawn from their usual financing of the sector, leaving producers alone to suffer the losses resulting from the closure of borders and markets. Several research studies (Ohnsorge and Yu, 2022; Capasso and Jappelli, 2013) confirm that the development of the funding system leads to a reduction in informality. In Tunisia, agricultural loans do not exceed 5% of business loans (BCT, 2023) and private investment is based more on self-financing. Small farmers' overdue and unpaid loans represent a barrier to access to funding, exacerbated by the fragmentation of land ownership, which forces them to turn to the informal financing system. Financial cooperatives can contribute to the diversification of financial services by offering products tailored to small farmers, thereby promoting their financial inclusion (McKillop *et al.*, 2020).

The resilience of the date sector also depends on the existence of an appropriate agricultural risk management policy (climatic risks and market fluctuations). In this respect, insurance is a key element, especially as the agricultural sector's share of insurance is currently marginal (estimated at 3% of the insurance sector in Tunisia, ADB, 2016).

Professionalising the collection business

Reducing the power asymmetry throughout the value chain can be achieved through initiatives aimed at grouping collectors into collective structures. These structures could help to strengthen guarantees of product traceability. However, implementing this structural solution raises the need to properly define the mode of governance. The failure of the attempt to professionalise the collection activity through the use of professional credentials shows the need to initially identify an official affiliation body for these operators. One solution would be for a core group of formal collectors, supported by public authorities, to join forces and create a model, a kind of "success story" that could attract not only other formal collectors but also, gradually, informal collectors, who would see the advantages of collective coordination outweigh the advantages of informality. Such an approach would contribute to the contractual governance of transactions, which is a priority. It would also consolidate product traceability and reduce quality risk, while avoiding losses. The introduction of a private certification for the collection stage will certainly help to meet this objective.

Promoting the territorial dynamics of oases

The issue of farmers' dependence and vulnerability, which stems from a lack of diversification, needs to be considered in the context of a more global reflection on the dynamics of rural areas and their contribution to economic development (Bechir *et al.*, 2022; Carpentier, 2017). Intercropping and diversification in the oases, as well as tourism, craft and cultural activities, provide farmers with additional sources of income, thus enabling them to reduce their dependence on date production. Incentives should be aimed more at creating value in the date sector according to quality, while considering the rational use of resources, rather than to a volume-based strategy for low-quality products. To meet this challenge, the economic model needs to be based on a more in-depth analysis centred on sustainable development strategies that help preserve natural resources.[10] Diversification through the development of new varieties reduces the environmental impact of monoculture. Similarly, diversification through processing helps to combat loss and wastage by increasing the shelf life of products.

Fight against voluntary and involuntary informal work

Actions to support workers into formal employment should be targeted according to whether the choice to remain in informality

[10] The rise in the salinity of irrigation water is a red flag for the risks of a drop in quality and, in the medium term, in price.

is involuntary or voluntary. In the absence of decent employment opportunities, informality can be involuntary due to the seasonal and occasional nature of agricultural work and low levels of education. The absence of a social security system specific to the agricultural sector means that employees are excluded from the formal labour market if they cannot prove that they have worked for the same employer for at least 45 days per quarter. The conditions of access to the social security scheme for agricultural employees should be made easier (Law 81-6 of 12 February 1981) to encourage affiliation.

Consider now workers who voluntarily choose informality. Public action has to review assistance programmes, currently insufficient to reduce the disincentive to formal work (UNDP-ILO, 2022). There are two types of costs involved in giving up informality: social security contributions and loss of income in terms of social benefits financed by assistance programs for vulnerable categories. Moreover, paying social security contributions does not guarantee quality of care or a higher retirement pension than social benefits. This explains the failure of the AHMINI programme for rural women in Tunisia, as evidenced by the low take-up. Integrating the informal sector therefore requires making social security schemes more attractive by improving the quality of care for members of the agricultural sector.

7. Conclusion

Tunisia experienced a sharp recession in 2020, with economic growth falling by 8.8% (World Bank, 2024). The Covid-19 health crisis undoubtedly played a role in this economic crisis. In the agricultural sector, and the date sector in particular, it has highlighted the role of the informal sector, which, by suddenly disappearing, due notably to the confinement measures and the closure of borders, has paradoxically led to the paralysis of the sector. The lack of a formal commitment has accelerated the disengagement of some informal collectors, who typically buy on the hoof and finance equipment to protect production and collection.

At the same time, informality largely contributes to the sector's low resilience in times of crisis. The accompanying measures adopted by the public authorities cannot effectively target informal actors leading to the bankruptcy of some small informal collectors. Thus, the interaction of the informal economy with official channels can generate effects that may seem paradoxical. Indeed, formal activities can develop resilience to exogenous shocks thanks to large volumes of informal trade generated through concealment practices (i.e. informality) or in the context of interactions with informal activities (suppliers, customers, etc.) with its vast, efficient and well-organised network. In such a context, the absence of a clear boundary between the two formal/informal systems makes it even more difficult for public authorities to control informal practices. The significant contribution made by this sector to value creation in the formal economy may partly explain the relative caution of public authorities in implementing measures aimed at completely eradicating the informal economy. As a result, a large number of economic stakeholders perceive the lack of public action in this area, as well as the ambiguity of the authorities' position towards this sector, as a sign of their unwillingness to eradicate the phenomenon.

However, the informal economy has high social costs: wastage of water resources through illicit extensions, reduced capacity to transfer knowledge to the formal economy and biased economic indicators. Reforms designed to support the informal economy must be defined through public policies that take account of these long-term social costs. However, the radical position of seeking to completely eradicate the informal economy is controversial.

Developing countries, and Tunisia in particular, have a greater interest in adopting a strategy based on supervising informal activities, especially when the latter contribute to a country's economic performance and offer significant potential that should be exploited. In this sense, public initiatives to integrate the informal economy are likely to create more jobs and boost GDP growth.

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Appendix 1 - Material and methods

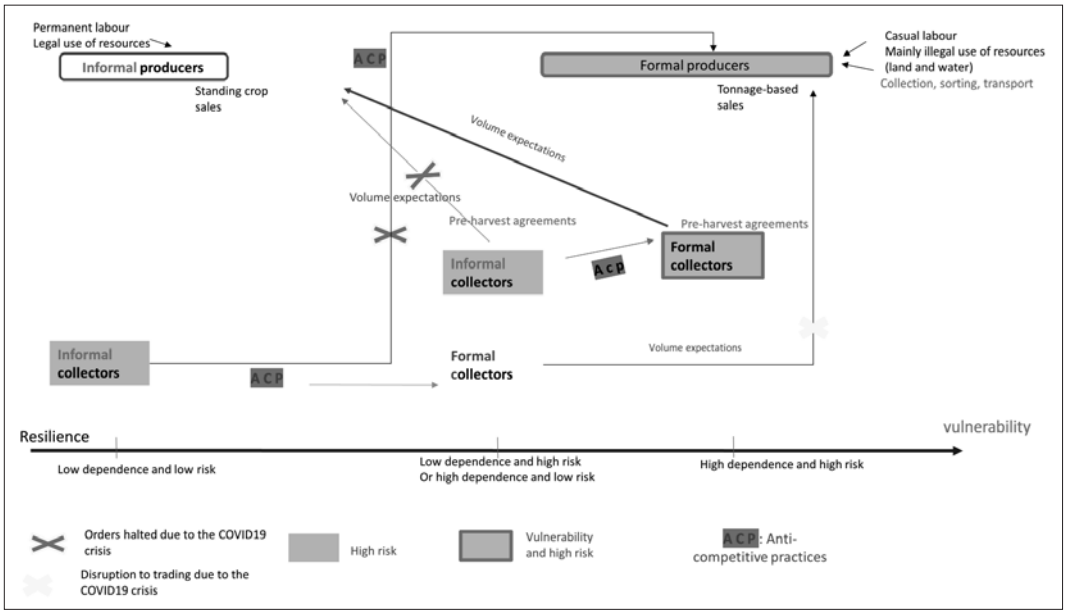
Table 1 - List of panellists and topics discussed in the FOPRODATTE forum (2022).

Panelists: 1-Regional Director of the Interprofessional Date Group, Tunisia, 2-General Director of processing dates company, Algeria, 3-Consultant, Manager & International Expert in Dates, Tunisia, 4-Consultant, specialist in contract agriculture, Tunisia., 5- Scientific Researcher, Morocco, 6-Food development researcher, Date exporter, Tunisia,7-Researcher and technical advisor to the agricultural sector support program, Algeria, 8-Scientific Researcher, Tunisia, 9-Expert in monitoring, evaluation and control of takeover bids, Tunisia, 10-President of the Chamber of Date Exporters, Tunisia, 11-Expert in financing agricultural value chains. Tunisia,12-Technical assistant, Chamber of Commerce, Morocco.

Topics discussed	Code	Category-Theme
T1: Difficulties and challenges encountered by the Tunisian date sector.	Dependence and specialization	Resilience Capability-Vulnerability
T2: Eventual link between strengthening requirements, price, and product profitability.	Risks and uncertainty	
T3: Criteria for the assessment of the performance of the date value chain (DVC).	Auto-organization ability and adaptability	Law and regulation-Informality
T4: Extent and impact of informality on the DVC. T5: Roles of the operator's type and partnership relationships in the DVC.	Adaptability and conformity	
T6: Impact of the COVID-19 crisis on the DVC's demand and supply.	Impact	Covid19-crisis
T7: Improvement of public intervention for strengthening the resilience the DVC. T8: The role of financial institutions in improving the resilience of the DVC.	Improvement in ability	Governance-Resilience
T9: Strategies and public policy to deal with informality: accommodation, integration, others. T10: Contribution of contract farming for strengthening the capacity of the upstream sector. T11: Perspectives from market diversification and varietal differentiation.	Improvement in capability	Capacity Building-Resilience

Appendix 2

Figure 1 - Impact of the Covid-19 crisis on transactions and operators in the date value chain.



Source: Authors.

The Croatian consumer responses to the European GIs scheme of wine labeling

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JEL codes: O15, Q17

Abstract

The EU GI scheme has enabled Croatian producers to new creative marketing, increasing label diversity. The aim of this study is to explore consumer attitudes toward the Traditional terms and the PDO/PGI terms implemented in wine labeling after Croatia's access to the EU. The results of 428 wine consumers' questionnaires were analyzed regarding age, gender, and subjective knowledge. The awareness of the meaning of PDO/PGI and certification differ among consumers; women and younger demonstrated a lower understanding of new labels. Understanding Traditional terms is much better, but younger are less familiar with their qualitative meanings. Trust in the labels significantly increases with age. Attitudes toward the PDO/PGI and Traditional terms with respect to age and gender do not significantly affect behavior in wine purchases. Whether buying wine for themselves or as a gift, consumers have similar approaches to these labels, indicating the deep and strong influence of inherited tradition. However, the importance of PDO differs significantly depending on subjective knowledge. The research findings signal the need for consumer education and promoting the PDO's meaning and value.

Keywords*: PDO/PGI, Traditional terms, Attitudes, Trust, Wine, Croatia.*

1. Introduction

A long tradition and importance are attributed to the European Geographical Indication (GI), delineating Burgundy wines in the fifteenth century as the first GI in history (Meloni and Swinen, 2018). Moreover, the history of the area's recognition and connection with wine quality is much older, with the worthwhile example of Falerno in Italy. The area and the wine Falerno from Roman times are described as famous throughout the Roman Empire because of its quality, and interestingly for us, Pliny demarcated its production area (Fairbank, 2012). Different authorities have been involved with this issue from the beginning, and according to the analysis (Sylvander *et al*., 2006; De Filippis *et al.*, 2022), they have had different objectives over time but always had a direct impact on economic indicators of success. In addition to Geographical Indications, the characteristics and quality of products can also be described and implied by other declared information based on external standards and producers' perceptions. Therefore, the significance of labels and label traceability of properties is understandable.

The European Union's wine sector uses a Geographical Indications scheme (GIs) that includes Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI),

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along with additional labels like Traditional terms (TT) or other supplemental terms. The objectives of this scheme include ensuring fair competition for farmers and producers, respecting intellectual property rights, maintaining the integrity of internal markets, developing and protecting rural areas, and ensuring consumer safety through reliable and transparent information (Regulation (EU) No 1151/2012). Espejel *et al.* (2011) obtained that this system is a distinctive and recognizable way to display wine's specific and intrinsic characteristics, helping consumers choose wine more confidently. The PDO label entails a certification process based on qualitative criteria (specifications) and protocol of wine compliance control with ecological and oenological conditions and chemical and sensory properties. The TT label should also guarantee production, specific maturation methods, or other quality aspects. The certification process to obtain PDO/TT is regulated by EU and national regulations, and grape and wine production must be controlled by authorities or authorized bodies that verify compliance with corresponding PDO specifications. In addition to the GIs protected names in the wine sector, it is possible to use a graphical symbol (logo) of PDO or PGI (https://www.europeantreasures.eu/index.php/en/pdo-pgi-2), which serves as an additional tool for visual communication in the market.

This formal system has been created as a beneficial tool for consumers to recognize quality and confidently purchase. It helps strengthen the competitiveness of food products in the global market. This system also serves as a form of protection for the concept of terroir and is a foundation for local, sustainable development (Belletti *et al*., 2017). Specifications of wine GIs are gradually becoming indicators and substitutes for the intrinsic attributes of products related to quality, safety, and authenticity, thereby becoming tools in purchasing decisions (Garavaglia *et al*., 2017; Costanigro *et al*., 2019). Stricter regulations and GIs, especially PDO in combination with TT, also have legal implications related to trust in labeling. However, most consumers have basic and inadequate knowledge of the certification system, and the existence of bodies responsible for food safety and trust in them varies (de Jonge *et al*., 2008; Latvala, 2010; Likoudis *et al*., 2015). Deselnicu *et al*. (2013) demonstrated the importance of the institutional framework for geographical origin labels: in the same country, products with higher quality standards, such as PDO, receive higher premiums than those with less stringent requirements (PGI). They also showed that stricter standards signal more significant benefits for consumers regarding food safety, quality assurance, and a stronger connection to culture or heritage, encouraging a greater willingness to pay higher prices for more strictly regulated products. Trust in certification labels is also associated with the credibility of control bodies or companies in the control chain (Sirieix *et al*., 2013). Uysal *et al*. (2013) found weaker trust in private ecological labels than in government labels. However, other researchers found opposing views (Padel and Foster, 2005; Eden *et al*., 2008).

Rupprecht *et al.* (2020) concluded that understanding of labels varies from country to country. In Japan, the USA, and Germany, the highest trust is placed in expert labels (data from expert and scientific sources), while in China and Thailand, expert labels are ranked second after government/administrative labels. These results are based on an online survey of 10,000 consumers from five countries and four types of food (milk, honey, oil, and wine). Trust in independent expertise and science underscores the importance and value of scientific research in food quality and safety. In recent times, the effectiveness of such wine labeling concepts has been called into question. According to Leufkens (2018) and Hinchliffe (2019), it is generally complex and heterogeneous, requiring a significant level of consumer awareness to be meaningful regarding consumer protection. In addition to the considerable increase in the global supply of wine, the proportion of inexperienced consumers is also growing, as Morrison and Rabellotti (2017) indicated. New generations of potential consumers rely on online information and perceive online reviews as informative, entertaining, credible, and valuable (Bevan-Dye, 2020). New approaches to consumer education about product value, such as nutritional informing or sustainability (Belharar and Chakor, 2023; Mesias *et al*.,

2023), are increasingly intriguing and can influence the importance of the current GI labeling system. Giacomara *et al*. (2020) systematically analyzed published research between 2009 and 2019 on the impact of geographical indications on consumer behavior. They concluded that consumption patterns and new consumer profiles are changing the significance of geographical factors. Their results and the results of some other authors (Ferreira *et al*., 2020) suggest the need for the engagement of wine industry managers to acquire more knowledge about consumer profiles on a global scale for marketing activities related to labeling and advertising strategies. This highlights the importance of adapting to the wine industry's evolving consumer preferences and behaviors.

In Croatia, the EU wine scheme of Geographical Indications has been used since 2013. The concept of "Protected Designation of Origin" (PDO) qualitatively differs slightly from the "Controlled Geographical Origin" (KZP) label that has been used for decades and was associated with the mandatory labeling of the most important quality labels, "Kvalitetno" and "Vrhunsko." These quality designations have become traditional terms, "Vrhunsko vino KZP" and "Kvalitetno vino KZP." Criteria for PDO labeling have been changed and simplified according to the EU regulations. National standards for acquiring the right to use Traditional terms have remained the same as those before Croatia acceded to the EU. However, their use has become optional (Regulation (EU) No. 1308/2013). This optional model has allowed the diversity of wine labels in the market, and it is questionable to what degree consumers are informed about these changes. The symbol (logo) of PDO in wine labeling is not used the same way as with other food products.

Given that wine labeling and marketing use different attributes and information that influence wine choice, questions arise about Croatian consumers' level of awareness and perception regarding geographical indications in the new circumstances. Research is outdated (Čačić *et al*., 2011) or specific in relation to interest, region, or designation (Cerjak *et al*., 2016). Some authors have discussed the importance of geographical indications in food production in general (Brečić *et al*., 2019). However, there is no information and studies regarding the understanding and awareness of the new wine GI scheme in Croatia after its accession to the EU. The value and stability of such a system depend on its recognition in the market, considering that consumers are increasingly analyzing various aspects of product quality with an emphasis on food safety (Bouranta *et al*., 2022). There is a growing number of producers who want to brand their wines in some other way, without PDO or PGI labels, and there are no available studies on what consumers in Croatia know about GIs or wine branding. The Croatian market is flooded with a variety of wines, each with different branding approaches, and consumers need assistance in understanding labels just as much as producers need help in creating informative tools. Understanding how labeling information influences consumer perceptions of a wine's quality and value is crucial for product management, choice of marketing strategies, and maintaining a competitive position.

The aim of this study is to assess Croatian consumers' comprehension and trust in the European Geographical Indications (GIs) scheme for wine labeling following Croatia's accession to the EU, as well as to examine the influence of familiarity with the new labeling system on the importance of various factors in wine selection. The key research questions included: Do wine consumers understand the significance of PDO (Protected Designation of Origin)? How crucial are national quality categories that have become traditional terms under the new system of optional use? Do consumers truly grasp the meaning of certification? The results of the research will provide an original contribution to understanding the current wine market in light of new creative labeling possibilities. The findings of this study will aid all stakeholders in the production-consumption chain in ensuring product competitiveness and consumer protection.

The paper is structured into four parts. The first part consists of the introduction and literature review. The second section outlines the official methodology, including the survey and questionnaire design, as well as the respondents'

main characteristics and their wine habits. The third section presents the results and discusses their implications. The final chapter summarizes the main conclusions and offers recommendations for future research.

2. Methodology

2.1. *Sample and data collection*

The research was conducted through a survey using a pre-prepared questionnaire. The questionnaire consisted of three groups of questions: socio-demographic information and consumer habits, attitudes regarding the importance of different attributes in wine purchasing measured by a Likert scale, and a group of questions about the understanding and trust in wine geographical indications PDO and PGI and Traditional terms "Kvalitetno vino KZP" and "Vrhunsko vino KZP" expressions. The Likert scale was designed with marks from 1 to 5, where a mark of 1 represented the lowest level of importance and a mark of 5 the highest. The questions regarding labeling understanding and trust provided three possible answers, from which respondents were required to select only one. Depending on their chosen answer, respondents were categorized into three clusters: consumers with a lack of knowledge, consumers who are uninformed but have some assumptions about knowledge, and consumers who are confident about their knowledge. In subsequent analysis, the collected data were utilized to examine the significance of differences between clusters concerning topic questions and factors of research interest, such as gender and age. There was also a question related to wine-purchasing behavior for gifts and personal consumption, structured similarly with provided options for responses and the possibility to specify personal factors.

The survey was conducted online and in person at a large supermarket during the winter and spring of 2019. Online participation was available for a period of four months, while in-person surveys were conducted over two weekends. Questionnaires from respondents who were not wine consumers or did not respond to thematic questions were excluded from the data analysis (constituting 8% of the total responses). The representative sample for statistical analysis comprised 433 responses. The representation of participant groups based on variables age and gender is shown in Figure 1. Age groups were based on the definition and periods of adulthood (Levinson, 1986), with a specific modification. In this analysis, two of Levinson's age groups (45-65 and 65+) were combined, assuming no significant changes in knowledge about wine during this life period. According to Levinson, adulthood begins at 22, but we adjusted this boundary to 18 when the consumer's right to purchase alcohol in Croatia begins. A more comprehensive sample description, including data about the respondents and information about their wine culture is given in the paper by Alpeza *et al.* (2023).

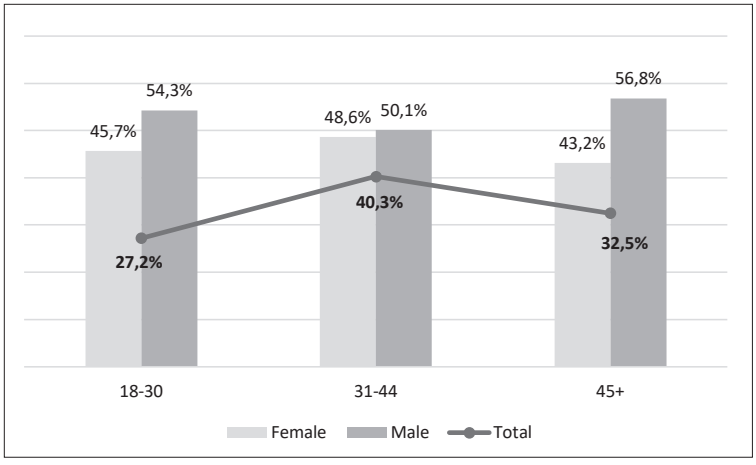

Figure 1 - Age and gender analysis of the sample.

Remark: The difference between the 100% and the percentages shown in Figure 1 pertains to respondents who did not declare their gender.

2.2. *Data analysis methods*

Descriptive statistics and methods for analyzing significant differences commonly used in survey analyses were used in data analysis. Before choosing the method, the sample's compliance with a normal distribution was tested using Kolmogorov-Smirnov (K-S) and Lilliefors tests. Both methods are widely used in statistical analysis to assess the assumption of normality, a prerequisite for many parametric statistical tests. The null hypothesis of the K-S test is that the sample is drawn from a population that follows a normal distribution. Suppose the calculated p-value from the K-S test is more significant than the chosen significance level (usually $\alpha = 0.05$), we do not reject the null hypothesis. If the p-value is less than α, we reject the null hypothesis, indicating that the sample does not follow a normal distribution. The Lilliefors test is a modified version of the K-S test specifically designed to test normality. Like the K-S test, the Lilliefors test compares the empirical cumulative distribution function (ECDF) of a sample with the theoretical cumulative distribution function of the normal distribution (Corder and Foreman, 2014). Regardless of the tested variables, all samples deviated from a normal distribution. In further data analysis, the non-parametric Kruskal-Wallis test was employed. The Kruskal-Wallis H test, also known as the "one-way ANOVA on ranks," is a rank-based nonparametric test used to ascertain if there are statistically significant differences among two or more groups of an independent variable concerning a continuous or ordinal dependent variable. This test was deemed appropriate for our study, as previously outlined (Cliff *et al.*, 2016; Alpeza *et al.*, 2023). Given that each question on the study topics allowed for three possible answers, we categorized respondents into three clusters based on their opinions on specific issues. Consequently, this method was well-suited for testing hypotheses regarding cluster differences. The null hypothesis is rejected if the P-value is less than the chosen alpha level (typically 0.05), suggesting a statistically significant difference between at least two groups. In this study, we tested different clusters according to their understanding of PDO/PGI and Traditional terms variables to determine whether they differ significantly regarding the importance of the same variables as attributes in wine purchasing. Given that the questionnaire included a section regarding the importance of various factors in wine selection, it was important to assess whether different clusters, based on their understanding of the new PDO/TT labels, prioritize these factors differently. This analysis was extended to encompass other studied attributes of importance in wine purchase, including grape variety, vintage, country of origin, price, sugar content, wine color, brand, and bottle/label design. Conducting these analyses will facilitate a deeper understanding of how the attributes' positioning on the Likert scale differs between different clusters, taking into account their level of knowledge of the PDO/TT labels.

Statistical analysis was conducted using the Statistica version 12.0 statistical software package (TIBCO/StatSoft, Tulsa, OK, USA).

3. Results and discussion

The term "Protected Designation of Origin" (PDO) is relatively common in discourse, and the public is informed about the importance of geographical origin as well as of Croatian products that are eligible to use the PDO label. However, the wine sector is unique; the term PDO is the successor to the "Controlled Geographical Origin" (KZP) label that has been used for decades. In this context, it was expected that wine consumers would be acquainted with the meaning of this label. The consumers who respond to the questions with the answer "assume" can be described as those who know/do not know or are inconclusive or indecisive. Figure 2 graphically separates consumers into two large groups with a vertical line: those who understand the meaning of the PDO/PGI terms and those who do not. Those unsure about their knowledge can be described as consumers who equally understand and do not understand. Therefore, they are equally positioned in the area of expertise and the area of knowledge lack. The same graphical display was used to visualize the understanding of other topics in this study, and, even more important-

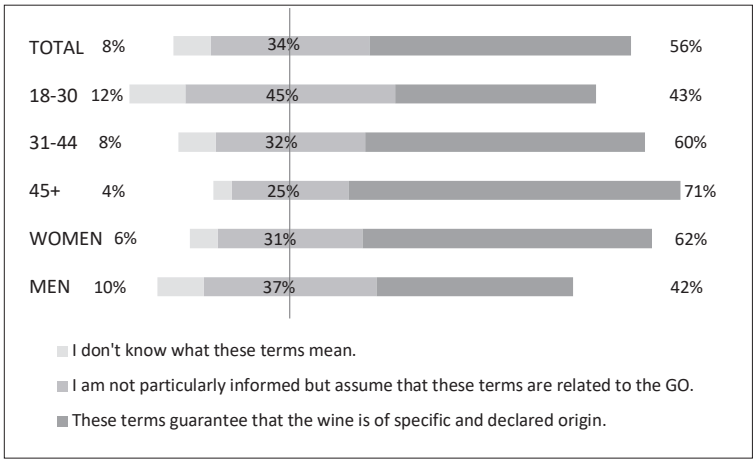

Figure 2 - Consumer understanding of the PDO/PGI terms.

ly, it allows fast comparison of the knowledge and attitudes (trust) about specific topics. A clear and practical example is the relation between TT knowledge and TT trust (Figure 4 and Figure 5).

The study has shown that six years after accession to the EU, 58% of Croatian consumers understand the concept of PDO, 8% are entirely unaware of the PDO label, and one-third of the participants assume its meaning (Figure 2). The wine market is faced with a lack of adequate communication regarding the new GIs' significance and value. Despite considerable public presentation and promotion about PDO and PGI in the food sector, for some reason, wine is very rarely included. Research has demonstrated the significance of these logos in identifying the product's origin and quality (Vecchio and Annunziata, 2011; Zisidis, 2014). Despite these findings, the possible importance of these logos is disregarded in wine label designs. Labels are generally content-complex; other EU countries have also maintained the tradition and traditional terms, and the logos are not presented on wine bottles. This is likely due to the long national tradition of regulated wine production and labeling, which leads to the assumption of understanding and objective knowledge on the topic.

Consumer awareness and understanding of Traditional terms (TT) are much better (Figure 5). In both cases, men are better informed than women, and the level of knowledge increases with years of experience. However, understanding the certification protocol for obtaining the right to use PDO and TT is relatively low. Knowing the definition and knowing the objective background are quite different. As many as 14% of respondents know

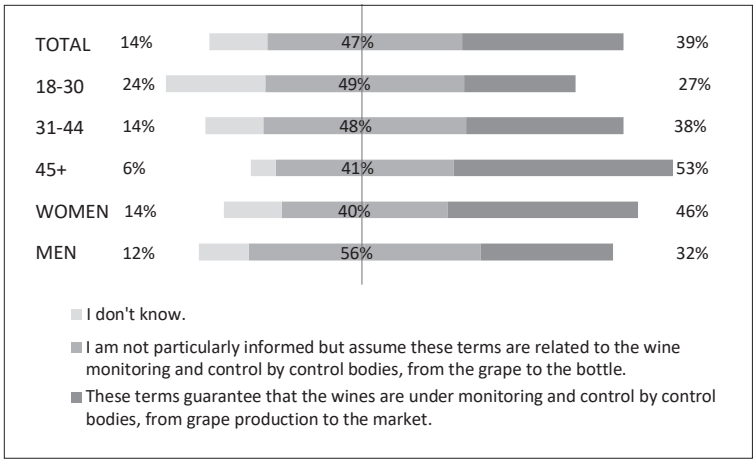

Figure 3 - Consumer understanding of the wine certification.

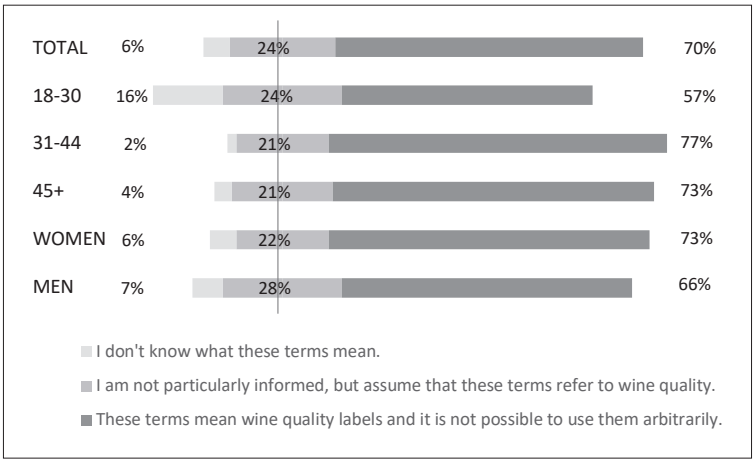

Figure 4 - Consumer understanding of the TT "Vrhunsko vino KZP" and "Kvalitetno vino KZP"

nothing about the independent institutional, systematic monitoring of grape and wine production, which is integrated into obtaining the right to use traditional terms in Croatia. 47% assume that some form of control exists, and only 39% of survey participants answered that they are familiar with the described system (Figure 4). Younger consumers are less informed than those with more experience. Women demonstrated indecisiveness about this topic; 56% assume what certification means, while only 32% truly understand what GIs entail. On the one hand, consumers express familiarity with the labels, but at the same time, they do not understand them as they should. This is a result of the enduring influence of tradition and upbringing, but this is likely to change with new generations due to the lack of proper communication.

In most cases, deciding on a particular purchase is conditioned by understanding the labels and the attitude toward the truthfulness of those labels and the quality. Personal experience influences attitudes that shape our trust in a product, and trust in the credibility gained by the proven and continuous product quality is ultimately more important to a consumer than how much she understands the declared information. Espejel *et al*. (2011) found that satisfaction and trust are the main drivers of consumers' commitment to PDO wine. People vary in their general tendency to trust; individuals with higher levels of social trust are expected to have more trust in the participants in the food supply system (Macready *et al.,* 2020). Therefore, consumers were asked about their trust in TT, and the results showed that the understanding was higher than

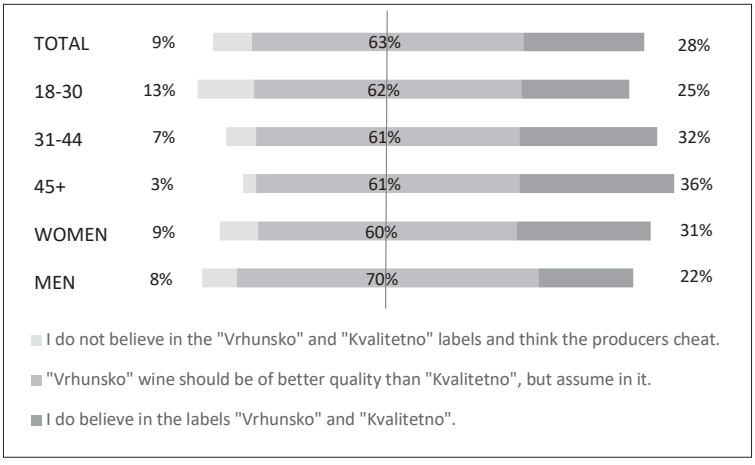

Figure 5 - Consumers trust in "Vrhunsko vino KZP" and "Kvalitetno vino KZP"

the trust level in those labels (Figure 5). While an approximately equal share of respondents does not understand nor trust TT labels, a third of participants have unconditional confidence in TT, which increases with age. Indecisive consumers who doubt the traceability of the label quality are similarly distributed across all age categories, and they are the majority. The downward trend of consumers' doubt with age is highly pronounced, with an R^2 coefficient of 0.9, indicating positive consumer experiences and the responsibility and seriousness of producers concerning these terms. Interestingly, women have more trust in these labels than men and express less doubt.

The questions related to wine-purchasing behavior for personal consumption and for gifts provided a deeper understanding of consumers' perceptions of labels. Specifically, the general assumption is that higher prices should signify higher wine quality, which, in turn, should result in higher subjective ratings (Mastrobuoni *et al*., 2014). We assumed that when choosing products for gifts, most consumers are willing to spend more money and aim for a higher expected quality. Therefore, this question served as an additional test of trust in labels. Among the offered answers and the opportunity to describe wine-purchasing behavior, 8.5% of respondents had a personal approach (online research, experience, recommendations, well-known brands). On the other hand, 17.6% of consumers considered price the key determinant in the purchasing process. The offered answer, "I read labels and choose based on Traditional terms, "Vrhunsko vino KZP" and "Kvalitetno vino KZP", was chosen by 73.9% of participants. Regarding the importance of parameters when purchasing gifts for wine, respondents could choose among offered answers (price, label of TT, price-TT ratio) or specify something personal. 13.3% chose price as the key element in their selection, 18.7% chose the "Price-TT ratio," and 52.2% the response "Kvalitetno/Vrhunsko" label, while the others (15.5%) sought and preferred various factors such as reputation, recommendations, online suggestions, personal experiences, and the preferences of the person. Consumers demonstrated greater sensitivity regarding their doubts while buying wine for a gift than purchasing it for themselves. Even when the price is a limiting factor, the consumers rely on TT as an indicator of better quality. The responses distributed in this way also offer an interpretation regarding consumers who doubt the truth of the declared TT (Figure 5). Although the majority expressed doubts about TT, the majority cared mostly about TT when choosing a wine for a gift. We can conclude that consumers express natural suspicions, and there is no doubt that it results from bad experiences with wine. Otherwise, other attributes, rather than Traditional terms, would be more pronounced when choosing wine for a gift. These findings can be helpful in future market research and in devising production and marketing strategies because they differ from other authors who show a relevant heterogeneity among consumers' preferences for the gift-giving scenario in Italy, with Geographical Indication having a low impact and brand and organic claim playing a pivotal role (Boncinelli *et al*., 2019).

Every purchase involves risk, and consumers perceive different risks when choosing a particular product. The level of risk is a consequence of consumer uncertainty and depends on, among other factors, trust in a product and the perception of the truthfulness of declared information; the higher the doubt, the greater the risk. Since perceived risk affects the decision-making process when choosing a product, we must analyze whether consumers' perception of targeted attributes influences their importance in wine purchasing. Skepticism and doubt are particularly pronounced among consumers with negative product experiences. Therefore, we were interested in whether skepticism about the credibility of labels impacts their importance in purchasing. When respondents were grouped according to responses to questions about their understanding of PDO/PGI labels and Traditional Terms, the Kruskall-Wallis test identified statistically significant differences among consumer clusters regarding the importance of some of the studied attributes in wine selection, whose importance is previously presented (Alpeza *et al*., 2023). Consumer groups concerning the knowledge of PDO/PGI terms significantly differed in their attitudes regarding the importance of PDO/PGI labels, grape variety, vintage, and price. However, those clusters do not differ in their percep-

Table 1 - The influence of PDO/PGI understanding on attributes importance in wine purchasing.

	These terms guarantee that the wine is of specific and declared origin.			*I am not particularly informed, but I assume that these terms are related to the geographical origin.*			*I do not know what these terms mean.*			
	AS	*SD*	$\bar{R}$	*AS*	*SD*	$\bar{R}$	*AS*	*SD*	$\bar{R}$	*P-value*
Grape Variety	3,54	1,42	224,8	3,35	1,32	222,78	2,72	1,45	169,3	0,0027*
TT	3,39	1,38	232,5	3,49	1,19	236,72	3,08	1,44	201,7	0,3397
Country of origin	3,31	1,37	234,7	3,35	1,23	234,87	2,81	1,45	186,4	0,9890
Price	3,1	1,17	214,6	3,44	1,12	223,51	3,44	1,38	262,9	0,0034*
PDO	3,25	1,4	241,0	3,15	1,25	229,72	2,58	1,18	173,8	0,1450*
Color	3,08	1,36	229,3	3,13	1,32	234,38	3,14	1,27	235,4	0,9120
Vintage	3,07	1,31	246,2	2,71	1,29	210,93	2,5	1,13	190,7	0,0045*
Brand	3	1,26	239,3	2,8	1,16	218,7	2,78	1,29	216,4	0,2274
Design	2,8	1,18	224,6	2,88	1,11	233,9	2,97	1,3	246,4	0,5509

*Remark: AS: mean of group answers from Likert scale; SD: standard deviation; $\bar{R}$: average group rank in Kruskall-Wallis test. *: The group differ significantly at p <,050.*

tion of TT, which is an important finding (Table 1). Contrary to the aforementioned, consumers' knowledge of TT does not influence the PDO but influences TT's importance in wine purchasing. The importance of PDO in the purchase of wine is equally expressed in all clusters, which differ significantly regarding knowledge about TT, and it shows a discrepancy in the understanding of PDO and TT and their qualitative connection (Table 2). This unconsciously nurtured importance of TT and its influence on behavior was also recognized in other analyzed attributes. This cultural heritage and behavior is associated with knowledge gained from immersion in tradition and traditional culture. Other authors have also demonstrated the importance of cultural influence on wine selection behavior (Alonso, 2015; Lourenco-Gomes *et al*., 2015; Reinares-Lara *et al.*, 2023). Moreover, de Magistris *et al.* (2011), for example, demonstrated that culture and tradition have more substantial influence than generational belonging when analyzing the preferences of young Americans and Spanish. The group "uninformed" in our study is not worryingly large. However, it still signals a severe need for thematic education and info-campaigns about the new label, its connection with the former and traditional system, and its value.

Other authors have presented similar findings and trends regarding trust in declared GI labels. A study by a group of authors (Verbeke *et al.*, 2012) on European consumers' awareness of PDO, PGI, and TSG labels and their use in six European countries with 4828 survey participants confirmed higher awareness of PDO (68.1%) compared to PGI (36.4%) and TSG (25.2%). Awareness is higher among men and consumers over 50. Consumers believe these labels signal product quality: PDO labels signal better quality than PGI or TSG. Overall, differences in the importance of these three labels are minor, both in countries with a strong tradition of quality labels and those without such traditions in agricultural and food policies. Gracia and de-Magistris (2015) segmented Spanish consumers based on preferences for labels, with the most significant share belonging to the so-called "PDO lovers," who are primarily men, and their numbers increase with age, education level, and financial status. According to Borda *et al*. (2021), certified food gives Romanian consumers a general sense of trust, but consumers do not understand what certification entails. A recent study on the Italian market (Sampalean *et al*., 2021) has shown that Italian consumers' perception, awareness, knowledge, and consump-

Table 2 - The influence of TT understanding on the importance of wine purchase attributes.

	These terms mean wine quality labels, and using them arbitrarily is allowed.			*I am not informed, but I assume these terms refer to wine quality.*			*I do not know what these terms mean.*			
	AS	SD	$\bar{R}$	AS	SD	$\bar{R}$	AS	SD	$\bar{R}$	P-value
Grape Variety	3,55	1,38	224,6	3,18	1,41	209,5	2,76	1,35	169,1	0,0014*
TT	3,42	1,32	233,7	3,51	1,29	241,3	2,76	1,41	169,5	0,0255*
Country of origin	3,35	1,32	237,0	3,19	1,32	221,2	2,97	1,46	201,5	0,2457
Price	3,15	1,19	220,9	3,42	1,14	251,1	3,62	1,18	275,3	0,0175*
PDO	3,21	1,36	236,2	3,16	1,30	231,9	2,65	1,498	184,9	0,1292
Color	3,11	1,32	231,5	3,05	1,34	225,9	3,28	1,56	252,5	0,6203*
Vintage	2,94	1,30	233,4	2,87	1,25	227,3	2,62	1,50	202,8	0,4627
Brand	2,94	1,26	232,7	2,88	1,16	226,8	2,79	1,26	220,3	0,8371
Design	2,70	1,11	213,8	3,15	1,19	262,5	3,26	1,33	278,8	0,0003*

*Remark: AS: mean of group answers from Likert scale; SD: standard deviation; $\bar{R}$: average group rank in Kruskall-Wallis test, *: The groups differ significantly at p <,050.*

tion of products with EU quality labels have significantly increased. Participants were asked about the safety of food products with European quality certificates, given the assumption that certified products are safer. When asked whether they consider products with a PDO certificate to be safer than conventional products, 58% of respondents answered "Yes," 22% answered "No," and 20% answered "I do not know." The authors suggest the implementation of targeted informational campaigns and the promotion of the actual content of labels. According to the authors, these conclusions reflect consumer trust in product certification, highlighting the need to inform consumers about the true scope of certification continuously.

4. Conclusions

This study offers insights into wine consumer attitudes regarding the changed Geographical indication scheme after Croatia assessed the EU. It confirmed the need to analyze consumer attitudes toward new circumstances where Croatian producers can have different approaches in wine labeling since the Traditional terms "Kvalitetno vino KZP" and "Vrhunsko vino KZP" became an option. It has been found that the label's perception of Croatian wine consumers is influenced by cultural heritage, linked to the knowledge acquired from immersion in tradition and culture. Understanding national Traditional terms is better than understanding the new terms PDO/PGI, with consumers under thirty being more confused and less informed. With age, there is a notably high trend of increasing trust in declared Traditional terms, suggesting the credibility of labels and producer responsibility. Despite variations in attitudes based on age and gender, consumers exhibit a similar purchasing behavior pattern when buying wine for personal consumption or as a gift, placing emphasis on Traditional terms and Geographical indications. This underscores the significant cultural element and the impact of inherited tradition.The level of familiarity with the new GI scheme affects the importance of certain factors in the choice of wine. The consumers from the "uninformed" cluster differ significantly from others in their perception of the importance of not only PDO and TT attributes but also grape variety and vintage.

The results concerning the limited comprehension of PDO/PGI terminology and the im-

portance of wine GI certification highlight the need to enhance consumer awareness and education, particularly among younger consumers and women. It would be beneficial to explore possible tools and potential participants that can improve the visibility of information and the availability of knowledge about these topics to the average consumer. Understanding labels, primarily when related to objective, intrinsic attributes, can and should be a tool for consumers to use in wine selection. Consequently, labels and the entire system of Geographical Indications become purposeful, where producers, retailers, and consumers can recognize and obtain the associated benefits. The paper offers insights that can also be valuable in bolstering the search for marketing strategy tools, both institutionally and at the practical operating level.

The primary limitation of the study is that the majority of participants were from the capital city, Zagreb. It is necessary to note that Zagreb serves as Croatia's economic hub and has a significant proportion of highly educated individuals. Additionally, Zagreb has a substantial share of financially affluent citizens compared to other regions. Consequently, the understanding of the wine GI scheme and the new wine labeling model in Zagreb may differ from that in other regions of Croatia. Therefore, for future research, surveys should be conducted with proportional participation of citizens and consumers from all regions across Croatia to obtain a comprehensive understanding and perception of the traditions and the impact of the new wine labeling system in the Croatian wine sector.

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Determinants and performances of food security in the Middle East and North Africa region countries

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Abstract

The current food security situation in the Middle East and North Africa (MENA) region is surrounded by uncertainty and bleak due to several domestic and global challenges, such as a rapid increase in population growth rate, a global slowdown in economic growth rate, climate change impacts, a reduction in water resources, the spreading of political instability, the prevalence of malnutrition, low food production, high food import dependency, weak transport infrastructure, weak drinking water and sanitation services, and suffering from a severe income gap between the population of this region. This paper aims to shed light on the food security situation in the MENA region by investigating the determinants of food security in that region and then measuring the food security performance of each MENA country. The study contributes to tackling the current food security situation in the MENA region by focusing on investigating the food security determinants and weights by using multiple regression analysis to understand the role of macroeconomic factors in improving food security performance in the MENA countries. The findings confirm that in terms of food availability and access, the MENA countries have decent stability on those dimensions, while food utilization and stability dimensions in MENA countries have poor performance.

Keywords*: Food Security, MENA, Multiple Regression Analysis, Food Security Determinants and performance.*

1. Introduction

Food security is a relatively recent concept, and the origins of this term go back to the conference held by the United Nations in 1943 at Hot Springs, Virginia, stating that "a secure, adequate, and suitable supply of food should be a cardinal aim in every country" (Clapp, 2022). This term developed in the 1980s when the international community realized that the progress of any country depends on its ability to achieve minimum levels of self-sufficiency, which gave birth to the concept of "food for development" (Sassi, 2018). In 1974, for the first time, food security was formally defined at the World Food Conference as: "the availability at all times of adequate world food supplies of basic foodstuffs, particularly so as to avoid acute food shortages in the event of widespread crop failure, natural or other disasters, to sustain a steady expansion of food consumption in countries with low levels of per capita intake, and to offset fluctuations in production and prices" (United Nations, 1974).

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The term "food security" was updated in 1996 at the World Food Summit in Rome, in which the food security dimensions were included in this new definition, stating: "Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996).

The definition of food security in 1996 sheds light on four dimensions of food security, which are as follows: The first dimension is "food availability", which means the necessity of providing food in quantities sufficient for the number of individuals in a country or region. It includes the amount of food available through all forms of local production, imports, food stocks, and food aid. The second dimension is "economic and physical access to food", which means "An adequate supply of food at the national or international level does not in itself guarantee household level food security. Concerns about insufficient food access have resulted in a greater policy focus on incomes, expenditure, markets and prices in achieving food security objectives". The third dimension is "food utilization", which means ensuring the health, safety, and suitability of food for human consumption, or food that is safe and nutritious and meets the nutritional needs of humans. The fourth dimension is "food stability", which means the necessity of maintaining food conditions and the necessity of the three previous dimensions being present with each other without any change occurring to them.

In this context, the Middle East and North Africa (MENA) region faces many internal and external challenges that affect its levels of food security. The first challenge lies in the rates of population increase, as this region is considered one of the most densely populated regions in the world, as the population in that region represents about 6% of the world's population, with an expected increase in the population number of up to 700 million people in the year 2050 (World Population Review, 2022). The second challenge facing this region, which is no less dangerous than the first challenge, is climate change, as it increases temperatures and decreases rainfall, which affects local agriculture, which is the main source of food supply to the population (about 50% of the total food supply), in addition to the fact that most of these areas live under conditions of water stress, which may lead to conflicts and disputes over land and water resources in the future (Belhaj, 2021). The third challenge is diet and nutrition, as the population of that region depends on wheat and other basic grains as a main source of food, and half of the quantities consumed of this food are imported from countries outside the region and what makes matters worse for the food security situation in the MENA region is the Russian-Ukrainian war. This war affected the food supply of wheat and basic grains for that region (Kandeel, 2022).

According to the United Nations International Children's Emergency Fund, the MENA region includes 20 countries, which are: Algeria, Bahrain, Djibouti, Egypt, Islamic Republic of Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, the State of Palestine, Sudan, the Syrian Arab Republic, Tunisia, the United Arab Emirates, and Yemen (UNICEF, 2021). Despite these countries sharing common challenges and cultural links, MENA countries can be classified into three groups based on their income level: (1) high-income countries like Qatar, the United Arab Emirates, Kuwait, Bahrain, Saudi Arabia, and Oman; (2) middle-income countries like Algeria, Tunisia, Jordan, Egypt, Libya and Morocco; and (3) low-income countries like the Palestine, Sudan, Syria, and Yemen. The phenomenon of climate change in African countries is expected to increase conflicts and socio-economic inequalities and jeopardize the continent (Mulazzani *et al*., 2020), in which rising temperatures and decreasing water resources will continue to accelerate the shrinking arable land and desertification rate in the MENA region. Desertification has negative effects on ecosystem dynamics, human health, air quality, land productivity, and conflict risks. In terms of food security, agriculture is a key sector for both social and economic development and plays a vital role in most MENA countries national economies, but agriculture is considered the largest water-consuming sector in the Middle East, which makes it the most vulnerable sector to climate change effects. Climate change has a negative impact on agri-

culture due to rising temperatures and declining rainfall, leading to a decline in crop productivity and yields, rising food prices, and spreading child malnutrition. Therefore, climate change is set to significantly decrease food security levels, and it will contribute to more conflicts and political unrest in the region.

The governments of MENA countries were pushed to rethink their development models due to the domestic challenges mentioned before, along with a rapid change in the global environment. The traditional development model for the net oil exporters in the MENA region has relied on oil wealth, state preference over markets, and import substitution industrialization. On the other hand, the conventional development model for the non-oil countries in the MENA region, particularly these countries that are around the Mediterranean Sea, has relied on agriculture, which plays a vital role for their economies, but it cannot be sufficient for the macro-level food security to meet the population needs of these countries (Abis & Demurtas, 2023). Moreover, the new development models for both the oil exports and non-oil exports countries in this region are facing complicated global and regional challenges such as the increasing severity of climate change, a decrease in food security levels, and increasing dependence on the international market. Therefore, it is not possible to apply a unified development model to improve food security performance in all MENA countries due to the diversity of resources available to them. But at the same time, it is possible to rely on a set of common indicators of food security for this region to capture the dimensions of food security at both the macroeconomic level and microeconomic level such as population growth rate, economic growth model, structural change, agriculture performance, oil role, poverty reduction, and climate change impacts (Breisinger, 2010).

This paper aims to shed light on the food security situation in the MENA region by investigating the determinants of food security in that region and then measuring the food security performance of each MENA country through a set of common food security indicators that reflect the four dimensions of food security. This paper contributes to expanding the understanding of the food security situation in the MENA region, as there are few previous studies in this regard. In addition, less attention has been given to the role of macroeconomic factors in improving the food security performance in that region. Therefore, the current paper will fill this research gap by answering the following two questions: (1) What are the determinants of food security in the MENA region? (2) What are the common food security indicators that can be used to measure the food security performance of the MENA countries? So, the paper will attempt to answer the first question via a literature review at regional and domestic levels to figure out the potential determinants of food security in the MENA region and countries. Then use multiple regression analysis to show weight of each determinate. After that, the author can answer the second question by estimating the current food security performances for each MENA country by combining the econometric techniques with indicator weights on each food security dimension on the global index and from principal component analysis (PCA). The data was collected from the Food and Agriculture Organization of the United Nations (FAO) and the World Bank (WB).

2. Literature Review

There are many previous studies that indicate a food security situation, especially in low-income countries around the world. But there are few studies indicating the food security situation in the countries of the MENA. In this context, at the regional level, a study like (Omidvar, 2019) aims to assess food security and socio-demographic factors in 18 MENA countries, which are: Lebanon, the United Arab Emirates, Kuwait, Saudi Arabia, Bahrain, Libya, Morocco, Pakistan, Jordan, Iran, Egypt, Tunisia, Afghanistan, Iraq, Yemen, Syria, Sudan, and Somalia. Results showed that the main determinants of food security are education, health, and income levels. (El-Mahmad and Amar, 2021) focused on the role of agriculture in food security in the MENA region. The selected MENA countries for this study are Qatar, Bahrain, the United Arab Emirates, Kuwait, Oman, Saudi Arabia, Jordan, Algeria, Lebanon, Egypt, Morocco, and

Tunisia. Results showed that the main determinants of food security are not only agricultural factors but also macroeconomic factors that play an important role in food security performance in the MENA region, such as global food prices, trade openness, and the main sector of the country (agriculture or oil sector).

Additionally, a study by (Fathelrahman, 2016) focuses on the food policy in the MENA region, which is associated with food security. The study includes 17 countries, which are: Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, the United Arab Emirates, and Yemen. Results showed that the main determinants of food security in the MENA region are food supply, food distribution, food processing, price stability, and households' income. Moreover, (Zolfaghari, 2021) investigates the role of economic, institutional, and climatic indexes associated with food security in the MENA region countries, such as Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, the United Arab Emirates, Malta, Iran, Iraq, Jordan, Lebanon, Syria, the West Bank and Gaza Strip, Yemen, Algeria, Djibouti, Egypt, Libya, Morocco, and Tunisia. Results showed that the main determinants of food security are political stability, economic growth, price inflation, and civil conflicts. In addition, (Koç, 2017) conducted a study that aimed to analyze the determinants of the food insecurity by examining the relationship between important (economic, social, and natural) factors and an overall food insecurity index that was derived by dividing the value of food imports by the sum of total exports and net remittance inflows. The study covers 18 MENA countries and Turkey. The MENA countries are as follows: Bahrain, Kuwait, Qatar, Oman, Saudi Arabia, the United Arab Emirates, Tunisia, Libya, Iran, Egypt, Jordan, Morocco, Syria, Yemen, Algeria, Lebanon, Sudan, and the West Bank and Gaza Strip. The findings of the study show that water resource availability, food prices, education, and population growth are the main socio-economic determinants of food security in the MENA region.

At the country level of the MENA region, there are many studies focusing on the determinants and/or performances of food security, particularly in middle- and low-income countries. Many studies have pointed out the food security situation in Egypt, such as Outhman, 2023; Mirgorod, 2023; Shi, 2022; Kamel, 2022; Ramadan, 2017 and Yassin, 2016. These studies investigate the major elements affecting food security on both sides (food demand and supply). The findings of these studies show that economic growth, agriculture role, poverty, population growth, education, food policy, food prices, and income are the main determinants of food security in Egypt. So, both agricultural and macroeconomic factors are affecting the food security performance in Egypt. In the same context, there are few studies focusing on the food security situation in Tunisia, such as Fares, 2023; Jeder, 2020; Chemingui, 2000 and Newman, 2018. These studies examine the main factors affecting food security. The results of these studies show that trade openness, global food prices, climate change, agri-food policies, water resources, and political stability are the main determinants of food security in Tunisia. Moreover, some recent studies examine the food security situation in Algeria. These studies identify the major elements affecting food security on both micro- and macro-levels, such as Touidjeni, 2022; Draou, 2022; Bouchentouf, 2021; Nnadozie, 2020 and Boudkhil, 2020. These papers conclude that the main determinants of food security in Algeria are the role of the oil and agriculture sectors, food prices, population growth, and education level. On the other hand, there are many studies that focus on the food security situation in high-income MENA countries.

Many studies have pointed out the food security situation in both Saudi Arabia and the United Arab Emirates. Both countries have a net oil export-based economy, so they have a different food security situation than middle-income countries like Egypt and Tunisia, which have an agriculture-based economy. Recent studies have pointed out the food security challenges in Saudi Arabia, such as Elneel, 2023; Alsarawi, 2023 and Rahman, 2019. The results show that food supply, inflation, population growth, water resources, the oil sector, climate change, and extension services are the major elements affecting the food security performance in Saudi Arabia. In addition, there are a few recent studies of the

food security situation in the United Arab Emirates, such as Ammar, 2023; Ali, 2022 and Manikas, 2022. These papers focus on the food security situation in the UAE by investigating the four dimensions of food security. The findings found that cereal imports, food prices, economic growth, water resources, the oil sector, climate change, and agri-food policy are the main determinants of food security in the UAE.

Based on this literature review, the author concluded that the major elements affecting food security and its dimensions in the MENA countries can be divided into two main factors, which are: sectoral factors (agricultural-based economies or oil-based economies) and macroeconomic factors (gross domestic product, inflation, trade openness, nutrition literacy, economic growth rate, political stability, etc.). In addition, a little attention has been given to macroeconomic factors and their indicators in order to measure the food security performance in the MENA.

3. Methodology

In this part of the paper, the author will describe the data characteristics, sources, and selected variables that have been taken into consideration to estimate an appropriate econometric model, which tackle the similarity and differences for specific characteristics between the MENA countries in order to measure the food security performances or scores for each MENA country in this study based on the data availability and limitations.

3.1. *Data Sources*

The data was collected from two main sources, which are the Food and Agriculture Organization of the United Nations (FAO) and the World Bank (WB). The main limitation of this study is that only secondary data has been used. Conducting a survey across the MENA region could have strengthened the study at the micro-level (microeconomic factors), but it was avoided due to the high financial cost required to gather accurate primary data. The data was collected for 13 MENA countries based on data availability, which are: Algeria, Egypt, Iraq, Jordan, Lebanon, Morocco, Oman, Sudan, Saudi Arabia, Sudan, Tunisia, the United Arab Emirates, and Yemen.

3.2. *Data Variables*

The approach of this paper that follows will be based on the suite of indicators presented in the State of Food Insecurity Report in 2013, in which each dimension of food security has five main indicators that can be combined and used to estimate the food security index/score, and they are as follows:

The food availability dimension includes five main indicators, which are: average dietary energy supply adequacy, average value of food production, share of dietary energy supply from cereals, average protein supply, and average supply of protein of animal origin. FAO or WB has defined those indicators as follows:

- *Minimum dietary energy supply requirements:* "The indicator expresses the Dietary Energy Supply (DES) as an amount of the minimum Dietary Energy Requirement (ADER). Each country's or region's minimum supply of calories for food consumption is normalized by the minimum dietary energy requirement estimated for its population to provide an index of adequacy of the food supply in terms of calories".
- *Food production index:* "Food production index covers food crops that are considered edible and that contain nutrients. Coffee and tea are excluded because, although edible, they have no nutritive value".
- *Dietary Energy Supply from cereals:* "The indicator expresses the energy supply (in kcal/caput/day) provided by cereals, roots and tubers from the total Dietary Energy Supply (DES) (in kcal/caput/day) calculated from the corresponding countries in the FAOSTAT food balance sheets".
- *Average protein supply:* "National average protein supply (expressed in grams per caput per day). This indicator provides information on the quality of the diet".
- *Average fat supply:* "National average fat supply (expressed in grams per caput per day). This indicator provides information on the quality of the diet".

The food access dimension includes four indicators, which are: rail lines density, domestic food price level index, prevalence of undernourishment, and gross domestic product per capita. FAO has defined those indicators as follows:

- *Rail lines density:* "Rail lines density corresponds to the ratio between the length of railway route available for train service, irrespective of the number of parallel tracks (rail lines, total route in km) with the area of the country, for example: rail lines density (per 100 square km of land area)".
- *Domestic food price level index:* "Food price index is a measure of the monthly change in international prices of a market basket of food commodities. It consists of the average of five commodity group price indices, weighted with the average export shares of each of the groups".
- *Prevalence of undernourishment:* "POU expresses the probability that a randomly selected individual from the population consumes a number of calories that is insufficient to cover her/his energy requirement for an active and healthy life. The indicator is computed by comparing a probability distribution of habitual daily dietary energy consumption with a threshold level called the minimum dietary energy Requirement. Both are based on the notion of an average individual in the reference population".
- *Gross domestic product per capita:* "GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products".

The food stability dimension includes six indicators, which are: cereal import dependency ratio, percent of arable land equipped for irrigation, value of food imports in total merchandise exports, political stability and absence of violence/terrorism, per capita food production variability, and Gini index. FAO has defined those indicators as follows:

- *Cereal import dependency ratio:* "The cereals import dependency ratio tells how much of the available domestic food supply of cereals has been imported and how much comes from the country's own production. It is computed as (cereals imports - cereals exports) / (cereals production + cereals imports - cereals exports) * 100. Given this formula the indicator assumes only values <= 100. Negative values indicate that the country is a net exporter of cereals. This indicator provides a measure of the dependence of a country or region from cereals imports. The greater the indicator, the higher the dependence".
- *Agricultural irrigated land (% of total agricultural land):* "Agricultural irrigated land refers to agricultural areas purposely provided with water, including land irrigated by controlled flooding".
- *Value of food imports in total merchandise exports:* "This indicator provides a measure of vulnerability and captures the adequacy of foreign exchange reserves to pay for food imports, which has implications for national food security depending on production and trade patterns".
- *Political stability and absence of violence/terrorism:* "Political stability and absence of violence measures perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism.

This indicator provides a measure of political shocks that might have implications for national food security".

- *Trade openness:* "Trade openness is one measure of the extent to which a country is engaged in the global trading system. Trade openness is usually measured by the ratio between the sum of exports and imports and gross domestic product (GDP)".
- *Gini index:* "Gini index measures the extent to which the distribution of income (or,

in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality, according to World Bank".

The food utilization dimension includes five main indicators, which are: percentage of people using at least basic drinking water services, percentage of people using at least basic sanitation services, percentage of children under 5 years of age affected by wasting, percentage of children under 5 years of age who are stunted, and percentage of children under 5 years of age who are underweight. FAO has defined those indicators as follows:

- *Percentage of people using safely managed basic drinking water services:* "drinking water services is defined as drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip. Improved water sources include piped water, boreholes or tubewells, protected dug wells, protected springs, and packaged or delivered water".
- *Percentage of people using safely managed sanitation services:* "The percentage of people using at least basic sanitation services, that is, improved sanitation facilities that are not shared with other households. This indicator encompasses both people using basic sanitation services as well as those using safely managed sanitation services. Improved sanitation facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, compositing toilets or pit latrines with slabs".
- *Percentage of children under 5 years of age who are underweight:* "Percentage of underweight (weight-for-height more than 2 standard deviations of the World Health Organization Child Growth Standards median) among children aged 0-5 months. According to (WHO)".
- *Percentage of children under 5 years of age affected by wasting:* "Wasting prevalence is the proportion of children under five whose weight for height is more than two standard deviations below the median for the international reference population ages 0-59 months.
- *Percentage of children under 5 years of age who are stunted:* "Percentage of stunting (height-for-age less than -2 standard deviations of the WHO Child Growth Standards median) among children aged 0-59 months. This indicator belongs to a set of indicators whose purpose is to measure nutritional imbalance and malnutrition resulting in undernutrition (assessed by underweight, stunting and wasting)".

So, author can summarize the food security variables that has been used as follows: minimum dietary energy supply requirement, food production index, dietary energy supply from cereals, average protein supply, average fat supply, rail lines density, food price index, prevalence of undernourishment, gross domestic product per capita, drinking water services, sanitation services, percentage of children under 5 years of age (who are stunted, affected by wasting, and who are underweight), cereal import dependency ratio, agricultural irrigated land, food imports, trade openness, and Gini index.

3.3. *Model Specification*

Descriptive and quantitative analysis will be used through simple regression and multiple regression, using the multiple regression method, to interpret the independent variables and determine the extent of their impact on the dependent variable and the extent of their compatibility with economic theory. However, there is one disadvantage of using multiple regression analysis in this case, which is the existence of poor-quality data, especially for food access and utilization dimensions, due to the absence of strong local institutions to collect accurate real data. The summary of food security indicator weights by FAO is presented in Table 1. So, to examine the determinants of food security in the MENA region, the author will conduct econometric methods for multiple regression analysis. Based on the conclusion of the literature review about the

potential determinants of food security, the general model can be expressed as follows:

$$Y_i = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \ldots\ldots + \alpha_p X_p + \varepsilon_i \quad (1)$$

In log terms the equation (1) becomes as follows:

$$Ln\ Y_i = \alpha_0 + \alpha_1 ln\ X_1 + \alpha_2 ln\ X_2 + \ldots\ldots + \alpha_p ln\ X_p + \varepsilon_i \quad (2)$$

Where

Y_i = Dependent variable

α_0…...α_p = Coefficient for the explanatory variables

X_1…...X_p = Independent variables

ε_i = Random error term

The empirical model can be written as following:

$$FSS = F(FAI, FCI, FUI, FSI) \quad (3)$$

In log terms the equation (3) becomes as follows:

$$\ln FSS = \alpha_0 + \alpha_1 ln\ FAI + \alpha_2 ln\ FCI + \alpha_3 ln\ FUI + \alpha_3 ln\ FSI + \varepsilon_i \quad (4)$$

Where

FSS = Food Security Score or performances

FAI = Food availability indicators (dietary energy supply, food production, protein …etc.).

FCI = Food access indicators (Rail lines density, POU, GDP per capita …etc.).

FUI = Food utilization indicators (drinking services, sanitation services, children stunting … etc.).

FSI = Food stability indicators (Cereal import dependency, political stability, Gini index … etc.).

Table 1 - Summary of food security indicator weights.

Food Security Indicator	*Food Security Dimension*	*Total Weight*	*PCA Weight*	*Global Weight*
Average Dietary Energy Supply (DES) Adequacy	Availability	0.25	0.18	0.04
Average Value of Food Production			0.17	0.04
Share of DES derived from cereals,			0.18	0.04
Average protein supply			0.24	0.06
Average supply of protein of animal origin			0.24	0.06
Percent of paved roads over total roads	Access	0.25	0.25	0.02
Road density			0.34	0.03
Rail-lines density			0.41	0.03
Domestic Food Price Level Index	Access	0.08	1	0.08
Prevalence of Undernourishment	Access	0.08	1	0.08
Water	Utilization	0.25	0.18	0.05
Sanitation			0.20	0.05
Stunting			0.22	0.06
Wasting			0.15	0.04
Underweight			0.24	0.06
Cereal import dependency	Stability-Exposure	0.125	0.40	0.05
Percentage of land equipped irrigation			0.32	0.04
food imports/total merch. exports			0.28	0.04
Political stability	Stability-Shock	0.125	0.28	0.04
Food supply variability			0.43	0.05
Domestic FPLI volatility			0.28	0.04

Source: AFCAS 23, 2013. FAO: New approaches to the measurement of food security.

4. Results and Discussion

In this section, the author investigates the food security situation by dividing the MENA countries into three main groups based on their income level (high-income level, middle-income level, and low-income level) (presented in Tables 3, 4, and 5). In addition, the author conducts a comparison between MENA countries in terms of each food security indicator. Then, the results of the multiple regression analysis for food security determinants in the MENA region are presented in Table 6. After that, the author measures the food security performance (score) for each MENA country and presents it in Table 7.

4.1. *Food Security in High Income MENA Countries*

Regarding the food availability dimension, the high-income countries of the MENA, such as the Emirates, Kuwait, Saudi Arabia, and Oman are considered countries that require a large amount of daily dietary energy supply, as the average food supply in the selected high-income MENA countries is 1926 kcal/day, while the global average is 1827 kcal/day. Wheat and major cereals represent the largest portion of the dietary energy supply (DES) for MENA countries, and the selected high-income MENA countries are not the exception, as the dietary energy supply from cereals represents about 43% of the total DES. The selected high-income MENA countries have a high protein consumption of 135 kcal/day compared to average global consumption of 89 kcal/day. In terms of the food access dimension, the rail line density is very low in the selected high-income MENA countries due to the small total area of those countries except Saudi Arabia. The selected high-income MENA countries have a low prevalence of undernourishment (% of population), except Oman, where the POU is 10% of the total population. GDP per capita in the selected high-income MENA countries is very high ($48,050) compared to the global GDP per capita ($18,381) since those countries are oil exported-based economies. In terms of the food utilization dimension in the selected high-income MENA countries, almost all the people are using safely managed drinking water and sanitation services, except Saudi Arabia, which suffers from some sort of unsafely managed sanitation service by 20% of the total population. About 22% of children under 5 years old suffer from stunting, being underweight, or being affected by wasting in the selected high-income MENA countries (a high malnutrition indicator). In terms of the food stability dimension, the average dependence of the selected high-income MENA countries on cereal imports is very high (91%). The selected high-income MENA countries are enjoying some sort of political stability, except Saudi Arabia, but those countries are suffering from a severe income gap between their populations based on the Gini index indicator. Therefore, those countries face a food instability shock (Table 2).

4.2. *Food Security in Middle Income MENA Countries*

Regarding the food availability dimension, the middle-income countries of the MENA, such as Algeria, Tunisia, Jordan, Egypt, Morocco, and Iraq are considered high food-consuming countries, as the average food supply in the selected middle-income MENA countries is 1814 kcal/day. Wheat and major cereals represent the largest portion of the dietary energy supply (DES) for MENA countries, and the selected middle-income MENA countries are not the exception, as the dietary energy supply from cereals represents about 50% of the total DES. The selected middle-income MENA countries are below the daily global protein consumption, in which middle-income MENA countries consume 88 kcal/day, while the daily global protein consumption is 89 kcal/day. In terms of the food access dimension, the rail line density is decent in the selected middle-income MENA countries due to the large total area and good transport (rail) infrastructure of those countries. The selected high-income MENA countries have a low prevalence of undernourishment (% of population), except Jordan (17%) and Iraq (16%). GDP

Table 2 - Food security situation in high-income MENA countries (2022).

Food Security Dimension and Indicators	*United Arab Emirates*	*Kuwait*	*Saudi Arabia*	*Oman*
Food Availability				
Min. Dietary Energy Supply Requirement (kcal/pc/d)	2040	1916	1870	1876
Food Production Index (2014-2016 = 100)	125	123	159	144
Dietary Energy Supply from Cereals (g/capita/day)	775	805	898	807
Average Protein Supply (g/capita/day)	140	127	144	129
Average Supply of Fat (g/capita/day)	134	104	95	98
Food Access				
Rail lines (total route-Km)	279	145	2939	333
Consumer - Food Price Index (2015 = 100)	115	127	126	106
Prevalence of Undernourishment (%)	6	3	4	10
Gross Domestic Product per Capita (No.)	53758	432334	30436	25057
Food Utilization				
Safely Managed Drinking Water Services (%)	99	100	98	91
Safely Managed Sanitation Services (%)	98	100	80	90
Children under 5 years old - Stunting (%)	13	7	12	13
Children under 5 years old - Wasting (%)	8	2	5	9
Children under 5 years old - Underweight (%)	2	3	4	11
Food Stability				
Cereal Import Dependency Ratio (%)	94	98	86	87
Agricultural Irrigated Land (%)	24	0.3	0.7	8
Food imported (% of Merchandise Exports)	5	7	7	8
Political Stability	1	1	-1	1
Average Trade Openness (%)	100	99	76	83
Gini index	0.59	0.64	0.65	0.67

Source: FAO, FAOSTAT - Food Security and Nutrition: Suite of Food Security Indicators.

per capita in the selected middle-income MENA countries is low ($9,883) compared to the global GDP per capita ($18,381) in 2022. About 23% of the total population in the selected middle-income countries suffers from unsafely managed drinking water services, and 32% of the population uses unsafely managed sanitation services. About 18% of children under 5 years old suffer from stunting, being underweight, or being affected by wasting in the selected middle-income MENA countries. In terms of the food stability dimension, the average dependence of the selected middle-income MENA countries on cereal imports is high (60%). The selected middle-income MENA countries have a low political stability indicator and those countries are suffering from a severe income gap between their populations based on the Gini index indicator. Therefore, those countries can face a high food instability shock scenario (Table 3).

4.3. *Food Security in Low Income MENA Countries*

Regarding the food availability dimension, the low-income countries of the MENA, such as Sudan, Lebanon, and Yemen have some sort of food supply shortage, as the average consump-

Table 3 - Food security situation in middle-income MENA countries (2022).

Food Security Dimension and Indicators	*Algeria*	*Tunisia*	*Jordan*	*Egypt*	*Morocco*	*Iraq*
Food Availability						
Min. Dietary Energy Supply Requirement (kcal/pc/d)	1787	1816	1831	1821	1845	1781
Food Production Index (2014-2016 = 100)	105	103	102	103	116	124
Dietary Energy Supply from Cereals (g/capita/day)	894	908	842	1202	1144	1069
Average Protein Supply (g/capita/day)	88	97	82	102	109	53
Average Supply of Fat (g/capita/day)	100	97	85	60	76	53
Food Access						
Rail lines (total route-Km)	4001	1777	507	5153	2295	2370
Consumer - Food Price Index (2015 = 100)	150	168	105	367	129	116
Prevalence of Undernourishment (%)	3	3	17	5	6	16
Gross Domestic Product per Capita	4274	3777	4205	4295	3528	5937
Food Utilization						
Safely Managed Drinking Water Services (%)	71	74	86	97	75	60
Safely Managed Sanitation Services (%)	62	81	82	67	61	53
Children under 5 years old - Stunting (%)	9	9	7	20	13	10
Children under 5 years old - Wasting (%)	3	2	1	8	2	3
Children under 5 years old - Underweight (%)	3	2	3	7	3	4
Food Stability						
Cereal Import Dependency Ratio (%)	70	55	93	43	37	56
Agricultural Irrigated Land (%)	3.3	3.9	8.8	3.4	6	4.5
Food imported (% of Merchandise Exports)	22	13	43	47	16	12
Political Stability	-1	-1	-1	-1	-1	-2
Average Trade Openness (%)	58	50	111	50	61	132
Gini index	0.49	0.57	0.59	0.57	0.60	0.61

Source: FAO, FAOSTAT - Food Security and Nutrition: Suite of Food Security Indicators.

tion in the selected low-income MENA countries is 1756 kcal/day, while the global average is 1827 kcal/day. Moreover, wheat and major cereals represent the largest portion of the dietary energy supply (DES) for MENA countries, and the selected low-income MENA countries are not the exception, as the dietary energy supply from cereals represents about 55% of the total DES. The selected low-income MENA countries have a low protein consumption of 67 kcal/day, compared to average global consumption of 89 kcal/day. The selected low-income MENA countries have a high prevalence of undernourishment (% of population), and the average POU of those countries is 22% of the total population. The GDP per capita in the selected low-income MENA countries is low ($6,400) compared to the global GDP per capita ($18,381) in 2022. About 58% of the total population in the selected low-income countries suffers from unsafely managed drinking water services, and 34% of the population uses unsafely managed sanitation services. About 63% of children under 5 years old suffer from stunting, being underweight, or being affected by wasting. In terms of the food stability dimension, the average dependence on cereal imports is high (74%). The selected low-income MENA countries are suffering from

Table 4 - Food security situation in low-income MENA countries (2022).

Food Security Dimension and Indicators	*Countries With Low Income Level*		
	Sudan	*Lebanon*	*Yemen*
Food Availability			
Min. Dietary Energy Supply Requirement (kcal/pc/d)	1728	1829	1712
Dietary Energy Supply from Cereals (g/capita/day)	899	805	1113
Average Protein Supply (g/capita/day)	68	83	50
Average Supply of Fat (g/capita/day)	71	104	42
Food Access			
Rail lines (total route-Km)	4313	401	47
Prevalence of Undernourishment (%)	13	11	41
Gross Domestic Product per Capita	4216	14331	3437
Food Utilization			
Drinking Water Services (%)	65	48	62
Safe Sanitation Services (%)	57	26	19
Children under 5 years old - Stunting (%)	36	8	35
Children under 5 years old - Wasting (%)	16	2	16
Children under 5 years old - Underweight (%)	33	3	40
Food Stability			
Cereal Import Dependency Ratio (%)	42	94	87
Political Stability	-2	-1	-3
Gini index	0.45	0.65	0.35

Source: FAO, FAOSTAT - Food Security and Nutrition: Suite of Food Security Indicators.

political instability and income gap between their populations based on the Gini index indicator. Therefore, those countries can face a food instability shock (Table 4).

4.4. *Food Security in the Selected MENA Countries*

In terms of food availability, the selected high-income MENA countries have a higher food supply than the selected middle-income and low-income MENA countries. The United Arab Emirates has the highest food supply among all MENA countries (2040 kcal/day), while Yemen has the lowest food supply among all MENA countries (1712 kcal/day). Wheat and major cereals represent the largest portion of the DES for the selected MENA countries, about 50% of the total DES. The daily protein supply in the selected high-income MENA countries is greater than that in middle- and low-income MENA countries. The United Arab Emirates has the greatest amount of protein supply (140 kcal/day), while Yemen has the smallest amount of protein supply among all MENA countries (50 kcal/day). In terms of food access, the selected high-income MENA countries have a low prevalence of undernourishment among their population compared to the selected middle-income and low-income MENA countries, where Yemen has the highest prevalence of undernourishment among their population (41% of the total population). The GDP per capita in the selected high-income MENA countries is greater than the selected middle-income and low-income MENA countries since those countries have oil-exporter-based economies. In terms of food utilization, the selected high-income MENA countries have better and more safe drinking water and sanitation services than the selected middle- and low-income MENA countries. All the

Table 5 - Food security determinants and weights in the MENA region (2022).

Food Security Determinant	*Determinant Weight by Author*	*Food Security Determinant*	*Determinant Weight by Author*
Min. Dietary Energy Supply Requirement	0.07	Drinking Water Services	0.26
Dietary Energy Supply from Cereals	0.03	Safe Sanitation Services	0.25
Food Production Index	0.30	Child Malnutrition	0.49
Average Protein Supply	0.40	*Food Utilization (Total Weight)*	*1.00*
Average Fat Supply	0.20	Cereal Import Dependency Ratio	0.49
Food Availability (Total Weight)	*1.00*	Agricultural Irrigated Land	0.08
Rail lines Density	0.20	Political Stability	0.07
Consumer - Food Price Index	0.40	Average Trade Openness	0.31
Prevalence of Undernourishment	0.40	Gini index	0.05
Food Access (Total Weight)	*1.00*	*Food Stability (Total Weight)*	*1.00*

Source: Author.

selected MENA countries have high malnutrition among the children under 5 years old. In terms of food stability, the selected high-income MENA countries have a higher dependency on cereal imports than the selected middle-income and low-income MENA countries since the middle-income countries have agriculture-based economies. All the selected MENA countries except the UAE, Kuwait, and Oman have political instability, especially Yemen, which has the highest political instability (-3) among MENA countries; Sudan and Iraq are in second place (-2). All the selected MENA countries are suffering from a severe income gap between their populations, based on the Gini index indicator. Therefore, those countries can face a high food instability shock scenario. Therefore, the author can conclude that the selected MENA countries, except low-income MENA countries, have some sort of stability in both food availability and access dimensions. On the other hand, all the selected MENA countries, without exception, have instability in both food utilization and stability dimensions.

4.5. *Food Security Determinants in MENA Region*

At the econometric analysis level, the author builds four main models using the same food security indicators to examine the food security determinants in the selected MENA countries according to the four food security dimensions. The adopted models use the same explanatory variables to understand the effects of each determinant on the food security dimension and tackle which macroeconomic factors have more influence on food security in MENA region (Table 5). The potential determinants were discussed in the literature review section.

4.6. *Food Security Performances in the MENA Region*

The author combines the results of food security indicators from (Tables 2, 3, and 4) with food security determinants and weights from (Table 5) to calculate the food security score in the selected MENA countries (Table 6) and for identify of significance level of different variables' scores (Appendix 1). The results of (Table 6) show that the United Arab Emirates have the highest food security score among all the MENA countries, while Sudan has the lowest food security score in the MENA region. In terms of food availability and access, most MENA countries have a high and/or decent score (good food supply performance) except Sudan and Yemen. In terms of food utilization, all the MENA countries have a very low score (bad food safety performance). In terms of food stability, most

MENA countries have high stability (low food instability-shock and/or exposure), except Tunisia, Egypt, Morocco, and Sudan, because those countries have a high population with low- or middle-income levels.

5. Recommendation and Conclusion

Based on the results obtained by the study, there is no doubt that the current food security situation in the MENA region is surrounded by uncertainty and bleak due to several domestic and global challenges, such as a rapid increase in population growth rate, a global slowdown in economic growth rate, climate change impacts, a reduction in water resources, the spreading of political instability, the prevalence of malnutrition, low food production, high food import dependency, weak transport infrastructure, weak drinking water and sanitation services, and suffering from a severe income gap between the population of this region. The study contributes to tackling the current food security situation in the MENA region by focusing on investigating the food security determinants and weights to understand the role of macroeconomic factors in improving food security performance in the MENA countries. The findings confirm that food utilization and stability dimensions in MENA countries have less attention given to them by the governments in those countries.

So, the author recommends that, in order to improve the performance of food security in the MENA region, the following can be done: one of the interventions that can be used to reduce the risks associated with high dependence on food imports by MENA countries is that each one has to manage the economic risks associated with volatile food prices, in which governments reduce the price volatility of commodities and food import costs, stabilize budgets, and develop tools for commodity markets. Moreover, improving the efficiency of the agriculture sector will lead to a rise in economic growth by reducing food imports through the adoption of the latest effective agricultural practices and technologies that respond to climate change, such as aeroponics and hydroponics. In addition, improve the safe management of drinking water and sanitation services. Another government intervention, reforming the social protection system especially during food instability-shock condition such as, nets of social safety and food aid programs targeting those most vulnerable

Table 6 - Food security scores in the MENA countries (2022).

Country	*Food Availability Score (%)*	*Food Access Score (%)*	*Food Utilization Score (%)*	*Food Stability Score (%)*	*Overall Food Security Score (%)*
UAE	23	23	10	21	77
Kuwait	21	23	11	21	76
Saudi Arabia	23	21	9	17	70
Oman	22	22	7	19	70
Algeria	17	20	7	14	58
Tunisia	17	22	8	12	59
Jordan	16	20	9	20	65
Egypt	17	18	6	10	51
Morocco	18	21	6	10	55
Iraq	14	18	5	16	53
Sudan	15	7	4	8	34
Lebanon	16	12	3	18	49
Yemen	12	14	7	15	48

Source: Author.

groups or households as a major key to ensuring that food is affordable.

Food security is a complex global phenomenon with many different dimensions affected by several macroeconomic factors. So, it is a necessity for all MENA countries to invest in the rural development of the region to achieve a higher food availability score. Creating economic opportunities, especially in rural areas, will lead to a higher food access score. Maintaining and developing both the economic and environmental resources, for example, by increasing people's access to better sanitation and water services, will ensure environmental sustainability and raise the food utilization score. Reducing cereal import dependency and conflicts in the region (increasing the political stability indicator) will lead to a better food stability score. Finally, policies and intervention programs at both local and regional levels should differ according to the targeted dimensions of food security and based on each MENA country's situation to increase the overall food security score, mainly for the food utilization dimension.

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Appendix 1 - Significance level of different variables' scores.

Variable/Indicator	*Food Security Score*
Min. Dietary Energy Supply Requirement (kcal/pc/d)	0.0006**
	-0.0466
Food Production Index (2014-2016 = 100)	0.07091*
	-0.0887
Dietary Energy Supply from Cereals (g/capita/day)	0.0788**
	-0.0474
Average Protein Supply (g/capita/day)	0.0015**
	-0.0252
Average Supply of Fat (g/capita/day)	0.0120*
	-0.1351
Rail lines (total route-Km)	0.0877*
	-0.0739
Consumer - Food Price Index (2015 = 100)	2.7657*
	-1.2029
Prevalence of Undernourishment (%)	-1.4307
	-1.3132
Drinking Water Services (%)	0.0032*
	-0.0810
Safe Sanitation Services (%)	0.0017**
	-0.0212
Child Malnutrition	-2.4499*
	-1.3163
Cereal Import Dependency Ratio (%)	0.0229**
	-0.0405
Agricultural Irrigated Land (%)	0.1198*
	-0.0685
Political Stability	0.0004***
	-0.0091
Average Trade Openness (%)	0.0450
	-0.3993
Gini index	0.0354**
	-0.0126

Source: Author
**** p<0.01, ** p<0.05, * p<0.1*

Impact of agricultural advisory services and innovativeness on perceived farms' performance: Case of dairy milk farms in Northern Algeria

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Abstract

Agricultural advisory services play a crucial role in rural development, particularly in supporting smallholder farmers. This study aims to explore i) the impact of agricultural advisory services and strategic orientations, including market orientations and innovations, on farmers' perceived performances, and ii) the role of advisory services on stimulating these strategic orientations. The focus pertains to a sample of 146 dairy farms in Tizi Ouzou region in northern Algeria. A SEM (Structural Equation Modelling) model using Smart-PLS software was performed. The results show that innovativeness and the access to necessary advices, influenced by the degree of access to various advisory systems, significantly and positively impact perceived performances. By catalyzing innovations, agricultural advisory services also exert an indirect influence on farms' performance. The farmers which are open to innovations tend to have a positive view of their farm's performance. This underscores the importance of supporting and strengthening agricultural advisory systems to meet local demands, encourage innovative practices and enhance overall performance.

Keywords*: Extension, Innovativeness, Perceived performance, Breeding, Algeria.*

1. Introduction

The development of the milk sector in Algeria has been a long-standing priority for the government, driven by the increasing demand for milk and meat products due to rapid demographic growth (Kardjadj and Luka, 2016). This is estimated at 148 liters/inhabitant/year (FAOStat, 2021). The high demand for dairy products can also be attributed to changes in dietary habits and improved income levels. The government has therefore established several policies and programs to support and encourage local production, including production subsidies, feed subsidies and financial assistance for the purchase of livestock equipment (Makhlouf and Montaigne, 2017; Oulmane *et al*., 2022). As a result, the local dairy production has registered a positive increase. However, despite numerous efforts and allocated budgets, the sector suffer from poor performance compared to the dairy potential of

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imported cows (Djermoun *et al*., 2017). Indeed, the increase in local production observed over the last two decades is not attributed to an enhancement in milk production and productivity per cow; instead, it is a consequence of a rise in the number of dairy cattle driven by import policies (Bellil and Boukrif, 2021). As such, local production covers only 60% of national needs in milk (Bessaoud *et al*., 2019) and the country still faces a significant deficit in milk production, leading to a heavy reliance on imports (Meklati *et al*., 2020). This situation places Algeria among the top two milk importers in the world after China (FAOStat, 2022). The import expenditure for milk and its derivatives reached 2.02 billion USD in 2022 (FAOStat, 2023). This positioned them as the second-largest category after cereals in terms of imports, constituting 17.1% of the overall food product import bill, which amounted to 11.8 billion USD in 2022 (FAOStat, 2023). Then, further actions need to be undertaken, especially to enhance the overall performance of the dairy sector, with a specific focus on farm-level operations.

In agriculture, previous studies have examined the specific factors that determine performance. Some have focused on the influence of socio-economic factors, such as farmer attributes (e.g.: age, education, experience) and farm attributes (e.g.: farm size, capital) (Dash *et al*., 2022; Imelda *et al*., 2022; Ameur *et al*., 2024). But more recently, researchers have begun to examine farm performance as a function of alternative managerial orientations such as an entrepreneurial orientation (Ross and Westgren, 2009; Verhees *et al*., 2011), innovativeness (Lone and Baba, 2023; Micheels and Gow, 2015; Puspaningrum, 2020), and strategic choice (Álvarez-Coque *et al*., 2018; Hansson, 2007). According to these authors, performance relies not only on the willingness to change and challenge current strategies but also on the commitment to acquiring information and ideas from consultants or extension personnel. This commitment to acquiring information mediate the relationship between the level of innovation adoption and performance (Micheels and Gow, 2015; Kalmuk and Acar, 2015). The performance depends also on the ability to react faster than the competition. Indeed, as noted by Slater and Narver (1995), learning faster than rivals may be the only way to gain a sustainable competitive advantage in the market. In these regards, our study will focus on understanding the relationship between access to Agricultural Advisory Services (AASs), innovativeness and the performance of dairy farms. More specifically, we analyze in this study (i) the impact of agricultural advisory services and strategic orientation -such as market orientation and innovation- on perceptions of farm's performance, and (ii) the role of advisory services on stimulating strategic orientation in the Tizi Ouzou region.

Given their substantial socio-economic significance, farms in the study area play a crucial role in the livelihood of the population (Ameur *et al*., 2024). Indeed, the wilaya of Tizi Ouzou, which is dominated by small dairy farms, ranks 5th in terms of the quantity of milk produced annually, behind the wilayas of Setif, Mila, Batna and Sidi Belabbes, with an annual average of 113 million liters (2009-2017). Production in 2021 was 136.7 million liters. In this study, we analyzed data from surveys conducted in Tizi Ouzou region, specifically focusing on 146 dairy farms. Our empirical model used the Structural Equation Modelling (SEM) approach. Assessing the effects of AASs on perceived performances of farms was relevant for determining key elements that contribute to enhancing both farm performance and innovation.

2. Theoretical background: literature and hypothesis

2.1. *Innovativeness*

Nelson and Winter (1982) define innovation as a change in routine. According to Micheels and Gow (2015), it encompasses the implementation of new products and processes. Going further, other authors, including Schumpeter (1934) and Stoneman (2010) incorporate a more comprehensive view, considering innovation, as embracing the concept of a new supply sources, changes in business organizations and marketing methods, or even societal, contractual and legal changes. According to Martín-de Castro et al. (2013), these changes are conditioned by

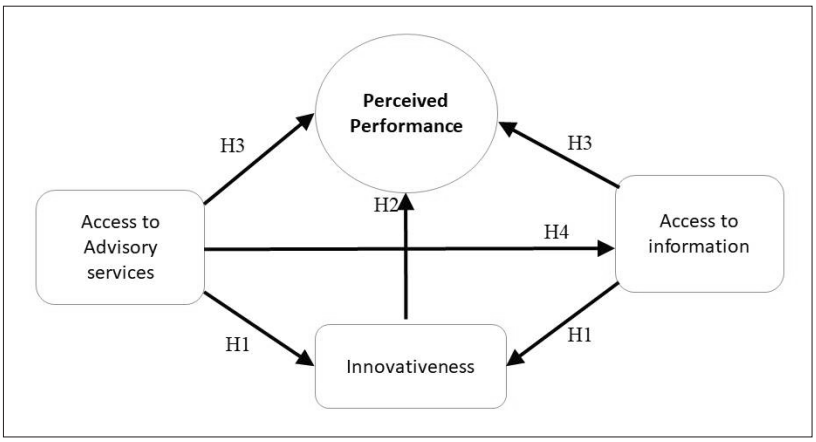


Figure 1 - Conceptual model and hypothesis.

continuous learning and information seeking activity. Recent research showed that access to information and new technologies fosters innovation, which has been evidenced through comparative analyses, such as those conducted between OECD countries and developing countries (Afzal et al., 2020).

H1: (a) Access to information and to (b) advisory services are positively related to innovativeness

Acquiring more information and being responsive to it may allow the firm to begin testing production or market innovations more quickly than other firms. This asymmetry in information access has adverse effects on companies unable to access a diverse range of information. Conversely, those with such access to information have an advantage (Lin et al., 2023; Sipahutar et al., 2020). As a result, the latest may have a favorable position that they can exploit to improve performance by becoming aware of new opportunities through new market channels or production processes (Micheels and Gow, 2015).

H2: Predisposition to innovate is positively related to perceived performance of farms.

2.2. *Access to information and extension services*

In agriculture, AASs play a crucial role in disseminating information derived from local and global research to farmers, by accelerating knowledge transfer and assisting farmers in becoming better managers (Anderson and Feder, 2007; Huffman, 1977; Mapiye *et al*., 2021). This plays an important role in improving farmer decisions and raising productivity, potentially contributing to agricultural development and higher incomes (Anderson and Feder, 2007, 2004). Furthermore, a commitment to learning – by seeking opinions from consultants or extension personnel – may mediate the relationship between the firm's awareness of new opportunities and the level of innovativeness and performance (Baker and Sinkula, 2002, 1999). Nevertheless, while numerous studies have identified access to AASs as an important tool to enhance farm performance (Herrera *et al*., 2019; Iakovidis *et al*., 2023), Oulmane *et al*. (2022) suggested in their study conducted in southern Algeria that the main weakness is the lack of effective knowledge among advisors on certain aspects.

H3: With better (a) access to information and (b) the availability of high-quality farm advisors, farmers can perceive better performance.

Depending on the type of information: information on farming practices (treatments against diseases, fertilizers to be administered, type of tillage, adapted varieties, etc.), information on functional and organizational aspects (credit, subsidies, creation or integration of cooperatives, etc.), information on the adoption of ICTs or digital agricultural tools or market tools (e-commerce, local market, exports, etc.), the advisory systems

used are diversified: public (Caffaro *et al*., 2020), private (Mbeche *et al*., 2022), cooperative (Villemaine, 2013) or in the form of public-private partnerships (Eastwood *et al*., 2017).

H4: Access to different farm advisory systems improves accessibility to information requested by farmers

3. Methodology

3.1. *Study area and data sources*

The study focuses on the wilaya of Tizi-ouzou, located in north-central Algeria. The primary agricultural activity in the region includes livestock (cattle, sheep, goats and poultry), olives and fruit production. We specifically selected the wilaya of Tizi-Ouzou due to its tradition in cattle milk production, making it the fifth largest wilaya in terms of milk production, with a production of 136,000 liters in 2021. The wilaya has a cattle population of 40,700, involving more than 3,654 dairy farms and 22 dairies, as reported by the wilaya's chamber of agriculture in 2020. Dairy cow production in this wilaya has witnessed a steady increase since 2000. It recorded an average of 57.10 million liters over the period 2000-2007 (MADRP, 2009) and reached an average of 113.60 million liters over the period 2009-2017 (MADR, 2020), almost doubling the production.

In the Tizi-Ouzou region, various stakeholders (Figure 2) are involved in training and advising farmers to improve the quality of their dairy production. State agricultural advisors provide general training on topics such as nutrition, reproduction, and animal health, often with the support of local specialists. Additionally, the Ministry of Agriculture organizes short-term training sessions (2 to 3 days) at the "Institut Technologique Moyen» in Tizi-Ouzou, particularly through the national PRCHAT program, with themes defined at the beginning of the agricultural season in collaboration with the Chamber of Agriculture. Tailored training sessions are also offered to address specific needs expressed by groups of farmers through associations or cooperatives. Veterinarians and dairy companies also provide tailored advice to optimize dairy production and maintain high-quality standards in line with the requirements of agri-food businesses. Furthermore, the only farmers' cooperative in the province provides technical assistance to farmers to encourage them to improve milk quality.

The data were collected from individual surveys conducted in 2021 among 146 dairy farmers in the wilaya of Tizi Ouzou. The sample was drawn from a population of 3654 breeders, using a simple random sampling method. During the surveys, the farm managers were asked to judge their level of agreement with the different elements constituting the indicators (Table

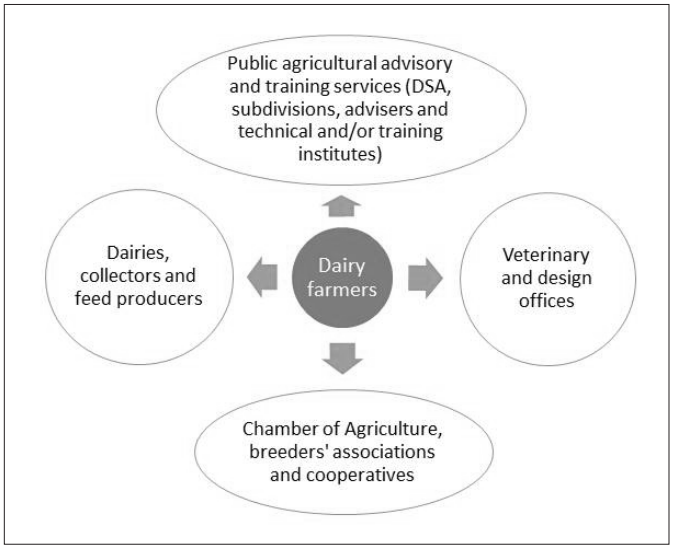


Figure 2 - Training and farm advisory services for livestock farmers.

1). To do so, a Likert scale, ranging from 1 if they disagreed to 5 if they completely agreed was used. The Likert scale, as described by Cheng (2012) and Kokolakis (2017), serves as a widely employed tool for collecting data aimed at exploring and measuring qualitative aspects. Recognized as the most popular psychometric scale, it finds extensive use in educational research and social sciences (Bishop and Herron, 2015). In line with the perspectives of Kokolakis (2017), this scale is particularly well-suited for determining individuals' opinions, perceptions, and attitudes towards a given phenomenon. In the context of our study, this method proves particularly suitable to gather data, facilitating the analysis of participants' perception and opinions concerning their performances.

3.2. *Model and variables used*

We utilized SEM-PLS (Structural Equation Model Partial Least Square) to verify our hypothesis. Structural Equation Modeling (SEM) is a statistical method known for its utility in assessing interactions between unobservable variables within complex models (Micheels and Gow, 2015). This is particularly useful for our case study as we are working with abstract concepts that cannot be measured directly. Also, SEM offers a major advantage as an innovative method of measuring simultaneous equations where latent variables can both influence (are exogeneous) and be influenced (are endogenous) by other variables.

In PLS-SEM, the specification of the model encompasses both the structural model and the measurement models. The structural model delineates the structural connections among the constructs -or latent factors-, while the measurement models delineate the associations between each construct and the respective indicators linked to it (Sarstedt and Cheah, 2019). Both models are commonly represented in the shape of a path model, visually depicting the hypotheses and the relationships among variables to be estimated in the PLS-SEM analysis.

To assess latent variables, scholars create items designed to accurately reflect the concealed construct. Here are the mathematical expressions for exogenous (1) and endogenous (2) variables.

$$x = \Lambda_x \xi + \delta \quad (1)$$

$$y = \Lambda_y \eta + \varepsilon \quad (2)$$

Equation (1) illustrates the exogenous latent variable, ξ, formed by a vector of *x* items, each weighted by Λ, and accompanied by the error term δ. Equation (2) displays how the endogenous variable, η, is comprised of a vector of y measurement items weighted by Λ, along with the error term *ε* (Bollen, 1989).

In the path model (Eq. 3), the endogenous latent variables (*η*) are described by a matrix of other endogenous latent variables *η*, weighted by a matrix of B coefficients, along with a matrix of ξ latent variables weighted by a matrix of coefficients. Errors in the model are measured by the ζ vector (Bollen, 1989).

$$\eta = B_\eta + \Gamma\xi + \zeta \quad (3)$$

The model constructed (Figure 1) consists of a set of exogenous variables grouped into three indicators, namely: 1) *Innovativeness*; 2) *Access to Advisory Systems;* and 3) *Access to Information*, and endogenous latent variables, grouped into perceived performance. In order to measure perceived performance, we asked respondents to rate their overall satisfaction with operating performance, expense coverage and their ability to invest. The list of representative variables of the indicators is presented in Table 1.

Although objective measures of performance are preferable to avoid biases associated with this method, several studies have shown a strong correlation between subjective and objective measures of performance (Dess and Robinson, 1984; Dawes, 1999; Wall *et al*., 2004; Richard *et al*., 2009). For our case study, subjective assessment was used due to the advantages its offers in analyzing opinions and perceptions (Warmbrod, 2014). Indeed, emphasizing that farm performance extends beyond measurable factors such as economic and zootechnical aspects. Subjective assessments offer a more comprehensive understanding of farms' performance as they include subjective factors.

3.3. *Reliability and validity*

Reliability and validity play a crucial role in ensuring the robustness and quality of the model. Scale

Table 1 - Percentages of responses for each indicator.

Construct and Indicators		*Respondents answers (%)*				
		1	*2*	*3*	*4*	*5*
Perceived performance						
I am Satisfied with my farm's results	PP1	12	18	27	23	20
My farm is profitable	PP2	68	21	6	4	1
I am not afraid to invest in my breeding	PP3	58	3	4	22	13
Access to advisory services						
I have access to advice from dairies	AS1	55	18	5	11	11
I have access to private advisors	AS2	54	22	7	5	12
I have access to public advisory	AS3	36	8	21	19	16
Access to information						
I have access to information on rationing	AI1	12	7	10	31	40
I have access to information on livestock management	AI2	23	16	17	17	27
I have access to information on health	AI3	44	18	11	7	20
Innovativeness						
A adopt innovation	IN1	20	1	7	14	58
I am motivated to innovate	IN2	11	10	8	13	58
Innovation is worthy	IN3	27	10	6	7	50
I am concerned about clients' quality guidelines	IN4	29	5	5	26	35

reliability measures the degree to which scales are free from error (Kline, 2005). In the literature, three measures are traditionally used to test the reliability and validity of a model, namely (i) standardized loading factor, (ii) Composite Reliability (CR), and (iii) Average Variance Extracted (AVE). The results of the SEM PLS model analysis are described in Table 2. The standardized loading factor shows the magnitude of the correlation between an indicator and its constituent variables, with the absolute value of the factor loading ≥ 0.5 being considered valid. Furthermore, composite reliability should be higher than 0.70 (in exploratory research, 0.60 to 0.70 is considered acceptable), while the average variance extracted (AVE) must be greater than 0.5 (Hair *et al*., 2011; Fornell and Larcker, 1981).

4 Results

4.1. *Characteristics of the surveyed sample*

The average size of the surveyed farms is 8.3 ha. These farms have a herd size of 18 heads on average, including 9 cows in lactation. Modern cows, particularly Montbéliarde, Holstein, and Fleckvieh, dominate the modern breeds, comprising 51%, compared to 8% and 41% for local and mixed breeds, respectively. Reproduction strategies in the region are characterized by the prevalent use of artificial insemination, practiced on 70% of the farms. This indicates a significant reliance on advanced breeding techniques for enhancing herd genetics. In addition to livestock, the farms are oriented towards the production of green fodder covering 48% of the Utilized Agricultural Area (UAA) with an average of 4 ha per farm, followed by horticultural crops and olive trees. The demographic profile of farm heads reflects a predominantly male leadership, with women representing only 5% of the surveyed sample. Their average age is 45 years, and 40% of whom are between 35 and 45 years old. 90% of them have at least primary education.

4.2. *Validation of hypotheses*

We conducted the analysis of the relationships depicted in Figure 1 using a SEM model achieved

by Smart-PLS software (Wong, 2013). We first started with the validation of our model by checking the value of the standardized loading factor. Based on the PLS results (Table 2 and Figure 2), all indicators have an absolute value of the loading factor ≥ 0.5 and significant p-values, showing that all variables have a strong correlation with the indicator and that the construct is valid. To strengthen our model, variables with a factor loading value less than 0.5 were removed. In addition to the factor loading for each component of the construct, Table 2 presents the composite reliability and average variance extracted (AVE).

Table 2 shows that the rest of the factors, in particular, the composite reliability and the average variance extracted exceed the above-mentioned criteria, which means that the result of convergent validity is adequate, except for the case of Perceived performance whose AVE value is equal to 0.482 but remains, however, near 0.5. Since we were satisfied with the results of the Reliability and validity tests, we proceeded with the path analysis. Subsequently, the value of the path coefficient and t-statistics of each construct was tested. Results of the path analysis representing the direct relationships between the independent and the dependent variables are presented in Table 3 or Figure 3.

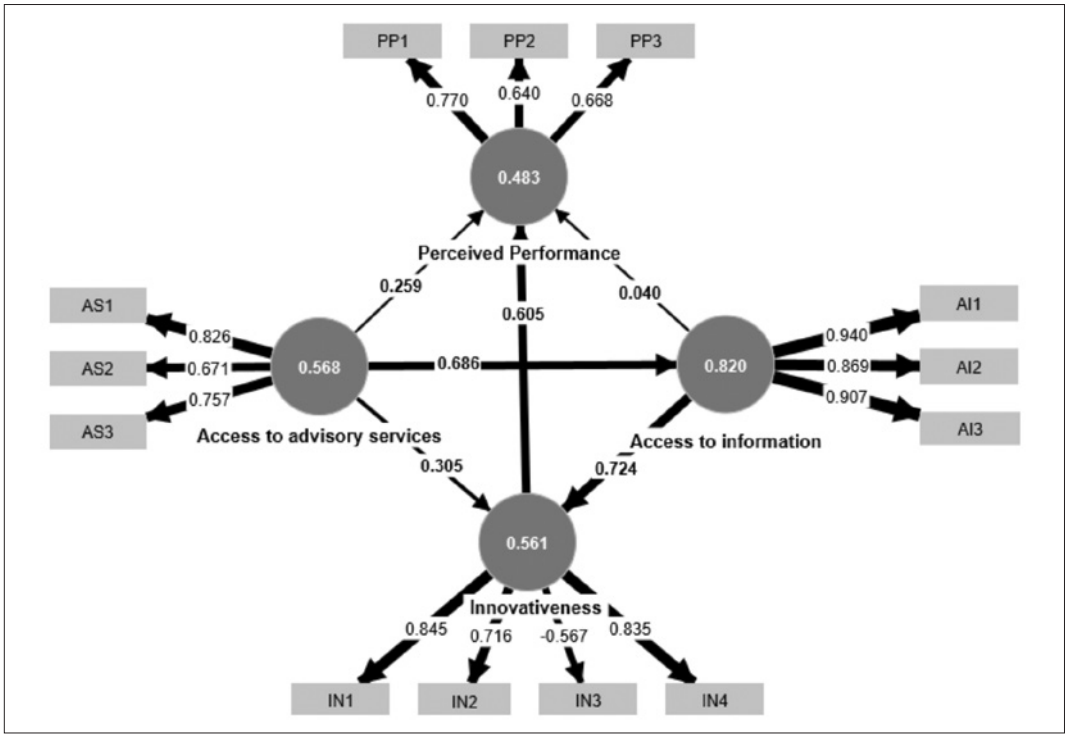
Based on the estimations, the results of the path model (Table 3) indicate that access to different advisory devices as well as access to information (Hypotheses 1) are significantly related to innovation capability (β = 0.305 (p = 0.038); β = 0.724 (p = 0.000), respectively). The results also show that market orientation and innovativeness have a positive and significant influence on perceived performance. Hypothesis 2 was validated (β = 0.605, p = 0.000). In addition to this direct link, the results show that perceived performance is indirectly influenced by access to information through stimulating innovation. Hypothesis 3 examines the relationship between access to several types of farm advisory systems and access to information. The results show that access to the information depends on the diversity of the advisory systems requested (β = 0.686, p = 0.000). Hypotheses 4, which examines, the relationship between requesting multiple advisory systems and access to information with perceived performance, is supported (β = 0.259 (p = 0.005); β = 0.040 (p = 0.026)).

Based on the results of the path model, the Table 3 highlights significant and strong relationships between certain key variables. Firstly, access to information shows a strong positive relationship with innovativeness, with a path coefficient (β) of 0.724 (p < 0.001). This indicates that farms with better access to information are strongly inclined to demonstrate a high level of innovativeness. Similarly, the relationship between innovativeness and perceived performance is also notable, with a path coefficient of 0.605 (p < 0.001). This positive association underlines the fact that high levels of innovativeness are strongly correlated with better perceived performance. In addition to this direct link, the results show that perceived performance is indirectly influenced by access to information through stimulating innovation. The path coefficient between access to advisory services and access to information is 0.686 with a p-value < 0.001. This indicates a significant and positive relationship, suggesting that those with access to diverse advisory services also tend to have better access to information.

Other results reveal significant but less robust relationships. For example, although access to information is statistically linked to a slight increase in perceived performance (β = 0.040, p = 0.026), this relationship is relatively weak compared to the others. Furthermore, the relationship between access to advisory services and innovativeness (β = 0.305, p = 0.038) shows a positive association, but this correlation is less pronounced than that with access to information. The path coefficient linking access to advisory services and perceived performance is 0.259, with a p-value of 0.005. This significant association signifies that access to consulting services is positively correlated with improved perceived performance.

The coefficient of determination, R^2, is 0.820 for the access to information endogenous latent variable. This means that the three other latent variables (perceived performance, access to information, and access to advisory services) moderately explain 82% of the variance in access to information. The model suggests also that innovativeness has the strongest effect on perceived performance

Figure 3 - Loadings and path diagram.



(0.605), followed by access to advisory services (0.259), and access to information (0.040).

5. Discussion

5.1. Extension advisory services determine farm performance

The results showed that access to diverse information types positively affects the perceived performance. This can be explained by the fact that access to information improves the level of knowledge of farmers in livestock management, particularly concerning two critical success factors: animal health by mitigating disease risks and feeding by facilitating better rationing, which allows them to obtain better technical and economic performance. Research consistently demonstrates this pivotal role of advisory services in influencing farm performance. Álvarez-Coque *et al*. (2018) revealed their positive impact on perceived farm performance, especially when fostering strategic orientations such as market orientation and innovation attitude. Dinar *et al*. (2007) underscored the significant influence of extension services in bridging technology and management gaps, thereby enhancing technical

Table 3 - Standardized regression estimates.

Path			*β*	*p-value*
Access to information	→	Innovativeness	0.724	0.000
Access to information	→	Perceived performance	0.040	0.026
Innovativeness	→	Perceived performance	0.605	0.000
Access to advisory services	→	Innovativeness	0.305	0.038
Access to advisory services	→	Perceived performance	0.259	0.005
Access to advisory services	→	Access to information	0.686	0.000

efficiency. However, the effectiveness of advisory services in multifunctional agriculture may not always be enhanced due to a lack of technical knowledge among certain farmers (Labarthe, 2005).

Access to multiple farm advisory systems also showed a positive relationship with access to information. This result is expected because the different types of advisory systems do not deliver the same types of information. The private ones, which are represented by veterinarians, mainly supply information on animal health, while the advice given by dairies -which are more concerned with milk quality- focus on advice related to feed intake and farm management. Mertens *et al*. (2008) and Faure *et al*. (2017) both highlighted the positive impact of these private advisory systems on dairy farms, with Mertens emphasizing the effectiveness of veterinary advice and Faure discussing the role of private advisers in facilitating access to technical support. However, while commercialized advisory service has its advantages, it may favor affluent clients, suggesting the need for complementary services to reach different types of farmers (Prager *et al*., 2016). Finally, the results also showed that access to information had indirect effects on performance via innovation. The results appear to contrast existing literature that argues that continuous learning mediates innovativeness and performance relationship (Eris and Ozmen, 2012; Mahmoud and Yusif, 2012, Wilson and Liguori, 2023). This is especially true when farmers are integrated into stakeholder networks that give them access not only to farm advisory services but also to other types of support: financial, organizational, capacity-building, etc. (Audouin *et al.*, 2021; Madureira, 2022).

5.2. *Innovativeness stimulate farm performance*

The results showed that innovativeness has a direct and positive impact on perceived performance. More concretely, this implies that farmers who are more motivated to adopt and prioritize innovations perceive higher levels of performance on their farms. This positioning as an innovation leader allows them to benefit from early adoption, while belated must adopt these technologies in order to keep pace with the technological treadmill. Indeed, the ability for the farm to earn rents from the use of agricultural innovations is short lived and is dependent on the rate of adoption (Micheels and Gow, 2015). This result can also be explained by recognizing that the openness to innovation, whether technical or managerial, reflects the farmers' willingness and adaptability to navigate an unpredictable agricultural environment. Similar to the findings of previous research on market orientation and innovativeness (Jimenez-Jimenez and Cegarra-Navarro, 2007; Tajeddini, 2010; Saeed *et al*., 2015 and Álvarez-Coque *et al*., 2018), the findings presented here also showed that innovative agricultural farms are able to achieve superior performance even in relatively homogeneous product markets. These farms excel by leveraging their innovation to establish a competitive advantage, adeptly adapting to market shifts, and enhancing operational efficiency. These benefits collectively empower them to attain exceptional performance and ensure sustained long-term viability.

6. Conclusion

This research explored the dairy sector, with a specific focus on small dairy farms in the Tizi Ouzou region, renowned for its longstanding tradition of dairy cattle farming. This study particularly examined how these farmers evaluate their farm performance, considering their access to advisory services, information and innovation.

The findings of the study underscored the essential role of information access, diverse advisory services, and innovativeness in shaping farmers' perceptions of farm performance. This impact is further emphasized by the indirect influence of information access on perceived performance, acting as a catalyst for innovation in the agricultural sector and highlighting the crucial role that innovation plays in the overall success of farming operations. Furthermore, the results demonstrate a positive link between access to multiple advisory services and the information needed by farmers. This emphasizes that to effectively meet farmers' needs and enhance overall farm performance, there is a critical need to diversify services, advisory methods, and topics. This includes integrating organizational strategies and marketing approaches. Additionally, supporting interconnected networks within

the farmers' environment and providing access to various information types, not just technical and technological, is crucial for fostering innovation in the agricultural sector.

In terms of policy implications, these results stressed the need for increased support and strengthening of agricultural advisory systems. Agricultural policies could channel their efforts towards facilitating farmers' access to relevant and innovative advice, particularly through investments in advisory programs and public-private partnerships. Recognizing the catalytic role of agricultural advisory services in the innovation process, policymakers are encouraged to view them as strategic levers for enhancing the sustainability and competitiveness of the agricultural sector. By actively supporting innovation through agricultural advisory services, they will contribute to boosting productivity and overall sectoral performance.

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Can fruit be more sustainable? A study on consumer preferences towards the use of natural preservatives in cherries

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Abstract

Consumer awareness on how food is produced, the effects of food consumption on health and the environment is growing, and with it the importance of sustainability and sustainable production. In this context, fruits are one of the healthiest and most demanded food products, but also, they are highly perishable, requiring the use of chemical preservatives to extend their shelf life. The latter is inconsistent with consumer demands for healthy and sustainable food products and paves the path for the development of natural harmless preservatives. Therefore, it was deemed necessary to study consumers' preferences towards different factors determining a sustainable approach in fruit production and distribution, such as the use of natural preservatives, the local/regional origin, or the organic production. Results reveal a growing interest in society for the use of natural versus artificial preservatives, linked to the increasing awareness of their benefits for health and the environment. However, there are also barriers that prevent these novel products from becoming more extended, such as the existence of a price premium which may turn many consumers away.

Keywords*: Natural preservatives, Consumer profile, Conventional, Organic, Fruit, Spain.*

1. Introduction

Fruit and vegetables – taken to be the edible parts of the plants (for example, seed bearing structures, buds, leaves, stems…), either planted or harvested in the natural environment, raw or minimally processed (FAO, 2020) – are a fundamental part of the world's food production and consumption. In fact, and against a world's meat production of 336 million tonnes in 2018, the world's production of fruit was 868 million tonnes, whereas for vegetables it reached 1,089 million tonnes (FAO, 2023). On the one hand, the main fruits in order of importance were Canary sweet bananas and ordinary bananas, citrus

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fruits (orange, mandarin, lemon, pomegranate, etc.), melon, apple and grape. On the other hand, the main vegetables were tomato, several kinds of alliums (onion, garlic, leek), brassica (cabbage, cauliflower, broccoli) and cucumber.

The major fruit and vegetable producing region in the world is East Asia, followed by South Asia. Other major producers are South America and Southern Europe (FAO, 2020). In fact, fruits and vegetables are an essential part of the Mediterranean diet, which is associated with the relevance these food products have in countries such as Spain, given that it is the first producer of fruits and vegetables in the European Union (EU) with 1,873,520 hectares of fruit and vegetable areas in 2021, representing over 26% of the European production and being the seventh top world producer (MAPA, 2023).

Fruit is considered to be an important part of a healthy and balanced diet, as it provides essential vitamins and minerals, having a crucial role in the prevention of malnutrition (Slavin and Lloyd, 2012; Pem and Jeewon, 2015; De and Tulipa, 2019; Ahmed *et al*., 2022). Additionally, the regular consumption of fruit in our diet can reduce the risk of chronic disease and premature death (Dreher, 2018; Frankowska *et al*., 2019; Sun *et al*., 2021).

Given the importance of fruit in the diet, the World Health Organisation recommends the consumption of at least 400 g of fruit and vegetables a day (FAO and WHO, 2004), although recent studies have recommended the increase of these amounts to reach 800 g/day per head in order to improve health and prevent disease (Mujcic and Oswald, 2016; Aune *et al*., 2017). However, the average daily consumption of fruit and vegetables in most countries is below the current indications, amongst other reasons due to the changes in the family and working models (Eldesouky and Mesias, 2014; Frankowska *et al*., 2019; Mesías *et al*., 2021).

The worldwide production of fruit and vegetables is growing in line with these recommendations. However, the world production reached only 306 g per person a day in year 2000, which scaled up to 390 g in 2017 (FAO, 2020), although these figures also include the non-edible parts, such as the core and the peel of the fruit, as well as the parts that are lost or wasted, which are often very many. In fact, it is precisely the high percentage of the losses, together with the intrinsic perishable nature of fruit, that significantly hinder the attainment of the nutritional objectives. It is known that a major part of the harvest is lost or wasted at the production and distribution stages.

Although such losses are very hard to quantify due to the vast diversity of food products that are included in this category and the length of the commercialisation chains, which can reach even various continents, it is however easier to confirm that fruits and vegetables suffer from higher rates of losses than any other kinds of food products (Kitinoja and Kader, 2015; Ludwig-Ohm *et al.*, 2019). Various authors have mentioned that the losses of these kinds of products can reach very significant levels, with the average of losses of fruit and vegetables in the United States being 12% between the production and consumption stages (Usall *et al*., 2016) and for fruits, vegetables, roots and tubers, of up to 45% according to Kitinoja and Kader (2015). More recent studies indicate that the level of waste worldwide was 17% of the total food products available to consumers in 2019, the equivalent of 121 kilos of food products being wasted each year per consumer – out of which 74 kilos are wasted in the homes – according to the estimates provided in the report on the "Food Waste Index Report 2021", published under the United Nations Environment Programme, 2021.

This issue must be analysed within a context of the growing demand for convenience food products from consumers – especially in developed countries – deriving from the new consumption patterns, but also a growing awareness of consumers towards sustainability. Therefore, in recent years, the interest of citizens in food produced using sustainable or ethical production methods has increased (Risius *et al*., 2019), which is associated with the sustainable use of resources and the concern for future wellbeing (Reisch *et al*., 2013; Çakmakçı *et al*., 2023).

This level of consumer awareness, which has given rise to the concept of sustainable consumption, has already been reflected for example, on the Sustainable Development Goals (SDG) for the Agenda 2030, particularly in Target 12.3 of

SDG 12, Sustainable consumption and production, which refers to the goal to "reduce food waste and losses along production and supply chains" (United Nations, 2015). In general, consumers are increasingly aware of the fact that sustainable consumption is key to protect the natural environment, offset current climate change and guarantee social fairness (Eldesouky *et al*., 2018, 2020b).

In this context, and in order to increase the shelf life of food products along the commercialisation and consumption chains, several technologies can be used. In the case of fruit, they are primarily focused on the use of chemical preservatives (fungicides) in order to prevent rotting during the distribution process. Nevertheless, the use of these chemicals to extend the shelf life of food products clashes directly with the aforementioned concept of sustainable consumption, on account of its consequences for human health (cancerous or teratogenic effects, etc.) and the environment. This context of growing social concern has led to a restriction in the post-harvest use of chemicals, (Spadaro and Gullino, 2004; Wisniewski *et al*., 2016) as well as to the development of abundant research to identify natural substances that can be used to prevent fruit deterioration and which are both less harmful and more appealing to consumers.

Amongst the new developments, biocontrol through the use of protective cultures – a set of living microorganisms deliberately added to food with the purpose of controlling its microbiological state without modifying its technological and sensorial qualities – (Ben Said *et al.*, 2019) stands out. These protective cultures contain biocontrol agents (BCA) and have become an interesting alternative to the synthetic fungicides used to extend the useful shelf life of fruit and vegetables (Droby *et al*., 2016; Leyva Salas *et al*., 2017; Linares-Morales *et al*., 2018).

From a market point of view, the future of BCAs seems promising, as the above-described consumer trends have already materialised into regulatory changes (Droby *et al.*, 2016) and, especially, into changes to the standards that the major food retailers demand from their suppliers. In practical terms, this has resulted in a reduction in the levels of allowed chemical waste (Usall *et al.*, 2016), which explains the increasing use of biopesticides and biopredators at the production stage, as well as the development of harmless BCAs in order to increase the shelf life of fresh fruit and vegetables during their marketing and consumption stages.

Nevertheless, and although the product proves to be interesting and safe for the industry from a technical point of view, it may not be necessarily in line with the attitudes of consumers in the subject. Consumers tend to be cautious when faced with new products and technologies on account of the potential perceived risks, lack of trust in the industry or neophobia – rejection of new things – (Mesías *et al*., 2021).

Considering all the above, in this study will be addressed the following research questions:

- Which are the perceptions of consumers regarding the use of natural preservatives in fruits?
- Will there be factors that may hinder the acceptance of the natural preservatives in fruits?
- Given the increasing concern on sustainability and the association between the use of natural preservatives and sustainable production, how do various factors, such as organic production, preservative type, geographical origin, and final purchasing price, collectively influence consumer fruit purchase decision?

This analysis could help the industry towards future training and information actions, as well as for the design of policies for producers and distributors in the food supply chain. Although the study may be applicable to all fruits, it was necessary to focus on a specific fruit with the purpose of making it easier for consumers to state their preferences. Therefore, for the purposes of this study the cherry was selected as a highly valuable fruit, on which the application of techniques to attain better preservation without a negative response from consumers, could prove very relevant. Additionally, this fruit has experienced an increase in consumption in the last decades (Rivero *et al.*, 2022) and it is mainly oriented to the export market, where price and demand for quality are higher. Given that this fruit is highly perishable at a commercial level, it is also an excellent example for study of consum-

er preferences of chemical or natural preservatives. Lastly, this product has an important role in the economy of rural areas, given the income it generates and its complementarity with other productions, allowing farmers to diversify their production, thus increasing the profitability of their farms and their continuity (López-Ortega and Frutos-Tomás, 2008).

2. Methodology

2.1. *Data collection*

Data were collected in March-May 2022 by way of a nationwide online survey with Spanish consumers. The survey was administered by a professional market research company that was responsible for programming the questionnaire, hosting the survey and recruiting respondents. Participants aged 18 or above were approached by email to fill out an online self-administered survey.

In order to capture diverse perspectives across different age groups and genders, quota sampling for age and sex was used (Futri *et al*., 2022) according to the last available Spanish demographic criteria (National Institute of Statistic of Spain, 2022). This approach allowed us to explore different nuances in consumers' preferences, ensuring that our findings accurately reflect the diverse attitudes of the general population towards fruit choices.

Based on the purpose of the research study, it was decided for the survey to be carried out only amongst fruit consumers and therefore the respondents were first asked about their fruit consumption. Only those respondents who indicated they ate fruit (even occasionally) were allowed to proceed with the questionnaire.

The research study was approved by the University of Extremadura's Bioethics and Biosecurity Committee (registration n. 137/2022). All participants agreed to participate in the study and were assured that their answers would be kept confidential and completely anonymous. Respondents did not receive any compensation for their participation in the study.

Although a total of 842 questionnaires were received, the final number of valid questionnaires used in this research study was 763, following the exclusion of 79 answers from the final sample (mainly due to incomplete questionnaires or because they did not pass the validation questions used for quality control). Table 2 presents the socio-demographic characteristics of the sample, comparing them with those of the Spanish population.

Table 1 - Sociodemographic characteristics of the Spanish population and the sample (%).

		Spain	*Sample*
Age	18-35 y.o.	24	19
	36-50 y.o.	29	38
	>50 y.o.	47	43
Gender	Female	51	55
	Male	49	45
Family size	1-2	56	37
	3-4	38	55
	5 and more	6	8

In order to make sure that the questionnaire was designed in an appropriate, unambiguous and unbiased manner and that it would be valid for all possible responses (Stone, 1993), 14 participants were chosen to pre-test the questionnaire. This approach was also used to ensure the questions were clear and to improve the final version of the questionnaire.

2.2. *Choice experiment*

Amongst the various tools employed to analyse consumer preferences, stated preference techniques are recommended when consumers are required to make choices in situations that involve hypothetical markets, such as the case of BCAs (Jaeger and Rose, 2008). Within these tools, choice experiment (CE) is one of the most frequently-used in the area of food, and it has been applied, for example, to analyse consumer preference for meat product packaging formats (Ortiz *et al*., 2020), new foods obtained from aquaculture (Banovic *et al*., 2019) or carbon footprint food labelling (Lami *et al*., 2022).

CE is based on the idea that a good or service can be described through its components' attributes (Lancaster, 1966), and that consumers make purchasing decisions based on these attributes

and their various levels (Steenkamp, 1987). A CE consists of alternative options of the same product made up of different levels of the attributes and prices, where the interviewee is required to select the option that best reflects his/her preference, although they may also choose to select none at all, if the options they are given do not meet his/her expectations. This procedure reproduces the typical purchasing situation consumers would face when buying products in real-life markets (Van Loo *et al*., 2011) which makes the task easier for the interviewee.

Over the last few years, this technique has been identified as a very useful tool to estimate consumer preferences and willingness to pay for the different attributes of various food products. It has also been pointed out that CE is a valuable method to obtain an unbiased welfare measure (Barreiro-Hurle *et al*., 2018). It has been used in several studies addressing food preferences towards different features, such as environmentally-friendly food (Aprile and Punzo, 2022; Mazzocchi *et al*., 2022), local food (Ditlevsen *et al*., 2020), fish products (Menozzi *et al*., 2020), meat and meat products (Escribano *et al*., 2021; Van Loo *et al*., 2014), etc.

The first step in a CE study is the selection of the attributes and levels that will make up the different cherry options to be presented to the consumers. For the purpose of this research, the attributes and their levels were selected from a literature review of consumer fruit preferences (Baselice *et al*., 2017; Thøgersen *et al*., 2019; Huang *et al*., 2021). The selected attribute levels must always be realistic and cover the full range of preferences that respondents might have. Table 2 shows the attributes and levels selected for this study.

Notably, price is a widely-used attribute in CE (Banovic *et al*., 2019; Carzedda *et al*., 2021; Vroegindewey *et al*., 2021) to determine the willingness to pay for a product and its component attributes, and it was therefore included in the analysis. Specifically, three price levels were defined for the purpose of this study, based on the research team's monitoring of cherry retail prices in Spanish supermarkets, with a low price (5 €/kg) reflecting the cheapest cherries; a second average price (7.5 €/kg); and finally, a third price (10 €/kg) corresponding to the highest-quality cherries, such as organic cherries. In addition to the price attribute, which is essential in the consumer's purchasing decision according to demand theory, three other relevant attributes were considered. The first is the production method, differentiating between certified organic and conventionally produced cherries, an attribute repeatedly used by different authors such as (Mesías *et al.*, 2012). Secondly, origin, with the aim of identifying to what extent consumers could have a greater or lesser preference for food produced in a closer environment, which was called regional, as opposed to cherries that may have been produced in other regions or in other producing countries (Giraud *et al.*, 2005). And lastly, a fourth attribute was included that would differentiate the possible types of cherries available for purchase, according to whether or not they had been added preservatives, in accordance with the objectives of this study. Furthermore, many other attributes which have been the focus of research in different countries and for different products, as reported in the recent meta-analysis by (Saija *et al.*, 2023), were discarded.

Table 2 - Attributes and their levels used in the choice experiment.

Attributes	*Levels (reference levels are underlined)*
Origin	Regional; Spanish; Imported
Production method	Conventional; Organic
Preservatives	Artificial; Natural; Without preservatives
Price	5€/kg; 7.5€/kg; 10€/kg

The total set of hypothetical products that can be created by combining the selected attributes/levels amounts to 54 (3 x 2 x 3 x 3), which would provide an excessive number of products to be compared by respondents. Considering that they are presented within "choice sets" that are made up of two products plus a "no-purchase" option, there would be a total set of possible comparisons of 2,862 (54 x 53), which is unmanageable in economic and time terms. Therefore, a fractional design is used to reduce the number of comparisons to a manageable level. Finally, six choice sets were created and used for the survey. Table 3 shows an example of a choice set used in this study.

Cheap talk was used to correct the hypothetical bias that may appear in this kind of research. Thus, in line with previous studies (Escribano *et*

Table 3 - Example of a choice card presented to respondents.

Choice set 3			
	Option 1	*Option 2*	*Option 3*
Origin	Regional	Spanish	None of these options
Preservatives	Artificial	Natural	
Production method	Conventional	Conventional	
Price	5€/kg	7.5€/kg	
I would buy	( )	( )	( )

al., 2021; Ortiz *et al.*, 2021), a text was included in the questionnaire explaining the hypothetical bias and its importance for the validity of the results. Finally, participants were asked to try to actively imagine themselves in a real purchasing scenario before answering the CE task.

2.3. *Econometric Model*

Conditional Logit, a model based on Random Utility (Mcfadden, 2015; Train, 2003), was applied in this research to estimate consumer preferences using JMP v.16 software. The model assumes that the utility function for each consumer is the addition of two components, a deterministic part that can be derived as a function of the factors influencing consumer utility and another random part, not directly observed and considered stochastic. Thus, the utility U_{njt} for a consumer n who chooses alternative j in the comparison t is:

$$U_{njt} = \beta_n' x_{njt} + \varepsilon_{njt} \qquad [1]$$

where β_n' is the individual-specific vector of coefficients, x_{njt} is the vector of the observable attributes for individual n; and ε_{njt} is the random term that is assumed to be an independently and identically distributed extreme value.

Reference levels have been selected for each of the qualitative attributes in order to set a benchmark (zero utility) for the other levels of the attribute. The selected reference levels were "Regional" (for attribute Origin), "Organic" (for Production method) and "Without preservatives" (for Preservatives). The econometric specification used in this paper is therefore defined as follows:

$$U_{njt} = \beta_0 ASC + \beta_1 Imported_{njt} + \\ + \beta_2 Spain_{njt} + \beta_3 Conventional_{njt} + \\ + \beta_4 Natural\ preservatives_{njt} + \\ \beta_5 Artificial\ preservatives_{njt} + \beta_6 Price_{njt} + \varepsilon_{njt} \qquad [2]$$

where β_0 relates to the present situation (ASC), i.e., do not purchase either of the two proposed products, and β_k is the marginal utility associated with each attribute provided by the specific product.

On the other hand, when we include the price as an attribute in a CE, the marginal substitution ratio between a coefficient and the price is called the willingness to pay (WTP) for the specific attribute, which is calculated as follows:

$$WTP_k = -\left(\frac{\beta_k}{\beta_{Price}}\right) \qquad [3]$$

Therefore WTP_k represents how much consumers would be willing to pay in monetary terms for each increase in the level of attribute k provided by the product.

3. Results and discussion

3.1. *Level of awareness of the presence of preservatives in tray-packaged fresh fruit*

As Table 4 shows, a very high percentage of the Spanish food consumers interviewed (78.37%) stated they were aware of the use of

Table 4 - Awareness and interest in the presence of natural preservatives (%).

	No	*Yes*
Are you aware or have you ever heard whether the fruit we eat has added preservatives in order to make them last longer?	21.63	78.37
Have you ever read on the label of plastic tray-packaged fresh fruit whether they contain any kind of preservative?	84.27	15.73
Have you ever bought fruit with natural preservatives?	86.89	13.11
Do you find it interesting for yeasts that are naturally present in fruit and harmless to consumers to be used to control the development of mould?	9.31	90.79
Would you be willing to pay more for the same fruit with natural preservatives?	12.84	87.16

preservatives in fresh fruit in order to increase their shelf life. However, the percentage was much lower when they were asked whether they had read information on the content of preservatives on the label of fresh fruit sold in plastic trays (15.73%), with an even lower percentage of respondents stating that they had bought fruits with natural preservatives (13.11%). These findings are in line with those of (Bouranta *et al*., 2022) regarding the high appreciation of the labelling of systems implemented by food companies such as the Quality Management System (QMS) or the Food Safety Management System (FSMS). Also, Spaniards showed a high level of trust in food manufacturers, and do not care much about food safety (Kennedy *et al*., 2008; Bouranta *et al*., 2022), which can explain why they don´t pay much attention to the content of specific information on labels.

It is worth mentioning as well, that on many occasions, no detailed information is provided on the presence of preservatives in tray-packaged fruit, whether these are chemical or natural.

The above results are in contrast with the stated interest of the majority of consumers (90.79%) for the use of natural preservatives that are harmless to consumers and useful to increase shelf life and consumption of fruit, with also a high percentage of consumers (87.16%) being willing to pay a premium to use these products. The selection of products with less preservatives or with natural preservatives has also been found in a study carried out by (Leyva Salas *et al.*, 2017), where there is a notable increase in demand of natural preservatives, although, at the same time, people are alarmed about food additives in general. Nevertheless, previous studies (Carocho *et al.*, 2014) have also found that natural preservatives are perceived as a healthier option.

We also analysed whether the purchase of fruit with natural preservatives was more common amongst consumers with higher frequency

Table 5 - Association between the frequency of daily fruit consumption and the purchase of fruit with natural preservatives (%).

Fruit consumption frequency per day						
Frequency (%)		Occasional fruit consumers (< 1 piece/day) 14%	Regular fruit consumers (1-2 pieces/day) 46%	Major fruit consumers (> 2 pieces/day) 40%	Total sample	Sig.
Have you ever bought fruit with natural preservatives?	No	3.7	3.7	5.6	4.5	**
	Don't know	87.9	86.3	76.1	82.4	
	Yes	8.4	10.0	18.4	13.1	

*Significance at: * p < 0.1, ** p < 0.05, *** p < 0.001; n.s.: non-significant.*

of fruit consumption, with the outcomes being shown on Table 5, where an association between these two variables can be observed.

3.2. *Interest in the presence of natural preservatives amongst organic consumers versus non-organic consumers*

Given the association between the use of natural preservatives and sustainable production as is the case in organic production, consumers were initially asked about their level of awareness of organic food. Although 88.47% stated they were aware of organic food, 11.53% stated they did not know what this was exactly. It is important to highlight that the sample reflected a yet scarce development of the organic market, with only 10.62% of the respondents stating they were regular consumers (with at least weekly consumption) of organic fruit – hereinafter Organic Consumers –, with the larger percentage (42.46%) being occasional consumers (some frequency) – hereinafter, Occasional Consumers –, or consumers who never eat organic fruit (46.92%) – hereinafter Conventional Consumers –.

The Organic Consumers are middle-age consumers with larger families and women are slightly more predominant. On the other hand, Conventional Consumers include a slightly higher number of young consumers than the other groups, with families of 1 to 2 members, which may be associated with their age range. Unlike the previous group, this group contains a slight majority of men. Finally, Occasional Consumers are a transition group that is the only group with a clear sex trend (the majority are women). These outcomes are in line with previous research studies, which found that women are more likely to act with moderation when selecting food, as they tend to be more concerned about their appearance (Chambers *et al.*, 2008). Besides, according to (Ragaert *et al.*, 2004; Chambers *et al.*, 2008), large families tend to have healthier eating habits including less processed foods, as the parents feel obliged to set an example for their children. On the other hand, no significant differences were found amongst the groups in terms of income, although (Shuai *et al.*, 2014; Vecchio and Annunziata, 2015) found in their research studies that monthly income is one of the main factors when selecting more sustainable products.

Once consumer groups were defined, Table 6 presents the average ratings granted by the different consumer groups to some statements about interest and willingness to pay for natural preservatives.

Based on the overall results we can conclude that, in response to the first research question, perceptions regarding natural preservatives in fruits are positive amongst all consumers, even though the more frequent the consumption of organic fruit, the higher the level of interest in

Table 6 - Interest and willingness to pay for natural preservatives for the different consumer groups.

Consumer groups according to consumption of organic fruit						
Frequency (%)		Conventional	Occasional	Organic	Total sample	Sig.
Have you ever read on the label of plastic tray-packaged fresh fruit whether they contain any kind of preservative?	No	54.5	48.1	44.4	50.7	*
	No, but I am aware	31.6	36.4	30.9	33.6	
	Yes	14.0	15.4	24.7	15.7	
Have you ever bought fruit with natural preservatives?	No	5.0	3.4	6.2	4.5	*
	Don't know	85.2	80.6	77.8	84.2	
	Yes	9.8	16.0	16.0	13.1	
Would you be willing to pay more for the same fruit with natural preservatives?	No	16.5	9.9	8.6	12.8	**
	Yes	83.5	90.1	91.4	87.2	

*Significance at: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$; n.s.: non-significant.*

the information on the use of preservatives and the higher the willingness to pay for the use of natural preservatives in fruit. This change in consumer attitudes is also seen in other studies (Gil *et al.*, 2000; Ragaert *et al.*, 2004), where consumers with healthier habits, like organic ones, were more willing to buy, pay or receive information on natural food and food that is less processed.

3.3. *Assessment of fruit attributes and food consumer attitudes in the various types of consumers*

With the purpose of gaining further insight into consumer profiles, the respondents were asked about the importance they placed on the various fruit attributes, as well as their food consumption habits, with Table 7 presenting the average ratings granted by the different consumer groups.

Table 7 reveals that flavour and freshness are the factors most highly valued by consumers, followed, in this order, by odour, origin, price, appearance, colour and natural production. In fact, quality indicators have previously proven to be one of the most relevant attributes in the purchase of fruit (Campbell *et al.*, 2013; Moor *et al.*, 2014; Migliore *et al.*, 2015).

Results in Table 7 also show that Organic Consumers are the group conferring the highest value to organoleptic factors such as flavour, freshness, odour, origin or, to a higher extent -as was to be expected-, to the fact that fruits come

Table 7 - Assessment of various fruit attributes and food consumption habits for the different consumer groups.

Consumer groups according to consumption of organic fruit					
	Conventional	Occasional	Organic	Total sample	Sig.
Assessment of fruit attributes (1: Not important a 5: Very important)					
Flavour	4.76	4.82	4.89	4.80	*
Freshness	4.63	4.66	4.79	4.66	*
Appearance	3.73	3.67	3.25	3.65	***
Colour	3.68	3.61	3.42	3.62	**
Odour	3.65	3.78	4.00	3.75	**
Origin	3.40	3.94	4.19	3.71	***
Natural production	2.61	3.73	4.53	3.29	***
Price	3.78	3.63	3.19	3.65	***
Attitudes and food consumption habits (1: Totally Disagree a 5: Totally Agree)					
I am concerned about how my diet can impact my health	4.37	4.57	4.77	4.50	***
I like to try new recipes/ food	4.15	4.32	4.41	4.25	**
I am interested in having information relating to food	4.00	4.28	4.62	4.19	***
I frequently eat fruit and vegetables	4.37	4.56	4.63	4.48	**
I frequently eat out	2.55	2.56	2.41	2.54	n.s
I tend to have a diet that contains little meat	2.83	3.18	3.40	3.04	***
I value sustainable production (lower environmental impact)	2.92	3.63	4.25	3.36	***
My lifestyle is healthy	3.70	3.88	4.11	3.82	***
Price is a determining factor for me when buying food	3.77	3.47	2.77	3.53	***

*Significance at: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$; n.s.: non-significant.*

from natural production systems. They are also the least concerned about appearance, colour or price of the products, with these aspects being the most valued by the Conventional Consumers group. (Ragaert *et al.*, 2004) found in a study on the perception and selection by consumers of minimally-transformed packaged vegetables and fruit that conventional buyers were the least interested in flavour and information relating to the food product, coincidentally with our study. On another line, price is usually a determining factor when purchasing food (Campbell *et al.*, 2013; Eldesouky *et al.*, 2020a).

Once again, in terms of attitudes and consumer habits toward food, it seems very relevant that the Organic Consumer group is the one conferring the highest importance to the factors above mentioned, except for price, for which this group was again confirmed to be less price sensitive. Price limitations (potential rejection of excessively high prices) and preference for natural preservatives versus artificial preservatives have been highlighted in the article written by (Carocho *et al.*, 2015) where health is the main reason for this behaviour.

Women have also been identified to be the segment placing the highest importance on appearance and organoleptic attributes, also giving higher scores in the attitudes and consumer habits under study. This finding could be associated with the fact that women are usually in charge of food purchasing in the household or because, as we mentioned earlier on, women tend to pay more attention to the food they select and maintain healthier lifestyles due to their higher concern for physical appearance (Chambers *et al.*, 2008). Price differences, however, are not significant between sexes.

In terms of age, although the differences are less significant, the trend has been that with the increase in age, the importance given to such attributes also increases, except in the case of price, where young people place higher importance on price. These outcomes are in line with those of (Chambers *et al.*, 2008), who conclude that young people are less likely to eat healthily due to lack of time, and moreover they don´t use labelling to find out information on a regular basis.

3.4. *Choice Experiment*

Table 8 presents the outcomes of the Choice Experiment for the entire sample. The sign of the estimated coefficients shows whether the presence of the level of an attribute adds (plus sign) or subtracts (minus sign) utility for consumers to or from the reference level of that attribute. As the methodology section states, the reference levels have a null utility assigned.

As Table 8 shows, all the coefficients were very significant. In terms of the origin, the level of preference was much higher for the "regional" level, followed by "national" with the least preferred being the imported products. The marginal utility that imported and national cherries provide is negative, which shows a lack of interest for these levels in comparison to the others. This outcome fell within the expected figures, as preference for local products had already been identified in various studies such as those of (Feldmann and Hamm, 2014; Meyerding *et al.*, 2018). Additionally, (Stefani *et al.*, 2012) found that one of the main drivers of preferences and attitudes in consumers towards food is the country of origin.

Also (Aytop and Çankaya, 2022) have found that consumers relate foods with geographical indication (GI) as "healthier", "higher quality", and "more reliable" and that they are willing to pay more for them, thus highlighting the importance of the origin of the food they purchase. Both regional origin and GI food products are often deeply rooted in the cultural identity of a specific area. Consumers may therefore value the authenticity and traditional production methods associated with these products, making them more appealing.

The minus sign before the coefficient of the artificial and natural preservatives reveals a greater preference for cherries without preservatives. This result is coherent with other studies that have proven that consumers are nowadays better informed on the food additives and tend to select natural additives against synthetic products (Devcich *et al.*, 2007; Bearth *et al.*, 2014). However, the lower value of the negative coefficient for natural preservatives – compared to cherries without preservatives – shows a smaller prefer-

Table 8 - Outcomes from the choice model for the global sample.

Level of the attribute	*Estimate*	*Std Error*	*Sig*
Origin [Imported]	-2.1864	0.0579	***
Origin [Spanish]	-0.2521	0.0429	***
Preservatives [Artificial]	-3.3540	0.0574	***
Preservatives [Natural]	-0.5568	0.0470	***
Production [Conventional]	-0.6822	0.0312	***
Price	-0.5263	0.0215	***
No Choice Indicator	-3.3695	0.1488	***

*Significance at: * p < 0.1, ** p < 0.05, *** p < 0.001; n.s.: non-significant.*

ence gap between these two options, which is likely to grow due to the increasing importance given to sustainable development (De Magistris and Gracia, 2016).

However, despite the positive perceptions regarding natural preservatives, these are not translated into actual purchases, which answers to the second question related to possible existing factors that may hinder the acceptance of natural preservatives in fruits.

In terms of the production method, organic production appears to be preferred over conventional production, a trend that has been quite common in various studies (Gil and Soler, 2006; Ureña *et al.*, 2008). And, lastly, as was to be expected, price shows a minus sign, which implies that consumers tend to have a negative attitude towards price increases, a common finding in consumer research studies.

Therefore, in response to the third research, question we can conclude that all the attributes used in the choice experiment influence consumers´ fruit purchasing decisions. Overall, the sample has a stronger preference for sustainable attributes,

3.5. *Preferences by consumer group*

The Choice Experiment, applied to each group of consumers, allowed to discover various patterns of preference for fruit. Table 9 shows outcomes of the Choice Model for each type of consumer.

The three groups show similar behaviours, although the intensity of preference varies. Organic Consumers have a more intense behaviour towards attributes relating to sustainability, for example, lower preference for imported cherries, or a much more intense negative preference for artificial preservatives or conventional production.

A strong preference for products without preservatives was also found in a study carried out

Table 9 - Outcomes of the Choice Experiment for each type of consumer.

	Consumer group according to organic fruit consumption					
	Conventional		*Occasional*		*Organic*	
Term	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error
Origin [Imported]	-1.370***	0.056	-2.063***	0.0644	-2.682***	0.137
Origin [Spanish]	-0.124***	0.046	-0.236***	0.0478	-0.328***	0.102
Preservatives [Artificial]	-2.459***	0.055	-3.311***	0.0634	-3.738***	0.143
Preservatives [Natural]	-0.910***	0.047	-0.658***	0.0521	-0.180***	0.114
Production [Conventional]	-0.037 n.s.	0.033	-0.610***	0.034	-1.108***	0.079
Price	-0.727***	0.023	-0.577***	0.024	-0.313***	0.050
No Choice Indicator	-4.812***	0.156	-3.777***	0.167	-1.630***	0.349

*Significance at: * p < 0.1, ** p < 0.05, *** p < 0.001; n.s.: non-significant.*

by (Gil *et al.*, 2000), where all the consumer groups, both organic and conventional, preferred and were willing to pay more for food without preservatives.

On the other hand, Conventional Consumers do not differentiate between organic and conventional production and they are the most price-sensitive segment, which makes sense, given that conventional products are usually offered at lower prices. These outcomes are in line with those of other research projects such as that of (Mesías *et al.*, 2011; Sama *et al.*, 2018), where the consumers that were most price-sensitive were also less inclined to choose organic production.

3.6. *Willingness to pay*

When price is included in a research study on stated preferences, it is possible to estimate consumer willingness to pay (WTP) per attribute level. Given that a preference level has been established, WTP must be understood here as the difference in euros/kg between what the consumer is willing to pay for a kilo of cherries with a specific level in comparison to the reference level. Table 10 reveals the outcomes of WTP for the various levels of the attributes.

Table 10 shows consumer willingness to pay (WTP) estimates for the product under study, the cherry, depending on whether it presents certain levels of the attributes considered. In addition, the results corresponding to the three consumer segments described (conventional food consumers, occasional organic consumers, frequent organic consumers) are presented in different columns.

Thus, and starting with the preference for cherries of regional origin over imported cherries, it can be seen that organic consumers have the highest positive WTP – indicating a greater preference –. This would mean, using the data obtained (+8.58), that if the purchase price were, for example, 4 euros/kg for imported cherries, they would be willing to pay up to 12.58 euros for a basket of cherries of regional origin.

This gap in WTP is significantly reduced in all groups – including the eco-consumer segment – when regional vs. Spanish cherries (thus produced at a greater distance but in other Spanish regions) are compared. The estimated data would indicate that, if a basket of cherries of regional origin cost, for example, only 0.17 euros/kg more than one of Spanish origin, it would lead to the group of "conventional consumers" being indifferent to the purchase of both product options.

Similarly, in the comparison of cherries with "artificial preservatives" vs. "no preservatives", the former is the option with the lowest preference in all consumer segments, although it is again the group of organic regular consumers where this WTP for food without preservatives is highest. Perhaps not as expected is the result achieved in the comparison of cherries with "natural preservatives" vs. "without preservatives", where, although the latter option is again preferred, the group of organic consumers has the lowest willingness to pay and is therefore the most willing to purchase the fruit with natural preservatives.

Finally, there is a higher positive WTP for organic cherries – compared to conventional ones – in both segments of organic consumers (either

Table 10 - WTP (€/kg) for the various levels of the attributes included in this study.

		Consumer groups according to organic fruit consumption			
		Conventional	*Occasional*	*Organic*	*Total*
Origin	Regional vs Imported	+1.89	+3.58	+8.58	+4.15
	Regional vs Spanish	+0.17	+0.41	+1.05	+0.48
Preservatives	Without Preservatives vs Artificial	+3.38	+5.74	+11.95	+6.37
	Without Preservatives vs Natural	+1.25	+1.14	+0.58	+1.06
Production	Organic vs Conventional	n.s.	+1.06	+3.54	+1.30

n.s.: non-significant.

occasional or frequent), whereas conventional consumers are indifferent to organic production.

Although some research studies have found that consumer behaviour is not consistent with their opinions, especially in terms of social, ethical or environmental attributes (Vermeir and Verbeke, 2006), this research study has found the segment that is most willing to pay is Organic Consumers, who showed much more sustainable consumption attitudes and habits. Besides, the highest willingness to pay is related to a reduction in chemical preservatives, which derives from the perception of the consumer that avoiding these products prevents health issues (Grolleau *et al.*, 2009).

4. Conclusions

This research study is set within the current context of increased fruit consumption, which generates enormous ethical, social and environmental issues due to the spoilage these products suffer along the food chain. This issue, which food industry has traditionally attempted to solve with the use of artificial chemical preservatives, clashes with an increasing consumer demand for more natural and healthier food with no negative effects on health, such as those attributed to chemical additives used in modern diets.

In this sense, the use of natural preservatives could prove to satisfy the needs of both stakeholders. Nevertheless, and even though consumers in this study have revealed a very positive behaviour towards natural preservatives, a weaker preference has been seen in comparison to fruits without preservatives.

This result suggests that, in general, citizens in developed societies want to ensure the maximum shelf life for the food they consume, an issue linked to current shopping and living habits. But it also shows that, although many consumers express a preference for the use of natural preservatives, they do not seem to be willing to pay the price premium that would result from replacing current chemical preservatives with more natural or harmless preservatives. All this shows the importance of consumer education and information, which could increase awareness and preference towards food without chemical additives, even if this would mean a shorter shelf life of fresh produce.

Frequent consumers of organic food would be the group with the greatest potential for developing the use of natural preservatives, since although it has been observed that this is the segment that most prefers local foods, it is also the one that is most willing to pay for the replacement of artificial preservatives by others that are more environmentally and health friendly.

Hence, any actions purporting to promote awareness of natural preservatives, both in terms of their characteristics and recognition at the time of shopping, can have a heavy impact on their acceptance and a positive influence on WTP the necessary price for these quality food products. Price continues to be the transcendent variable affecting consumer decision to purchase, and therefore the industry must always take into account the limitation of prices in order to avoid overpricing.

In spite of this, the consumer positive attitudes and perceptions towards the more sustainable attributes and their willingness to pay for them generally show once again the increasing concern and participation of consumers in sustainability.

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Structure and dynamics of date export sector in Algeria, 2000-2018: A quantitative study

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Abstract

This study conducts a quantitative analysis of the date export sector in Algeria over a 19-year period, spanning from 2000 to 2018, utilizing data sourced from different official organizations. The study explores the structure and dynamics of date exports, through export propensities and further employs the gravity model as an econometric tool in order to identify key determinants influencing trade patterns. The main findings of this study are twofold. Firstly, it reveals a pronounced and positive growth trajectory in the propensity to export Algerian dates over the past decade, highlighting a promising upward trend in the sector's development. Secondly, the study establishes a significant correlation between the observed date export patterns and the predictions of the gravity model, further affirming the model's relevance in explaining the dynamics of the date export sector. The findings offer evidence for policymakers and stakeholders seeking to enhance Algeria's position in the global date market and facilitate sustainable growth in the export sector.

Keywords*: Date exports, Propensity to export, Gravity model, Quantitative analysis, Algeria.*

1. Introduction

The palm date sector in Algeria stands as a significant pillar of the nation's agricultural and economic landscape. With a rich history and cultural heritage deeply intertwined with date cultivation, Algeria has emerged as one of the leading producers and exporters of premium dates worldwide (Bouguedoura *et al*., 2015; Amor *et al*., 2015; El-Juhany, 2010). According to the FAO statistics 2023, Algeria's production of palm dates in 2021 is 1.18 million tons, which ranks the country fourth globally among producers. This quantity represents approximately 12% of the total global date production. Despite favorable date production and yields, Algerian date exports are indeed inversely proportional to production. Algerian exports account for only about 5% of the total date production, while the exports are about 68.8 thousand tons and it is currently ranked as the seventh largest exporter of dates in the world, behind countries such as Saudi Arabia, Iran, Egypt, and Tunisia.

More particularly, the palm date industry plays a crucial role in contributing to the country's trade balance, providing employment opportunities, and fostering socio-economic development, particularly in the arid regions of the country. Over the past two decades, from 2000 to 2018, the palm

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date sector has undergone notable transformations and witnessed remarkable growth. Despite its significance, the industry also faces a myriad of constraints that pose challenges to its full potential realization (Cheriet & Benziouche, 2012).

The palm date sector is not only crucial for its economic contributions but also for its socio-cultural importance in Algeria. It serves as a central pivot around which the life in the arid Saharan regions revolves (Mokdad, 2002; Benmehaia & Benmehaia, 2018; Benmehaia, 2019; Mokdad *et al*., 2020, 2019). Palm date cultivation is deeply ingrained in the traditions and livelihoods of the local communities, playing an essential role in sustaining their way of life and preserving their cultural heritage. In terms of economic impact, the palm date industry has proven to be a major player in Algeria's export market. With over 17 million palm trees and more than 800 date varieties, Algeria occupies a prominent position among the world's date-producing and exporting countries (Benziouche & Chehat, 2019). The premium *Deglet Nour* variety, known for its exceptional taste and quality, accounts for a relatively substantial portion of the country's date exports (Ben Mya *et al*., 2017; Benmehaia, 2019). Furthermore, the revenue generated from date exports makes it one of the primary agricultural products exported by Algeria. The share of date exports in Algeria typically ranges between 5% and 15% of agricultural exports. In 2018, date exports ranked second after the sugar and confectionery group (Abdelmalek, 2022).

Despite the efforts made by the public authorities to promote date exports, the sector is not exempt from challenges and constraints. Despite its potential, it faces technical and economic obstacles that hinder its exploitation. One of the major challenges is the prevalence of informality in many activities along the date value chain, particularly among date collectors. These collectors largely operate in the informal sector, and their numbers are estimated to be between 2500 and 5000 (PASA, 2020). Additionally, exports through border routes evade governmental oversight, contributing to a lack of product traceability, a crucial requirement for exports. Additionally, Water scarcity remains a significant concern, affecting production and imposing restrictions on the sector's growth (Cheriet & Benziouche, 2012, for details on these aspects).

This study sets out to comprehensively explore the structure and dynamics of Algeria's date export sector, relying on data sourced from various official organizations covering the extensive time frame of 2000 to 2018. The primary objective is to identify and analyze the key determinants that exert influence over trade patterns, unraveling the factors that drive Algeria's date export performance. In pursuit of this goal, the study harnesses the gravity model, a widely recognized and well-established econometric tool commonly employed in international trade analysis[1]. The gravity model has demonstrated its effectiveness in understanding the impact of crucial factors, including distance, cultural similarities, partner country GDP per capita, and the distance between trading partners, on the volume and direction of trade flows. Results by studies of Matallah *et al*. (2021) and Matallah & Benmehaia, (2019) for the Algerian case corroborated the gravity model approach. Several research works have utilized the gravity model to explain and analyze the determinants of exports and foreign trade in the agricultural sector (Hatab *et al*., 2010; Natale *et al*., 2015; Jagdambe & Kannan, 2020).

2. Research Methodology

In this study, a gravity model of exports is presented using as a dependent variable the exports of dates from Algeria (all varieties combined) to the world. The data used is a balanced panel that covers all importing countries (70 cross-sectional units) and for the period from 2000 to 2018 (19 years).

Dates export data was obtained from the National Center for Information and Statistics (CNIS, 2020) database in quantity and value (constant 2010 USD). The Gross Domestic Product per capita (GDP) variables between

[1] See Arfaoui *et al*. (2022) for other approaches applied to the olive exports sector in the Tunisian case.

2000-2018 are obtained from World Bank reports (2018). The distance between the importing country and Algeria comes from the official website[2] of distance between cities and places.

To put it as simply as possible, the formulation of the gravity model in economics can be generalized from Newton's law of gravity in terms of trade between countries as follows: trade between the two countries is determined positively by the size of each country and negatively by the distance which separates them. It follows the basic formula (Anderson, 1979; Harris & Mátyás, 1998; Eaton & Kortum, 2002; Anderson & van Wincoop, 2003; Head & Mayer, 2014):

$$X_{ijt} = g \cdot Y_i^{\alpha} \cdot Y_j^{\beta} \cdot D_{ij}^{\delta}$$

where X_{ijt} is the flow of date exports to country j from country i, Y_i and Y_j are the sizes of country i and country j, D_{ij} is the geographical distance between the countries, g is the gravity constant, and α, β, δ are parameters to be estimated.

The gravity model of trade states that the volume of exports between pairs of countries, X_{ij} is a function of their sizes (in terms of income), and their distance (as a proxy for transport costs). Nevertheless, the augmented version of the gravity model implies that additional variables could be added to improve the basic formulation of the selected gravity equation (Martínez-Zarzoso & Nowak-Lehmann, 2003; Nawrot, 2023). However, a set of variables could be included that could facilitate or restrict trade between them or relevant to the country's bilateral trade.

In order to construct appropriate explanatory variables in our model, we use country GDP (Y) as a measure of country size. For the spatial dimension, we use the distance (D) between countries (in kilometers). We also add a set of dummy variables (Z) to reflect factors that influence trade: first, the existence of a common border as commonly measured by a dummy variable. Second, a dummy variable for a common culture. In the empirical literature, this is frequently captured by the use of the same language only. In our case, unlike previous studies, we measure the common culture by a binary dummy variable referring to the same official language or the same majority religion insofar as they both represent essential components of the culture of the nations. Using a multiplicative error term, the simple empirical expression of the augmented gravity model is:

$$X_{ijt} = g \cdot Y_{it}^{\alpha} \cdot Y_{jt}^{\beta} \cdot D_{ij}^{\delta} \cdot Z_{ij}^{\omega} \cdot e^{\mu_1+\mu_2+\varepsilon}$$

The modeling of Algerian date export flows will be based on the log-linear form of this equation. In our estimation, we used a balanced panel regression, where the time effect (μ_1) and the individual effect (μ_2) are included in the regressions. From the structure of the data and preliminary estimations, it was suggested that panel regression with fixed effects is the appropriate model for our study (through the Hausman test).

In order to gauge the flow intensities, this study uses propensities coefficients. The propensities are obtained from panel regression between exports and an index of cross-sectional units (i.e. importing countries). Thus, the estimates of the coefficients for each country represent the propensity to export from Algeria to this country over 19 years. Moreover, another panel regression is performed on a time trend to extract the coefficients of the overall propensity of the dates sector of the country.

3 Results and Discussion

In this section, we will undertake the empirical verification of the hypotheses by processing the data at hand. Our analysis will encompass data counting, presentation, and thorough examination. Furthermore, we will apply the specified econometric model to extract some insights from the collected data.

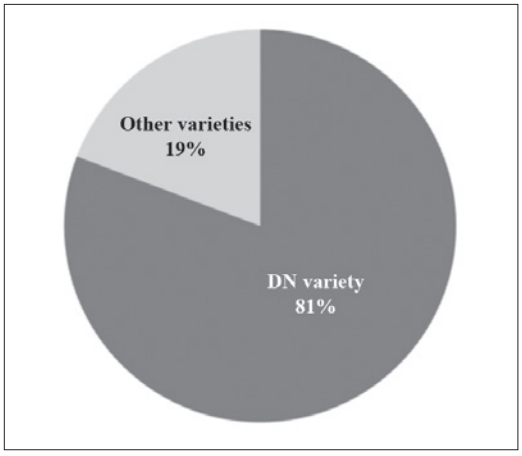
3.1. *Overview of the Algerian Date Sector*

Figure 1 provides a comprehensive overview of the structure of Algerian date exports in the year 2018. Notably, the data highlights the prominent role of the *Deglet Nour* variety, often referred to as the "fine date" or "noble date",

[2] From www.distancefromto.net.

which dominates the export market, accounting for a substantial 81% of the total Algerian date exports. The *Deglet Nour* variety's widespread representation underscores its exceptional popularity and desirability among consumers both domestically and internationally. Often hailed as the "queen of dates", *Deglet Nour* is renowned for its luscious sweetness, juicy texture, and unique translucency. These exceptional attributes have propelled it to the forefront of the date industry, making it the most sought-after and preferred date variety in the global market. The global reputation of *Deglet Nour* as a premium date variety has significantly contributed to its extensive demand, both locally and worldwide. Its unique combination of delightful flavors and appealing appearance has solidified its position as the epitome of high-quality dates. Consequently, *Deglet Nour* enjoys robust demand in various industries, including the confectionery, bakery, and health food sectors, further driving its status as the preferred date choice among consumers. While *Deglet Nour* enjoys unparalleled popularity, it is important to recognize that other date varieties, such as *Ghars*, *Mech Degla*, *Tafezouine*, and *Degla Beida*, collectively constitute around 19% of the total Algerian date exports in 2018. These varieties possess distinct characteristics, offering diverse taste profiles and nutritional benefits. However, the exceptional fame and appeal of *Deglet Nour* have inevitably overshadowed the recognition of these other varieties, leading them to occupy a relatively weaker position in the market particularly in Europe. However, it is worth noting that the other varieties find their appreciation among consumers in African countries.

Figure 1 - Structure of exported quantity of dates in 2018.



Source: Established by authors based on CNIS (2020) database.

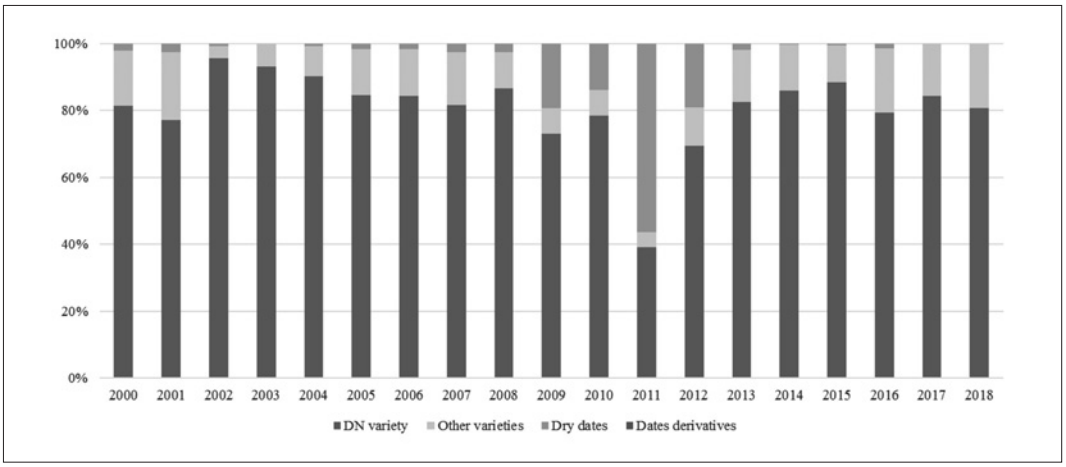
Despite the comparatively lower market share, it is worth noting that the production of these alternative date varieties has evolved in recent years. Algerian date producers have recognized the importance of diversifying their offerings to cater to varying consumer preferences and demands. As a result, efforts have been made to enhance the cultivation and production of these varieties, positioning them as valuable options for consumers seeking novel and unique date experiences.

Figure 2 provides a dynamic representation of the changes in the structure of Algerian date exports over the period from 2000 to 2018, expressed in percentage values. The data highlights the evolving trends in the export quantities of different date categories during this timeframe. Throughout the years, the *Deglet Nour* variety has consistently held the majority share in the evolution of Algerian date exports. This continued dominance reaffirms the significance of the *Deglet Nour* variety in the Algerian date export industry. Its enduring popularity and exceptional demand have sustained its prominent position as the primary contributor to Algeria's date export volumes. This can also be explained by the structure of date production and by variety, which reveals that the *Deglet Nour* variety accounts for 54% of the total production (MADR, 2018)

However, an interesting shift in the export landscape is observed during the years 2009, 2010, 2011, and 2012. During this period, the export of dry dates experienced a considerable surge, occupying a notable share of the total Algerian date exports. The substantial increase in the export of dry dates during these specific years indicates a growing global demand for this category of dates. The export of dry dates presents an opportunity for Algerian date producers to capitalize on the diverse applications of these products, such as in the confectionery, baking, and snacking industries.

Moreover, it is crucial to highlight that during 2017 and 2018, the export of processed date products began to emerge. While still negligible

Figure 2 - The dynamics of the exported quantity of dates in percentages.



Source: Established by authors based on CNIS (2020) database.

compared to other date categories, this development indicates a potential avenue for growth and value addition in the Algerian date export market. The emergence of processed date products signifies a strategic move by Algerian exporters to enhance the value and market appeal of their date offerings. By investing in processing technologies and diversifying their product range (date honey, date syrup, date paste…) Algeria can tap into new markets and cater to the preferences of consumers seeking convenience and innovation in date products. The dynamic changes observed in Figure 2 reflect the adaptability and responsiveness of the Algerian date export sector to changing global market trends. The ability to respond to shifts in consumer demand and preferences positions Algeria as a competitive player in international date trade. The continuous evolution of export trends, especially the increasing focus on dry dates and the emergence of processed date products, showcases the industry's capacity for innovation and growth.

Figure 3 provides some insights into the distribution of Algerian date exports among the top 10 importing partners from 2000 to 2018, presented in terms of cumulative quantities. The data reveals that Algerian dates enjoy a broad international market presence, with exports reaching several countries worldwide. Among the top importing partners, France stands out as the dominant recipient, monopolizing a substantial share of 50.36% of the total Algerian date exports during the specified period. This strong trade relationship between Algeria and France is a testament to the historical ties and well-established commercial relations between the two nations. Additionally, the presence of a significant Algerian diaspora in France further contributes to the robust demand for Algerian dates in the country. The combination of these factors has positioned France as the leading European destination for Algerian date exports. Following France, Russia holds the second-largest share with 8.27% of the total Algerian date exports. Niger and the United Arab Emirates (UAE) also command significant shares at 6.87% and 4.94%, respectively. These countries' interest in Algerian dates demonstrates the global appeal of Algerian date products and their ability to cater to diverse consumer preferences. Other notable importers include Morocco, the United States, and Spain, each accounting for shares between 3.92% to 3.38%. These figures indicate the demand for Algerian dates in various regions, including North America, Europe, and the Middle East.

Furthermore, Canada, Germany, and Belgium are also importers, with shares ranging from 2.82% to 2.09%. Their inclusion in the top 10 importing partners further underscores the broad international reach of Algerian date exports and reflects the country's successful efforts in diversifying its export destinations.

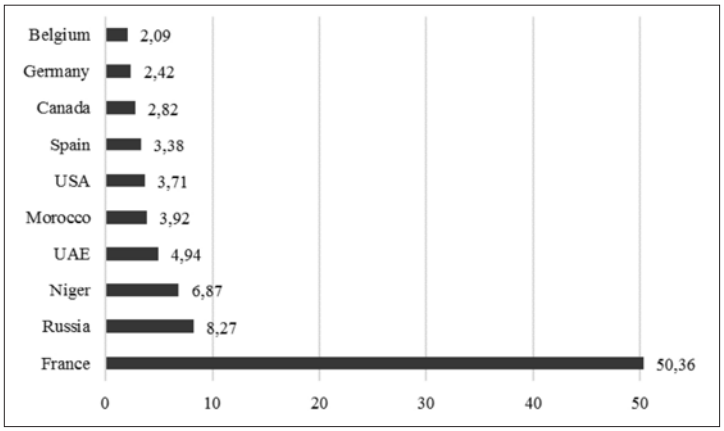


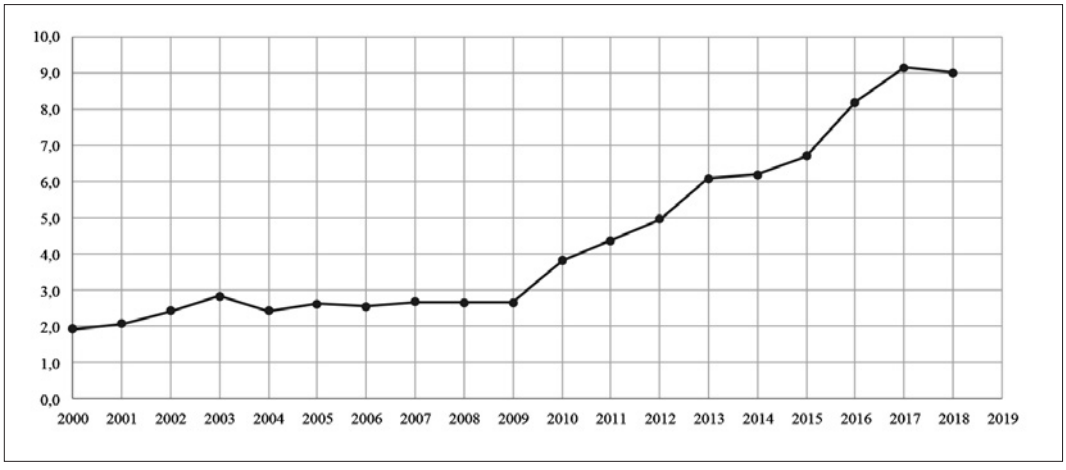
Figure 3 - The shares of 10 first partners in terms of cumulated quantities 2000-2018.

Source: Established by authors based on CNIS (2020) database.

3.2. *The Propensity of Export Dates in Algeria*

Figure 4 provides a compelling visual representation of the evolution of the propensity to export dates in Algeria over the period from 2000 to 2018. This unique analysis aims to confirm the presence of an upward trend in Algerian date exports, not solely in terms of absolute export values but in relation to the propensity to export over time. To validate this trend, a thorough panel regression analysis was conducted, revealing statistically significant estimated coefficients (with a statistical significance level of 1%). The presence of statistically significant coefficients strengthens the credibility of the findings and affirms the robustness of the analysis. The positive slope observed in the evolution of the propensity to export dates underscores the fact that Algeria's date export sector has experienced substantial growth over the years. This upward trajectory signifies an increasing interest in date exports and reflects the country's ability to leverage its agricultural expertise and product quality to cater to international demand. Moreover, the pronounced expansion of the attractiveness of the date export sector since 2010 is a notable highlight. The date industry's expanding allure suggests that Algeria has successfully captured the attention of international markets, positioning itself as a formidable player in the global date trade.

Figure 4 - Evolution of the export propensity of dates in Algeria.



Source: Established by authors based on CNIS (2020) database.

Table 1 - Top 20 partners in terms of dates export propensity 2000-2018.

Country	*Export Propensity Coefficient*	*Country*	*Export Propensity Coefficient*
France	16.039	Turkey	9.303
Morocco	13.132	Italy	9.121
Canada	13.025	UK	8.674
Spain	12.835	Niger	7.971
Russia	12.562	Germany	7.923
Belgium	12.401	Indonesia	6.763
USA	12.113	Malaysia	6.652
UAE	10.818	Equa Guinea	6.488
Sweden	10.062	Netherlands	6.131
Mauritania	9.375	Switzerland	6.130

Source: Established by authors based on CNIS (2020) database.

The positive evolution of the propensity to export dates also implies a favorable business environment and effective export promotion strategies. These factors play a crucial role in encouraging Algerian date producers and exporters to actively engage with international markets and explore new opportunities.

The analysis of export propensity serves as a valuable indicator of the trading relationships between Algeria and its partner countries. Table 1 presents a comprehensive list of the top 20 partners based on their propensity to export Algerian dates from 2000 to 2018. At the forefront of this group is France, displaying the highest propensity, signifying a strong and enduring trade partnership between the two nations. Following closely are Morocco, Canada, Spain, and Russia, further underscoring their significant roles as key partners in the export of Algerian dates. Additionally, Belgium, the United States, the UAE, Sweden, and Mauritania hold the second position in terms of their propensity to export Algerian dates. This indicates the importance of these countries as valuable trade partners, contributing substantially to Algeria's date export activity.

Moreover, the table reveals Algeria's trade engagement in exporting dates with other European countries, including Turkey, Italy, the United Kingdom, Germany, the Netherlands, and Switzerland. This diversification of export partners in Europe showcases Algeria's efforts to tap into various markets and broaden its export reach across the continent. The presence of export trade flow with Asian countries, such as Indonesia and Malaysia, further highlights Algeria's global outlook in date exports. This expansion into Asian markets signifies the country's willingness to explore new opportunities and cater to the preferences of consumers in these regions.

In terms of trade with African countries, the export propensity of the top 20 partner countries indicates relatively low trade ties with nations like Morocco, Niger, Mauritania, and Equatorial Guinea. The "neighborhood factor" is evident here, as countries close to Algeria benefit from the efficient export trade flow of Algerian dates. Furthermore, the trade relationships with these countries exemplify how geographic proximity plays a role in fostering trade collaborations. The convenience of logistics and reduced transportation costs in neighboring countries facilitate robust trading partnerships in the region.

3.3. Determinants of Dates Exports through Gravity Model

Table 2 presents the regression results for the augmented gravity model, which goes beyond the basic gravity model to incorporate additional factors that influence trade between countries. In this augmented version, crucial elements like

the common border factor and common culture are taken into account to provide a more comprehensive understanding of trade dynamics. The significance of all variables at the 1% level indicates that the augmented gravity model is highly robust and reliable in explaining the trade patterns of Algerian dates. The high level of significance strengthens the model's credibility, affirming that the factors considered have a substantive impact on the trade of Algerian dates with partner countries.

The coefficient of the Common Border variable (*FRONT*) is positive and statistically significant (*t*-ratio of 4.96). This suggests that countries sharing a border with Algeria tend to have higher date exports, supporting the neighboring country effect. The positive coefficient indicates that geographic proximity plays a crucial role in reducing logistics and processing costs, making trade of dates more feasible between neighboring countries.

The coefficient of the Common Culture variable (*CULT*) is also positive and statistically significant (*t*-ratio of 3.07). This implies that countries with shared cultural aspects, such as language and religion, are more likely to engage in higher date exports with Algeria. However, the coefficient value being below 1 (0.780) suggests that while cultural similarities contribute to trade, they have a relatively moderate impact compared to geographic proximity. Nevertheless, this can be explained by the presence of Arab and Muslim diaspora in importers countries (Hadjou *et al*., 2014).

The coefficient of the Algerian GDP per capita (*GDPPC_DZ*) is negative and highly statistically significant (*t*-ratio of -7.21). This negative coefficient indicates that a higher local Algerian date consumption has a detrimental effect on date exports. The larger the domestic consumption of dates, the less surplus is available for export, which could limit the quantity of dates sent to other countries and this is the case, as 95% of our production is consumed locally.

The coefficients of the Partner Country's GDP per capita (*GDPPC_PART*) and Distance (*DIST*) variables are positive and highly statistically significant, with t-ratios of 8.99 and 4.73, respectively. This implies that higher GDP per capita in partner countries positively influences date exports, while increased distance negatively affects trade. Higher GDP indicates greater purchasing power and demand, while distance affects trade by adding transportation costs and logistical complexities.

Table 2 - Regression results for the augmented gravity model applied to panel data of dates exports in Algeria 2000-2018.

	Estimation for export quantity	*Estimation for export value (USD 2010)*
const	220.33 (7.18)	237.83 (7.414)
GDPPC_DZ	−1.416 (−7.21)	−1.528 (−7.44)
GDPPC_PART	0.628 (8.99)	0.695 (9.47)
DIST	−0.883 (−4.73)	−0.981 (−4.99)
FRONT	2.894 (4.96)	3.015 (4.94)
CULT	0.780 (3.07)	0.875 (3.31)
CS unit	0.042 (8.09)	0.045 (8.10)
Time trend	0.835 (13.10)	0.894 (13.41)
Adjusted R-squared	0.346	0.355
F(7, 1322)	101.50***	105.88***

The coefficients of the Cross-sectional unit and Time Trend variables are positive and highly statistically significant, with t-ratios of 8.09 and 13.10, respectively, for the quantity exported, and 8.10 and 13.41, respectively, for the value in USD2010. These positive coefficients indicate a steady increase in both the quantity exported and the value of Algerian dates over time, reflecting the continuous growth and development of the Algerian date export sector.

Overall, the regression results provide important insights into the factors influencing the export of Algerian dates. The positive coefficients of the Common Border and Common Culture variables support the neighboring country effect and highlight the importance of geographic proximity and cultural ties in promoting trade.

The negative coefficient of the Algerian Population variable confirms that high local consumption limits the quantity available for export. The positive coefficients of the Partner Country's GDP per capita and the negative coefficient of Distance highlight the economic factors and transportation costs as significant influences on trade. These findings are corroborated by Matallah *et al*. (2021) and Matallah & Benmehaia (2019), for the exports in the Algerian case. The adjusted R-squared values indicate that the model effectively explains a considerable portion of the variance in date exports, making it a robust analytical tool for studying the dynamics of Algerian date trade over the years.

4. Conclusions

This study aimed to provide a comprehensive analysis of Algeria's date export sector by exploring its structure and employing a gravity model to reveal the determinants of date exports over 19 years (2000-2018). The data utilized in this research consisted of a balanced panel dataset, encompassing all importing countries (70 cross-sectional units), and was sourced from reputable databases such as the National Center for Information and Statistics (CNIS, 2020) for export data and the World Bank reports for Gross Domestic Product per capita variables. The gravity model served as the econometric tool to examine the factors influencing Algeria's date exports to destinations worldwide.

The main findings of this study revealed compelling insights into Algeria's date export sector. Notably, it was observed that there has been a clear upward trend in the propensity to export Algerian dates over the last decade. While France currently holds the largest share of date exports, its export trend has been showing a decline. Moreover, the gravity model provided a robust framework for analyzing trade patterns and demonstrated its usefulness in understanding Algeria's competitive position in the global date market.

Some policy implications for enhancing the date export sector emerge from the study's findings. Overall, policymakers should prioritize targeted initiatives to address the identified structural and institutional constraints faced by date producers. Correspondingly, public support organizations could play a prominent role in enhancing the performance of the dates sector, as Rouached *et al*. (2023) stressed for the Tunisian case. The results also highlight the importance of common borders and cultural ties in promoting the date trade. Thus, it is crucial for policymakers to consider policies to strengthen trade relations with border countries. This could be accomplished by facilitating trade and reducing tariff and non-tariff barriers. By fostering a more fluid and cooperative commercial environment with neighboring countries, Algeria could benefit from an increase in date trade and strengthen its position on the international market, while promoting commercial partnerships in the region, particularly within the framework of the African Continental Free Trade Area (ZLECAF). This approach could include the export of other date varieties outside of *Deglet Nou*r, which are extremely valued by neighboring countries.

Furthermore, given that the distance between Algeria and its trading partners negatively impacts the date trade by increasing transportation costs, it is crucial that policymakers consider investments in transportation infrastructure. These investments could include the development of roads and ports to reduce logistics costs and improve the competitiveness of Algerian date exports. Moreover, policymakers should focus on improving quality standards and certification processes for date exports to meet international market requirements. Additionally, endeavors in establishing and enforcing rigorous quality control measures, including certification for organic and fair-trade practices, can enhance the reputation of Algerian dates in global markets and command premium prices.

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Technical and economic evaluation of the olive oil value chain in the semi-arid zones: The case of the Tiaret region (Western Algeria)

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Abstract

The development of agriculture in the world's arid regions has always faced specific economic and environmental constraints. This study aims to evaluate the performance of the olive oil value chain in the semi-arid zones of Algeria (Tiaret); by carrying out a technical and economic analysis of this sector, in order to establish optimization strategies. The data was gathered through surveys of local olive growers and oleifactors. The results showed that olive growing in semi-arid areas is a profitable and economically efficient activity. Thus, one hectare of olive trees grown in a semi-arid area brings in nearly 7000 €/year to olive growers of the region, with a high economic efficiency coefficient reaching 4.4 in intensive systems. The encountered constraints are mainly localized upstream of the value chain and particularly affect the cultivation techniques used. Indeed, the production costs represent nearly 70% of the total charges. They are mainly affected by the costs of harvesting, phytosanitary treatment, and irrigation, which occupy 25%, 18%, and 16% of direct costs, respectively. Moreover, production costs are directly proportional to the dryness of the growing area. The principal component analysis confirmed the results of the economic study on the data set.

Keywords*: Value chain, Olive oil, Technical and economic analysis, Performance, Semi-arid zone, Algeria.*

1. Introduction

Olive growing is known for its economic, social, and environmental importance in numerous countries around the Mediterranean basin. This traditional growing area accounts for 98% of the world's olive production. Most of this production is intended for the olive oil market, which accounts for almost 3% of all edible oils consumed worldwide (Barjol, 2014). Over the past few years, the demand for olive oil has risen sharply (IOC, 2022), reflecting consumers' growing interest in its highly appreciated organoleptic qualities and approved therapeutic properties. This booming market is attracting interest from a growing number of countries around the world. Thus, Mediterranean countries with an olive vocation have undertaken plans to extend and modernize their olive farms, while other countries outside the native geographical areas have decided to create new farms in countries such as Australia, Argentina, and Chile (de Lat-

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tre-Gasquet, 2012). These initiatives to increase olive production have strengthened olive-growing capacity (mechanization, intensification and labeling) and encouraged the establishment of new plantations, even in conditions unfavorable to olive-growing such as desert and arid lands.

The largest nation in North Africa, Algeria, is renowned for its advantageous Mediterranean environment, which is favorable to the development of agriculture. The country is capable of achieving food self-sufficiency, meeting the needs of the entire population and thus contributing to the promotion of the national economy. The expansion of the olive sector is one of the strategies chosen by the government to diversify its economy, which is heavily dependent on oil earnings. National agricultural development plans have been in place since 2000, intending to improve the productivity and development of arboriculture, particularly the olive growing sector. These efforts have boosted the productivity of olive farms, mainly by modernizing production techniques, intensifying orchards, and extending acreage to the country's arid and semi-arid regions. The latter are generally known for their agropastoral vocation, such as Algeria's steppe regions (Bencherif, 2011). Thus, growth in the national olive orchard increased from 190550 ha in 2002 to almost half a million hectares in 2018, and olive oil production increased from 26.5 to 76.5 thousand tons from 2000 to 2018 (IOC, 2018).

Despite all of these efforts, the Algerian olive sector is still poorly organized, and affected by several upstream constraints, mostly connected to high production costs, but also by downstream constraints associated with low production quality and quantity, and market informality. Furthermore, due to a lack of skilled manpower, cultivation methods unsuited to the country's dry climate, and the introduction of olive growing in areas with a weak olive-growing tradition, the development of olive growing in the country's arid territories has not met the State's expectations. As a result of this circumstance, we ask the following questions: Which geographical areas are best suited for cultivating olives? What is the region's most economically efficient system?

In order to develop long-term improvement strategies for the OVC in semi-arid regions, our work aims to understand the economic situation of olive growing in the semi-arid region of Tiaret (Algeria), with a focus on evaluating the performance of different production systems. To address our objectives and to study the factors limiting the development of the olive oil chain (OVC) in the semi-arid zone of western Algeria as well as the potential for improvement, we have adapted the value chain approach to the case studied and organized our study into four main sections: 1) Chain delimitation; 2) Technical analysis of the OVC according to the delimitation; 3) Economic analysis, which consists firstly in the determination of the production costs of 1kg of olive and olive oil, according to the farms typology, to then study the performance of the olive value chain; 4) Prospects and

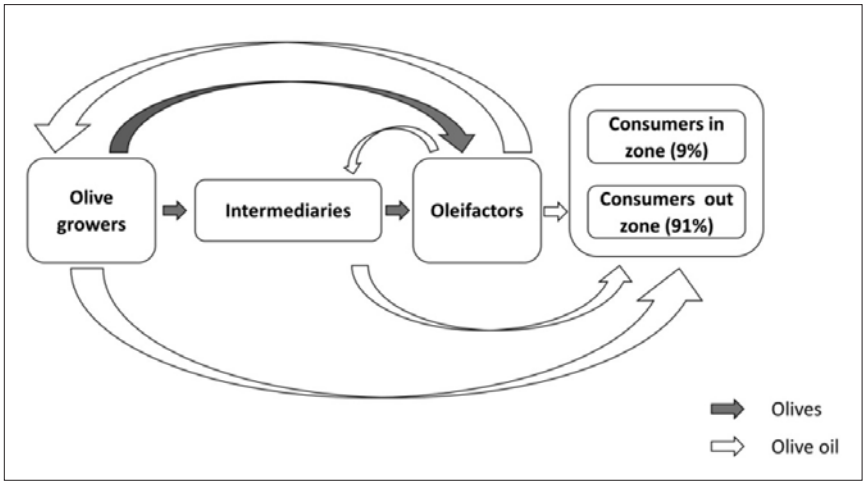


Figure 1 - Olive oil value chain map.

proposed solutions for improvement. The value chain studies the interactions between the different operations and stakeholders required to bring a well-defined product or service to the final user, from the production stage to the consumption, where each link in the chain adds value to the product. (Kinha et *al*., 2009). This approach is considered by several experts to be a relevant research tool for analyzing the agricultural and agri-food sector through a multi-disciplinary study addressing technical, social, economic, organizational, and environmental components (Bencharif et Rastoin, 2007). This approach enables the various stages in the chain to be divided up in a strategic manner that highlights the progression of costs and margins incurred in the creation of a product or service at a given price, thus identifying the exact source of added value throughout the chain and carrying out an accounting analysis to determine the profitability of the system (Arfaoui et *al*. 2022). The olive oil sector of the study area (Tiaret) is characterized by a short production and marketing circuit with a predominance of micro-actors at each stage of the chain. These are mainly private-sector operators, with the main stakeholders being farmers, intermediaries and processors (Figure 1).

2. Overview of the olive sector

Development policies

Algeria is considered to be one of the world's traditional olive-growing regions. The olive crop represents a major part of the country's agricultural development. However, the sector has always tended to be less competitive at regional and international levels. Indeed, since colonial times, the country has struggled to develop olive growing, affected by the marginalization of rural and mountainous land, particularly with the decline of olive-growing areas and the relocation of populations by the settlers (Hadjou et *al.*, 2013). After independence (1962), a number of policies were implemented by the State to provide financial and material support to the population in rural areas, with the main aim of limiting the rural exodus on the one hand and recovering the olive-growing heritage on the other. In the 70s, the country tried to modernize the olive industry by setting up processing units to improve olive oil and table olive production, a challenge taken on by the Algerian National Office for Olive Products (ONAPO). The situation of the Algerian olive grove worsened in the 1990s with the country's economic and political crisis, which led to increased abandonment of olive land and a significant drop in production as a result of the government's disengagement and the reduction of support plans for the sector (Mendil *et al.*, 2009).

It is only from 2000 onwards that Algerian agricultural policies have played a real role in the relaunch of the sector and that olive cultivation has begun to be given serious consideration, through the implementation of the National Plan for Agricultural and Rural Development (PNDAR). This plan aims to finance and support the sector and develop rural areas. Since then, and with the advent in 2010 of the agricultural and rural renewal policy, olive growing has been recognised as a strategic crop capable of ensuring the country's food security. The objective of this policy was to expand and intensify the sector by modernizing the country's olive farms and providing support for inputs and services, with a view to improving the sector's profitability and sustainability (Lamani and Ibert, 2016b). Indeed, these plans led to a considerable increase in the olive cultivation area, reaching almost half a million hectares of land with over 35 million olive trees (ENPARD, 2018). Production has increased significantly over the last decade, reaching almost 8.7 million quintals in the 2019/2020 olive season. Besides, the arid and semi-arid regions of the country have experienced real dynamic growth, reaching 34% of the national olive-growing area, with almost 146 000 ha with 17 million trees in production (DSISP, 2021).

Actual situation of the olive sector and impact of policies

After 60 years of efforts, several support plans and different development policies for the olive sector, Algeria has not succeeded to meet all the expected challenges. In fact, olive production, particularly olive oil, is still insufficient to cover national demand, and even more so for the international market; mainly due to the poor modernization of orchards and the lack of organization in

the sector. The national olive grove is still characterized by a predominance of traditional farms located on generally hilly terrain in the northern regions of the country. Almost 32.7% of the country's olive farms are less than 3 ha in size, mainly due to the fragmentation of land and small-scale investment in the sector. These farms are generally extensive and rain-fed systems; and only 29% of the total olive-growing area is irrigated (ONFAA, 2016). This situation has led to instability in production over the years, which is particularly affected by the alternation phenomenon. In addition, the predominance of small producers, the lack of organization (cooperatives) in the sector, and the absence of a structured distribution circuit have encouraged the emergence of an informal market and unfair competition. Olive oil is marketed through traditional channels where the relationship between distributors and consumers is based on trust and preference (taste) rather than quality. This situation has encouraged the maintenance of agricultural practices that favor the production of olive oil of mediocre quality, even though the government has made a number of efforts to improve it. Moreover, per capita consumption of olive oil has tripled over the last three decades to reach 2.4 kg/year, so despite the increase in production, the entire quantity is often self-consumed (Lamani and Ibert, 2016a; FranceAgrimer, 2020); and the shortfall is generally offset by imports of seed oils. As a result, Algerian olive oil exports are almost non-existent on the international scene. The rare quantities exported in recent years have come from private, vertically integrated companies that control all procedures from production to marketing. Nearly 78% of olive oil exports are destined for Algerian immigrants in certain countries, notably France (70 tonnes) and Canada (35 tonnes), attracted by nostalgic rather than qualitative reasons (ONFAA, 2018).

3. Methodology

3.1. *Study area*

The study was conducted in the semi-arid region of western Algeria (Tiaret), which has a total agricultural area of 1.6 million hectares. It is known for its heterogeneous relief (Figure 2), characterized by a mountainous zone in the north, high plains in the center (dominated by

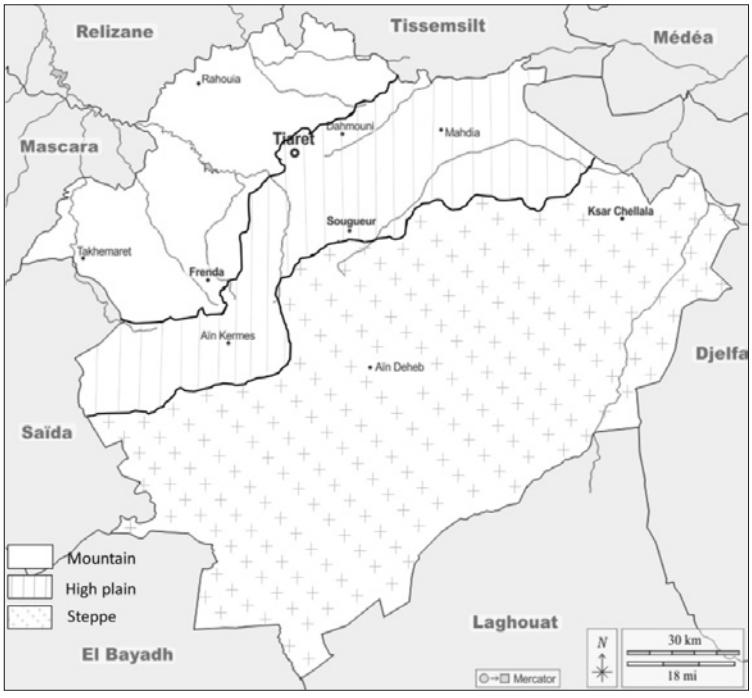


Figure 2 - Geographical location of the Tiaret region and the relief-based boundaries of the study areas.

Source: https://d-maps.com/pays.php.

Table 1 - Geo-climatic data for the Tiaret region.

Region	*Agricultural area*	*Olive acreage*	*Average temperature*	*Average precipitation*	*Average altitude*	*Geographical position*	*Climate*
Tiaret	1.6 m. ha	4596 ha	15.15°C	370 mm	1150 m	35°23'16" N 1°19'22" E	Semi-arid

cereal crops), and a steppe zone in the south with an agro-pastoral vocation (Bencherif, 2011). Olive-growing accounts for almost 35% of the region's tree-cultivation area. Tiaret is known for its semi-arid climate marked by harsh winters and hot summers, with an annual temperature of 15°C. The region is known for its low rainfall, especially in summer, with averages not exceeding 400 mm/year (Achir, 2016). The geo-climatic information has been described in Table 1.

The Tiaret region has benefited from several plans to support the expansion of olive-growing potential in the country's arid and semi-arid zones, notably through the National Agricultural Development Plan (PNDA), which was introduced in 2001. Olive production increased by 25-fold between 2000 and 2019, according to data from the Tiaret region's Directorate of Agricultural Services (DAS) in 2020.

3.2. *Sample*

Surveys were conducted over two successive years (2019 and 2020) among olive growers and oil producers in the study region via face-to-face interviews, and using a detailed questionnaire as a working tool, oriented to meet the research objectives. Data required for our study was also collected in collaboration with the Directorate of Agricultural Services and the agricultural subdivisions (ASD) of the Tiaret region. The DAS provided general data on olive-growing, including information about the surface occupied by olive trees, the number of trees cultivated, and the total production of olives and olive oil in each municipality. The selection of farms is based on a list provided by the DAS of all olive growers in the region, their location, and contact details. This list enabled us to select the farms to be surveyed, which are distributed in such a way as to cover the different climatic conditions and production systems. We also targeted for this study only farms in production, as they are the most supervised due to the fact that they apply the most suitable technical package (Ben Abdallah *et al.*, 2014). The various subdivisions of each municipality provided us with field agents who accompanied and guided us throughout the visits to olive growers and oil producers.

3.3. *Surveys*

Localized surveys are considered to be one of the most relevant and frequently used methods of gathering real data from the various players in the sector. They allow a sample to be better targeted and the results obtained to be easily extrapolated to the entire population in order to address a major objective. The data obtained from the questionnaire survey can be easily processed and enables performance indicators to be assessed more accurately (FAO, 2016). They also help to give a clearer picture of the sector as a whole and make it easier to compare results between production systems and areas on a regional or international scale. Based on the literature and the DAS's information on the Tiaret region, a questionnaire was drawn up and structured to collect as much data as possible. The questionnaire includes direct and indirect questions relating to the three main phases of the value chain (production, processing, and marketing) to provide in-depth quantitative and qualitative data. The questionnaire provides information on the structure and productivity of the farms (surface area, density, variety and yield), the technical itinerary (soil management, phytosanitary treatment, fertilization, weed control, irrigation, harvesting and pruning) and the production costs generated (inputs, manpower, transport and depreciation costs). The second section includes questions related to the process (type of oil mill, olive crushing capacity, olive supply, oil yields, and storage time and conditioning). The last section covers questions about marketing (type of circuit, crushing price, product promotion,

distribution and selling price) and the nature of relationships between the suppliers, the intermediaries, and the manufacturers.

Once the questionnaire had been established, preliminary surveys were carried out in the field before the in-depth surveys were initiated. The aim of this step was to test the questionnaire to avoid any redundancies or inconsistencies and to adapt it to actual field conditions. This test helped to make the questionnaire clearer and more relevant. The data formulated by the interviewed stakeholders was coded and entered to create a database in an Excel workbook. This latter was organized into two distinct sections: technical and economic, then processed and analyzed to meet the study objectives.

3.4. *Farms typology*

Establishing a typology means organizing farms into homogeneous groups, where each class is characterized by a major classification criterion that meets the objectives of the study, and each homogeneous group must be heterogeneous in relation to another (Gibon, 1999). According to Perrot (1990), the typological model chosen makes it possible to establish an effective system for studying farm performance, making a relevant diagnosis, and formulating appropriate solutions. For this reason, we developed a typology for the farms surveyed, partly following the method described by the International Olive Council (IOC, 2015), which allowed us to organize the farms surveyed into nine classes according to density (extensive, semi-intensive, and intensive) and relief (mountain, high plain, and steppe) (Table 2).

3.5. *Evaluation of production costs and olive value chain performance*

The estimation of production costs is an essential element for studying the situation of the olive chain upstream and downstream. To determine the production costs of one Kilogram of olive and olive oil, we partly adopted the method proposed by the International Olive Council (IOC, 2015), described in the international study on olive oil production costs. Production costs are converted into euros according to the exchange rate at the national bank (1 Euro = 132.93 Da, in 2019). The method proposed by the IOC is the most appropriate for determining production costs specific to the olive-growing sector in the traditional growing areas of Mediterranean countries. This sector is characterized by the predominance of a small-scale value chain, generally managed by the farmers. However, this method has certain weaknesses as it is limited to the expert estimations in the field. Thus, the validity of the data may be affected by the subjectivity of the responses resulting from a lack of representativeness and/or insufficient information. To overcome these limitations and obtain real data on the olive growing chain, the various production costs were determined by direct interview with the players in the sector, over two successive years, with the aim of limiting the variation in yields linked to the alternation phe-

Table 2 - Farms typology.

Classes	*Farm characteristics*
Class 1	Mountain farms. Extensive system
Class 2	Mountain farms. Semi-intensive system
Class 3	Mountain farms. Intensive system
Class 4	Farms located on high plains. Extensive system
Class 5	Farms located on high plains. Semi-intensive system
Class 6	Farms located in the high plains. Intensive system
Class 7	Farms located in the steppe. Extensive system
Class 8	Farms located in the steppe. Semi-intensive system
Class 9	Farms located in the steppe. Intensive system

nomenon. To calculate the cost of producing one kilogram of olive oil, it is first necessary to determine the direct costs (labor and inputs for the various cultivation operations) and the indirect costs linked to energy (fuel and electricity) and management costs. Total operating costs are the sum of direct and indirect costs. To calculate the total cost of one kilogram of olive, the total operating cost is added to depreciation cost. The latter corresponds to the expenses required to maintain the equipment over their lifetime. On this point, and in contrast to the IOC method, land rental costs are not taken into consideration, since all the surveyed farms are free of land charges. Finally, the production cost of one kilogram of olive oil was obtained by the production cost, summing transport costs, and processing prices (corresponding to the average price of crushing one kilogram of olive oil in the region's private oil mills).

The determination of production costs is complemented by an analysis of performance, which has enabled us to have a better view on the efficiency, productivity and profitability of the different production systems and zones, and in particular to report them as quantitative data. Our approach adopted to evaluate economic indicators is based in part on those defined by Mushagalusa and Kesonga (2019), and Gharbi and El Fahem (2004). Various parameters were chosen to assess the performance of the olive industry in semi-arid zones, including:

- Gross product (GP): calculated by multiplying the production volume by the production unit price.
- Gross value added (GVA): obtained by subtracting the value of intermediate consumption (IC) from the gross product. IC corresponds to total costs minus the costs of the labor force working throughout the value chain.
- Break-even point (BE): the ratio of the sum of all production costs per hectare to the selling price of a quintal of product.
- Productive efficiency (PE): the ratio of value added to agricultural production.
- Economic efficiency coefficient (EEC): calculated by dividing gross income by total expenses.
- Profit ratio (PR): obtained by dividing Gross product by Gross value added.

Table 3 - Olive orchard characteristics in the semi-arid region of Tiaret.

	Farm distribution	
Olive-growing area	≤1ha	72.60%
	]1-5ha]	25.77%
	]5-11ha]	1.34%
	> 11ha	0.29%
Varieties	Chemlal	53.42%
	Sigoise	46.31%
	Others	0.27%
Density	Extensive	20.32%
	Semi-intensive	76.76%
	Intensive	2.68%
	hyper intensive	0.24%

Source: Survey, 2019/2020.

3.6. *Statistical analysis*

Data processing was carried out using Minitab statistical software (Minitab Software 2019, USA). Principal component analysis (PCA) was applied to the survey data to determine the most important components influencing (positively or negatively) the performance of the olive sector in semi-arid zones.

4. Data finding

4.1. *Olive orchards characteristics in the Tiaret region*

The survey results (Table 3) show that the most adopted planting systems by local farmers are semi-intensive and extensive, with values of 76.76% and 20.32%, respectively. The olive growing in Mediterranean regions is characterized by the dominance of traditional planting systems (Barjol, 2014). Moreover, the results of the survey by zone (Table 4) show that the most common planting system is semi-intensive, either in the mountains (82.93%), the high plains (68.04%) or the steppe (69.10%). On the other hand, mountainous and steppe areas are characterized by low orchard intensification, with values of 1.09% and 3.32%, respectively. The hilly terrain and the land fragmentation in mountain

Table 4 - Olive orchard characteristics by planting zone.

		Mountain	*High plain*	*Steppe*
Planting systems	*Intensive*	1.09%	22.68%	3.32%
	Semi-intensive	82.93%	68.04%	69.10%
	Extensive	15.99%	9.28%	27.57%
Varieties	*Chemlal*	58.87%	55.61%	25.12%
	Sigoise	41.13%	44.39%	74.88%
Areas	*≤1ha*	81.84%	60.67%	69.93%
	]1-5ha]	17.35%	37.83%	22.88%
	> 5ha	0.82%	1.50%	7.19%

Source: Survey, 2019/2020.

areas are a real obstacle to the modernization and intensification of olive groves.

In addition, the most widely grown olive varieties in Tiaret are *Chemlal* and *Sigoise*, with a predominance of the autochthonous *Chemlal* variety. Olives of this dominant variety are used exclusively for olive oil production. In contrast, foreign varieties such as *Arbequina* (adapted to the hyper-intensive system) represent a planting rate of less than 0.27%. This recorded value may explain the low development of the hyper-intensive system in the region (Table 3). The results show that *Chemlal* (the most widely planted cultivar in Algeria) is the main variety in the mountains and the high plains, with percentages of 58.87% and 55.61% respectively. By contrast, the most widespread variety in the steppe is *Sigoise*, with a percentage of 74.88%. The planting of the *Sigoise* variety in steppe regions is probably due to its exceptional adaptation to dry, arid climates of these regions. Indeed, the varietal guide of the Technical Institute of Fruit Arboriculture and Vine (ITAFV, 2017) mentioned that this is one of the most drought-resistant cultivars. In addition, data collected on the olive orchard area show that the semi-arid region of Tiaret is characterized by small farms of less than one hectare (Table 3). This is probably due to the limited investments in olive growing. These small farms are mainly concentrated in the mountainous area of the region, with a percentage of 81.84% (Table 4).

4.2. *Technical analysis of the olive oil value chain*

The results of this survey relate to the technical conditions of olive oil production in arid zones. A number of technical indicators are taken into consideration, making it possible to assess the situation of the production chain and to identify the main constraints to the development of the sector, particularly those linked to its structure. To better analyze this part, we have chosen to delimit the chain in three stages: 1) Olive production stage; 2) Olive processing stage; 3) Olive oil marketing stage.

Production stage

The results in Table 5 show that the most common method used in the mountainous zone is the gravity-fed irrigation system (72.77%). The development of this system is due to the slopes that characterize mountainous terrain. Indeed, this system is known for its low energy consumption. However, the quantity of water used is high and not very advantageous for this semi-arid region. In the other two zones, the high plains and the steppe, irrigation is either drip or gravity-fed, with more or less equal percentages. Spray irrigation remains the least-used method in all three zones.

Moreover, the majority of surveyed farmers practice tillage, with a frequency of 2 to 3 times/year. The highest percentages were observed in the high plains (90%) and mountains (83.33%).

Table 5 - Crop operation data.

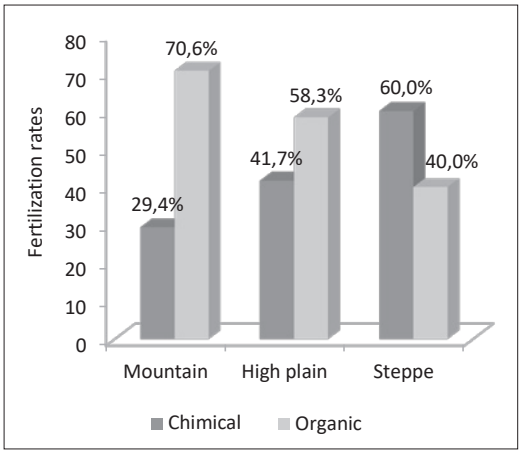
		Mountain	*High plain*	*Steppe*
Irrigation	*Drip system*	08.64%	42.14%	40.45%
	Gravity fed	72.77%	40 .36%	45.64%
	Spray irrigation	18.52%	17.51%	13.91%
Fertilization		72.22%	77.78%	80.00%
Phytosanitary traitement		50.00%	66.67%	80.00%
Soil management		83.33%	90.00%	75.00%

Source: Survey, 2019/2020.

In olive cultivation, tillage is used for soil aeration and especially to eliminate adventitious weeds (Soriano et *al.*, 2014). The survey data show that fertilization is adopted by most farmers, particularly in the steppe region where the percentage recorded is 80%. Two types of fertilizer (chemical and organic) are used by the farmers. Figure 3 shows that the most widely used fertilizer in the mountains and high plains is livestock manure, with values of 70.59% and 58.33%, respectively. This can be explained by the fact that most of these olive growers are also engaged in livestock farming, which provides them with a fertilizer that is both natural and free of charge. On the other hand, in the steppe zone, the farmers opt for chemical fertilizers (60%) rather than natural fertilizers.

In addition, we notice that the use of inputs increases as one moves southwards in the region and follows the aridity of the land. The same applies to phytosanitary treatment, where the highest percentage is recorded in the steppe zone, with a value of 80%. The excessive use of fertilizers and phytosanitary products was unfortunately observed during our survey in view of the doses announced by the majority of local farmers.

Figure 3 - Fertilizer application by zone.



Source: Survey, 2019/2020.

Processing stage

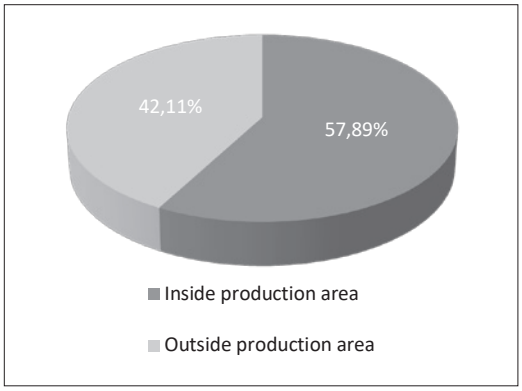
The Tiaret region has two modern, automatic processing units with a three-stage crushing system. One is located in the mountainous region, with a crushing capacity of 30 q/day, and the other in the steppe region with a higher capacity of 240 q/day. The total milling capacity for the region is 270 q/day, representing an average of 24300 quintals per 90 days of the olive-growing campaign from end-October

Table 6 - Olive mills description.

Olive mill	*Localization*	*System*	*Crushing capacity*	*Operating time*	*Storage time*
M1	Mountain	Three-phase continuous system	30 q/day	90 days	6 days
M2	Steppe	Three-phase continuous system	240 q/day	90 days	7 days

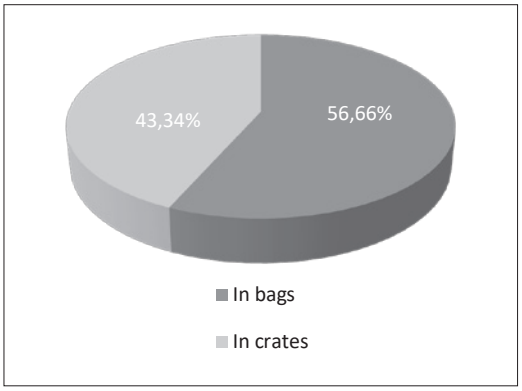
Source: Survey, 2019/2020.

Figure 4 - Olive processing zones.



Source: Survey, 2019/2020.

Figure 5 - Olive reception mode.



Source: Survey, 2019/2020.

to early-February (Table 6). These data show that the processing industry is insufficient to process the region's olive production of 40800 quintals/year destined for olive oil (according to the DAS data in 2020), therefore, farmers turn to other processing units located outside the region. Indeed, almost 42% of surveyed olive growers claim to have crushed their crops outside the production zone (Figure 4). This also explains the long storage time of olives in oil mills (7 days).

The relationship between industrialists and olive growers is limited to the transformation of olives into olive oil. Millers often fail to establish a schedule for the receipt of olives. Figure 5 shows that the raw material is mainly received in bags (56.66%) due to their availability and low cost. The crushing activity is remunerated in cash with an average price of 8.5 €/quintal and rarely in kind (2 liters of olive oil per quintal).

Table 7 - Olive oil destination, marketing and distribution.

		percentage
Sales circuit	Intermediaries	32.63%
	Farmers	67.37%
Destination	Auto-consumption	4.72%
	Sale	95.28%
Marketing mode	Bulk sale	80.00%
	Retail sale	20.00%
Distribution	Outside production area	90.91%
	Inside production area	9.09%

Source: Survey, 2019/2020.

Marketing stage

The farms specializing in olive oil production in the Tiaret region are characterized by small and medium-sized estates, not organized into cooperatives. As a result, olive oil production and sales are generally carried out by individual growers, without the intervention of intermediaries. The survey results (Table 7) showed that almost 70% of production is processed directly by farmers. The olive oil marketing network in the study area is the traditional one, and the sale of olive oil is carried out through a small and maintained circuit between producers and consumers. Moreover, marketing is essentially determined by the trust relationship that exists between the seller and the consumers rather than by the quality of the product. This has encouraged the development of an informal market within the region but also observed in other parts of the country, and as a result, olive oil prices are set empirically without any prior study.

The results showed that almost 95% of oil production is destined for sale, and only 5% for self-consumption. The vast majority of production (91%) is marketed outside the Tiaret region. Olive oil-based food is still not firmly rooted in the region's culinary habits, having been introduced recently thanks to the development of olive growing, which explains the low level of self-consumption of olive oil by the local pop-

Table 8 - Production costs per kilogram of olive and olive oil in the Tiaret region, based on planting systems.

	Extensive (€)	*Semi-intensive (€)*	*Intensive (€)*
Soil management/ha	47.73	71.41	63.31
Phytosanitary treatment/ha	143.78	248.43	364.30
Fertilization/ha	122.18	161.28	305.15
Weed control/ha	33.53	37.32	34.34
Irrigation/ha	198.21	226.38	215.18
Harvesting/ha	196.87	544.18	559.99
Pruning/ha	45.56	161.79	327.11
Direct costs/ha	787.84	1450.78	1869.37
Indirect costs/ha	98.56	181.49	316.11
Total costs	886.40	1632.27	2185.48
Amortisation costs/ha	18.00	15.11	76.00
Total cost /ha	904.40	1647.39	2261.48
Production kg/ha	2000.00	4754.47	10571.43
Total costs of 1kg of olives	0.45	0.35	0.22
Olive oil yield	17.30	17.53	17.99
Transport costs of 1kg of olives	0.04	0.04	0.04
Processing price 1kg olive	0.09	0.09	0.09
Total costs of 1kg olive oil	3.35	2.78	1.95

Source: Survey, 2019/2020; calculated according to the International Olive Oil Council method (IOOC, 2015).

ulation. Olive oil is packaged and sold either in plastic, transparent glass bottles or bulk plastic containers. About 80% of oil production is loose sold in plastic containers.

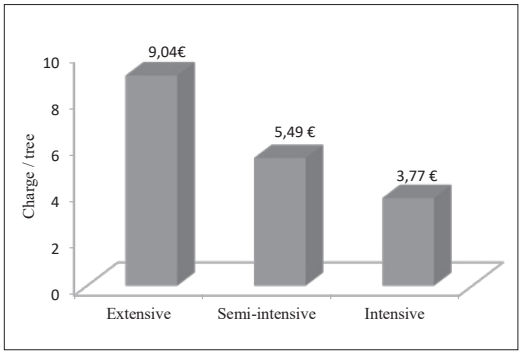
4.3. *Economic analysis of the olive oil value chain*

Determination of production costs

The production costs determined in this study are the sum of expenses related to the various operations involved in producing and processing olives into olive oil. The findings (Table 8) show that the most important expenses in olive production are those of the harvest, which account for 25% of direct costs in extensive systems, 69% in semi-intensive, and 71% in intensive. The olive picking is carried out manually for all systems. Moreover, the family labor, most often encountered in traditional systems, is generally considered free (Jackson *et al.*, 2015). The latter is included in this study, estimating that these workers are paid the guaranteed national minimum salary of 132.8 € per month, which is partly responsible for the increase in harvesting costs. This is followed by the phytosanitary treatment costs, which represent almost 18% of direct costs for all three systems. The high cost of this operation is due to the high price of these products; according to farmers, they vary between 140 € and 200 €/ha/year, depending on the type of treatment and the quantity used. These products are generally used to control olive pests and diseases (mainly olive fly and peacock eye). Water is an essential source for olive-growing development in arid zones. The results of Table 8 show that irrigation costs constitute a significant charge, reaching 198.21 €/ha, 226.38 €/ha and 215.18 €/ha for the three systems, respectively. Irrigation costs appear to be unrelated to orchard density, and the installation of drip systems in intensive systems has helped to reduce this operation cost.

The survey data show that the majority of olive production costs are proportional to the density of the orchards concerned. The intensive system

Figure 6 - Production costs per tree based on the planting system.



Source: Survey, 2019/2020.

has the highest olive production, with 10571.43 kg/ha, which is more than twice the yield of the semi-intensive system and more than four times that of the extensive system. However, these costs are inversely proportional when it comes to costs per tree and per kilogram of olive oil (Figure 6). Production costs of 1 kg of olive oil vary between 3.35 €, 2.78 €, and 1.95 €, depending on the crop system. The highest value is recorded in the extensive system, which is characterized by the lowest olive yields per hectare (20q/ha). According to Emmanuel *et al.* (2022), the generated yield is one of the main determining production costs. In addition, based on the olive-growing area of the three cultivation systems, the weighted average cost of producing 1 kg of olive oil in the semi-arid region of Tiaret is 2.83 €/Kg. The data from the survey show that the production stage induces much higher costs than those generated by processing and transport, which account for 71.36% of total charges against 28.64%, respectively.

In terms of economic analysis by class (Table 9), the highest total expenses per hectare are observed in class 9 orchards (Intensive x steppe) with a value of 2532.44 €/ha. In contrast, intensive farms located in the mountains have lower costs due to the availability of cheaper family labor, compared to the more expensive labor found in the steppe. The main findings from the survey show that the cost of producing 1 kg of olive oil differs from one area to another, and between systems. Overall, yields in the mountainous zone are higher than the other studied zones. Indeed, the highest olive yields (20q/ha to 120q/ha) and olive oil yields (18%) were observed in the mountainous orchards for all systems. Thus, for the intensive system, the lowest production costs per 1 kg of olive oil were recorded in the mountains (1.67 €/kg).

Economic performance of the olive oil value chain

Determining the performance of the OVC in the study area is essential for its diagnosis. It is also complementary to the technical analysis and calculation of production costs (Cochet and Devienne, 2006). Economic performance indicators are presented by class in Table 10. The survey results show that the break-even point is generally proportional to farm density. Thus, the lowest value was recorded in class 4 (Extensive

Table 9 - Production costs of one kilogram of olive and olive oil by class.

Classes	*Total coasts/ha (€/ha)*	*Olive yield (kg/ha)*	*Total costs of 1kg of olive (€/kg)*	*Olive oil yield (%)*	*Total cost of 1kg of olive oil (€/kg)*
Class 1	1069.85	2000	0.53	18.83	3.60
Class 2	1453.09	4198	0.35	18.31	2.63
Class 3	2317.49	12000	0.20	18.72	1.67
Class 4	738.95	2000	0.37	15.77	3.09
Class 5	2137.94	5416	0.39	16.52	3.30
Class 6	1906.49	8000	0.24	17.38	2.08
Class 7	1300.79	3062	0.43	15.00	3.64
Class 8	1683.95	6714	0.25	15.00	2.51
Class 9	2532.44	11000	0.24	17.50	2.25

Source: Survey, 2019/2020.

Table 10 - Performance analysis data of the olive oil value chain by class.

Classes	*GP (€/ha)*	*GVA (€/ha)*	*BE (Q/ha)*	*BE (€/ha)*	*PE (€/Kg HO)*	*EEC*	*PR (%)*
Class 1	2015.17	1120.16	10.62	1074.19	2.97	1.88	56
Class 2	4113.01	2765.68	14.83	1455.96	3.60	2.83	67
Class 3	12019.67	9893.55	23.14	2332.26	4.40	5.19	82
Class 4	1687.48	1143.38	8.76	751.47	3.62	2.28	68
Class 5	4785.80	2779.88	24.19	2150.58	3.11	2.24	58
Class 6	7436.50	5721.38	20.51	1926.21	4.12	3.90	77
Class 7	2457.26	1680.09	16.21	1316.72	3.66	1.89	68
Class 8	5388.21	3841.67	20.98	1693.14	3.81	3.20	71
Class 9	10298.75	7957.69	27.05	2551.30	4.13	4.07	77

Source: Survey, 2019/2020. GP: Gross product, GVA: Gross value added, BE: Break-even point, PE: Productive efficiency, EEC: Economic efficiency coefficient, PR: Profit ratio.

x High plain) with a break-even point of 8.76 quintals of olives per hectare. These values are almost three times higher in the intensive orchards, where the highest threshold is observed in class 9 (Intensive x Steppe) corresponding to 27.05 q/ha. Furthermore, the results obtained showed that in extensive orchards, 8.76 q/ha of olive must be produced, with a minimum break-even point of 751.47 €/ha, for the farmer to make a profit and fully cover the costs incurred in olive production. In terms of productive efficiency, the values are also proportional to the planting systems and follow the same trend as the break-even point. Indeed, 1 kg of olive oil from class 3 (Intensive x Mountain) yields 4.40 € (that corresponds to the highest value) compared to class 1, which earns only 2.97 €/Kg. This is explained by the fact that the production volume, closely linked to this indicator, is more significant in intensive orchards than in extensive ones.

The determination of the coefficient of economic efficiency (CEE) indicates that olive oil production in the three study areas is economically efficient for all systems. Since all the values of this indicator are greater than 1, this indicates clearly that farmers in all classes are making a

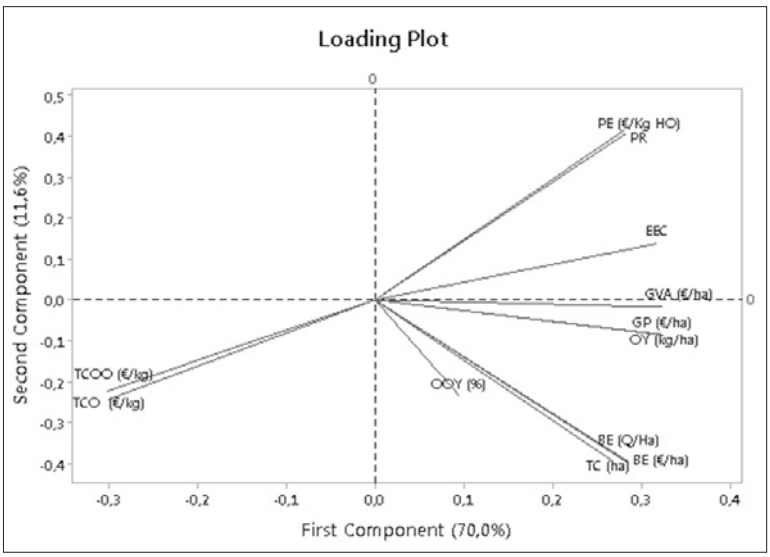


Figure 7 - Loading plot graph.

Note: GP: Gross product, GVA: Gross value added, BE: Break-even point, PE: Productive efficiency, EEC: Economic efficiency coefficient, PR: Profit ratio, TCOO: Total costs of 1kg of olive oil, TC O: Total costs of 1kg of olive, OOY: Olive oil yield, OY: Olive yield, TC: Total coasts per hectare.

profit, which is all the more important for the intensive system. This latter is the most efficient system, offering better expense coverage. Profit margin ratios (PR) vary between 56% and 82% across the region. This high-profit margin means that olive growing in the semi-arid zone is highly profitable, and heralds strong growth for investors in the years ahead.

4.4. *Principal component analysis (PCA)*

Principal component analysis was applied to all the economic variables in order to obtain an optimal visualization of all the information obtained. Axis 1 of the PCA alone accounts for around 70% of the variability, while the second axis accounts for only 12%. Together, the two axes explain almost 82% of the total variance. Figure 7 clearly shows that the economic variables PR, PE, EEC, GVA, GP, OY, BE, and TC are positively correlated with axis 1 of the PCA. The latter are superposed on classes C9, C3, and C6 in the observation plot, which represent the intensive farm system. This confirms that intensive farming is the most efficient and economically profitable. TCO and TCOO, on the other hand, are in the opposite direction to the above variables and are negatively correlated with Axis 1. These variables overlap with classes C1, C4, and C7, which represent the extensive system. This shows that traditional plantation systems have the highest costs per kg of olive and olive oil. Thus, Axis 1 of the PCA provides better dispersion of individuals and variables.

Looking at the arrangement of the components along axis 2, we can see that the PR and PE variables are positively correlated to the axis and in opposite directions to the GP and TC variables. Besides, classes C3 and C6, corresponding to intensive farms, follow the same direction as the PR and PE variables regarding axis 2. In contrast, classes C5 and C9 are superposed on the GP and TC variables according to the same axis. The farms represented by these last two classes are those with the highest production costs. In conclusion, PCA separated all observations into three main groups (G1: extensive system, G2: semi-intensive system, and G3: intensive system) according to orchard density (Figure 8). In addition, this analysis confirmed the various observations made on the data set and approved that the best production systems are intensive ones.

5. *Discussion*

5.1. *Olive production in semi-arid region*

Olive cultivation practices and production techniques

The technical and economic analysis of the OVC in the Tiaret region has shown that, despite the efforts made by the government, particularly

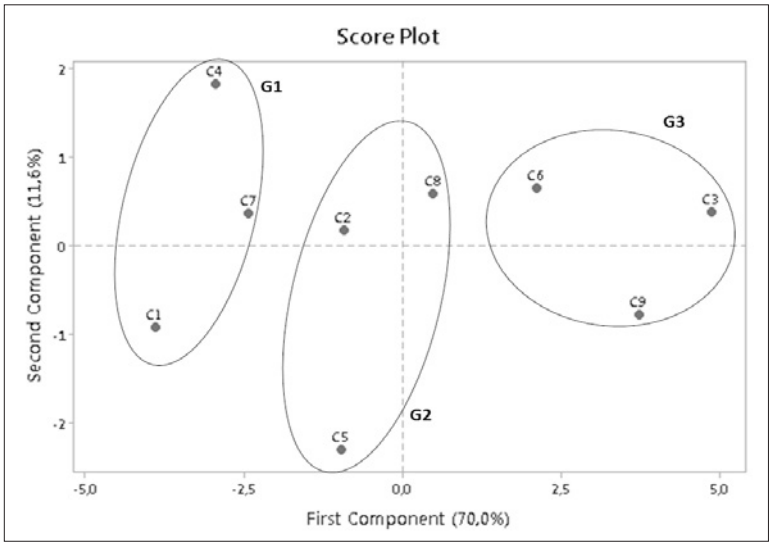


Figure 8 - Score plot graph.

Note: The letter 'C' represents the classes and 'G' the groups.

through the various plans implemented (PNDA, PNDAR, etc.) over the last decade to develop the olive oil sector in arid and rural areas. The sector remains highly traditional, characterized by small orchards, usually managed on a semi-intensive system and dominated by small private producers. According to Barjol (2014), the strong roots of traditional production in Mediterranean countries are due both to low investment in the sector and to structural reasons. Furthermore, the development of this system in the Tiaret region is due in part to the government's choice of varieties that are more resistant (*Chemlal* and *Sigoise*) to the arid climatic conditions of these regions, without taking into account their adaptability to orchard intensification. In addition, the low availability of mechanization equipment and the fact that farmers are not encouraged (institutionally or financially) to modernize their production techniques also contribute to the entrenchment of the traditional system. Thus, the most widely used irrigation technique is the gravity-fed system, despite the fact that it consumes a lot of water. Farmers favor it because of its low installation costs compared with other systems, particularly drip irrigation. As a result, irrigation costs are high, particularly in extensive orchards, generally located in mountainous areas, where the gravity-fed system is most widely used. Moreover, irrigation costs in Tiaret (varying between 198.21 and 215.18 €/ha) are higher than those reported by Boudi *et al.* (2013) in the sub-humid zone of northern Algeria (Bejaia), ranging from 71 to 106 €/ha. Daly-Hassen *et al.* (2019) have shown that rain-fed olive groves are not profitable for farmers. To improve productivity, several countries on the southern side of the Mediterranean have initiated plans to convert from rain-fed to irrigated cultivation. However, due to insufficient supervision and sensitization, major problems have arisen in the management of water resources, which are particularly scarce in these arid regions of the world (Balaghi *et al.*, 2010).

In olive growing, the integration of fertilization and phytosanitary treatments aims to improve yields, maintain production and ensure the economic profitability of farms (Ouaouich and Chimi, 2007). The survey results showed a high use of chemical inputs, having a significant impact on production costs. Compared to IOC data (2015), the costs generated by phytosanitary treatments for the intensive system in the arid region of Tiaret are higher than those for the Tunisian (45 €/ha) and Italian (101 €/ha) orchards. The same system generates fertilization costs twice higher than Tunisian orchards (175 €/ha). According to Guerrero-Casado *et al*. (2021), the excessive use of fertilizers and plant protection products increases production costs and represents a real public danger, especially when used unreasonably. The inappropriate use of these agricultural inputs is the result, in part, of the government's support policy, which focuses primarily on productivity to the detriment of sustainability, and also of farmers' preoccupation to prioritize yield over quality and the environmental impacts generated by these practices.

Olive harvesting management

In addition, the highest production costs are those of harvesting, which is exclusively manual in the region studied. Several countries in the Mediterranean olive-growing region, such as Morocco and Lebanon, still favor manual harvesting systems (IOC, 2015). This method, generally adopted for quality purposes, can have serious economic consequences (Ouaouich and Chimi, 2007). The high costs of this operation are mainly due to the high cost and scarcity of labor in the region. This shortage is linked to social constraints, particularly the difficult working conditions in the fields, the seasonal nature of olive growing and the absence of a social security system for farm workers. The study carried out by the International Olive Oil Council on production costs in different countries around the world revealed that this operation is the most expensive (IOC, 2015). The harvesting costs determined for the intensive system in the Tiaret region (560 €/ha) are twice as high as those generated in Tunisia (202 €/ha) and Italy (328 €/ha), mainly due to the lack of mechanization on farms in the region. According to Fernández-Escobar *et al*. (2013), harvesting costs can be reduced by introducing mechanization.

Olive growing systems

High-density olive growing is a modern and economical technique used to increase farm

profitability while limiting production costs. The cost of producing one kilogram of oil decreases with the intensification of the orchards. The values recorded for the intensive system (1.95 €/kg) are less than half those for the extensive system (3.35 €/kg) and are very close to the costs reported in Morocco for the two systems, 2.26 €/kg and 1.94 €/kg respectively (IOC, 2015). These costs are directly linked to the olive yields of the surveyed farms, which are 20 q/ha in extensive and 105.7 q/ha in intensive. These data show that olive-growing in Tiaret region is highly competitive compared with other Mediterranean regions, reflecting the widespread use of the farming techniques. In the intensive orchards of the Tiaret region, the break-even points to be reached are between 2,332.26 and 2,551.30 €/ha for the farmer to make a profit. These results are close to those reported by Zoubeidi and Dahane (2017) in the semi-arid region of central Algeria, with a break-even point of 1,743 €/ha for intensively managed orchards. These results indicate no significant variations in production costs between the two regions, suggesting an economic equivalence that can encourage competitiveness and market stability. The study by Fernández-Escobar *et al.* (2013) showed that intensive production systems have always been the most economically efficient in terms of agricultural production. The results of the survey confirm this statement, since the intensive farms in the Tiaret region make an annual profit of almost 7,000 €/ha (with an EEC of 4.4). A study of these high values compared with the extensive system shows that the intensive system minimizes the costs of producing 1 kg of olive oil and maximizes the revenue per hectare. In addition, the survey results show that the best zone for developing the intensive system in the Tiaret region is the mountain area, mainly due to the low production costs associated with the inexpensive family labor and slightly higher yields compared with other zones studied. However, the relief of this area does not allow much mechanization of orchards, particularly for harvesting, in contrast to the steppe zone, which has vast tracts of land with greater potential mechanization. The introduction of mechanization in this zone will help to reduce production costs and make it the most suitable area for intensifying olive growing.

5.2 *Olive oil transformation*

Analysis of the chain downstream has shown that the Tiaret region suffers from low milling capacity. This situation can have multidimensional repercussions on the economic and technical levels, impacting both qualitatively and quantitatively on the value of the final product and its place on the market. From a technical point of view, low crushing capacity leads to an increase in the olive storage time, causing deterioration in nutritional quality and a downgrading of the extracted olive oil. A similar situation has been observed in processing industries in Tunisia, where olives are stored for 6 days, while an opposite case is observed in Spain and Italy with 2.5 days of storage (Gharbi *et al*., 2014). From an economic point of view, olive growers' recourse to other processing units outside the production area generates not only additional costs (transport and unloading costs), leading to an increase in selling prices, but also delays the availability of olive oil on the market, which has a negative impact on promoting the product's competitiveness. Over the last twenty years, the semi-arid region of Tiaret has benefited from only one olive processing unit, set up as part of the state-supported investments initiated in 2000 by the National Agricultural Development Fund (FNDA) and the National Agricultural Production Regulation Fund (FNRPA), which are mainly aimed at promoting production (DSA, 2020). However, the development dynamic generated by these plans to revitalize the olive industry in the country's arid zones remains insufficient, as the region currently counts just two processing units.

5.3. *Sector organization*

OVC in the semi-arid area of Tiaret is carried out by an informal market. Hadjloun *et al.* (2021) noted this informal circuit in the steppe region of M'sila in Algeria. This issue has also impacted on the olive oil sector in other Mediterranean countries, such as Tunisia (Fetoui *et al*., 2020). The lack of horizontal integration between the various players has led to fragmentation of the sector, resulting in the absence of

structured sales channels. To improve the quality of Algerian olive oil, the new agricultural and rural development policies have attempted to promote quality by encouraging the various players in the sector to reorganize into agricultural cooperatives, segmenting supply to ensure different qualities of oil on the market, and introducing geographical indications (Lamani and Ibert, 2016a). The failure of these policies in Tiaret and in other regions of the country is mainly due to the divergence of player interests and the negative experience of the former public cooperatives (Hadjou *et al*., 2013). This failure to address common problems has led to unregulated technical practices and competitiveness, affecting both the price and quality of olive oil (which does not meet marketing and quality standards), while compromising the structured development of the market. According to Parrilla-González and Ortega-Alonso (2021), the cooperative structure fosters an environment conducive to social innovation, affecting the economic, cultural, environmental, and technological aspects that stimulate and support sustainable development, particularly in rural areas. However, the study by Ozden et Rafaela (2016) shows that private companies can perform better, particularly from a technical point of view, thanks to their ease of adaptation to the market and the flexibility of work constraints (favored by the number of partners) but will have to get involved in environmental and quality issues.

5.4. *Olive oil marketing*

The study results of the Tiaret region show that the entire production of olive oil is commercialized on the national market. It is generally sold in bulk by manufacturers at oil mills or by the farmers on the local and regional markets, a common practice in other national regions and Mediterranean countries (El Antari *et al.,* 2015; Hadjou *et al.*, 2013). The viability of this practice of selling on the market is helped by the lack of packaging facilities and the high initial investment costs required for olive oil conditioning. Moreover, Algerian olive oil production does not generate a significant excess for the export market, and the lack of efforts to innovate and add value leads to less competitiveness on the international market which is very demanding in terms of quality and packaging (Lamani and Ibert, 2016a). The raised constraints constitute a real break to the development and the performance of the Algerian olive oil sector, but also in other countries of the world, particularly in Tunisia, where they limit the contribution of the olive oil sector to the national economy and its position on the international markets of export (Karray and Kanoun, 2013). The creation of competitive olive oil sector capable of maintaining a foothold on the international market depends on constant production, multidimensional organization, effective commercial policies, and communication based on transparency and a collaborative mindset between the different actors (Mili, 2006; Türkekul *et al.*, 2010). In addition, the study of Mozas-Moral *et al.* (2020) on the Spanish marketing experience reveals the importance of investing in new information and communication technologies (ICTs) and in specialized human resources.

6. Conclusion

The technical and economic analysis of olive farms in the semi-arid region of Tiaret has enabled us to identify the strong and weak points in the olive sector and to provide a better understanding of the factors that determine its performance. The carried out survey showed that olive growing in this region is a profitable and economically efficient activity. Production costs for a kilogram of olive oil are comparable and competitive with those of other Mediterranean regions in the country. Furthermore, a hectare of olive trees cultivated in the semi-arid zone yields almost 7,000 € per year for the region's farmers, with an EEC of 4.4 in the intensive system. We have found that the profitability of olive orchards is generally proportional to the density of the plantation; thus, intensively-managed farms are the most profitable and offer better coverage of expenses. On the other hand, olive orchards located in mountainous areas present the lowest production charges due to the advantage of cheaper family labor. However, the steppic zone, with its vast land tracts, offers great potential for

intensifying and modernizing olive growing. As a result, the highly advantageous economic potential of the semi-arid region of Tiaret can provide promising investment opportunities for the actors in the sector.

Despite all these advantages, the OVC in the semi-arid zone remains poorly organized and confronted by several constraints, particularly upstream the chain. The sector remains poorly organized and faces a number of technical, economic, political and environmental constraints. These problems are spread throughout the olive oil value chain. At the production stage, the main problem is linked to non-optimized cultivation practices, which have led to a considerable increase in production costs and inadequate use of inputs and natural resources. Thus, upstream costs are the most significant in the olive oil chain. Although the government has been successful in its plan to extend olive orchards and increase production in the Tiaret region, it has failed to further integrate modern cultivation techniques and sustainable farming practices, mainly due to the difficulty of implementing various policies in the face of stakeholders' concern to maximize yields and capital rather than the sustainability of cultivation, taking into account environmental and quality aspects.

Further down the chain, other constraints had been observed, which are more organizational than technical. There is a lack of an integrated approach and balanced development of the sector, particularly in creating a robust processing industry and a structured market to accompany the expansion and intensification of cultivation. Although the government has launched a plan to revive the olive industry in rural areas of the country, the capacity of the olive industry remains insufficient to ensure the transformation of the entire production and fails to meet market expectations in terms of both quantity and quality. As for marketing, the absence of a formal local market presented difficulties in selling olive oil produced in the region; in fact, 91% of olive oil production was sold outside the production area. Moreover, the lack of cooperation between the various OVC stakeholders reflects the precariousness of its functioning and the vulnerability of its structure. The new policies for adding value to olive oil and organizing players in the sector into cooperatives have been a real failure, the result of the bad experience of the former public cooperatives and the divergence of player interests in the chain. Thus, the expansion of the olive sector in regions with a weak olive-growing tradition remains limited by the absence of preconditions and integrated support strategies for sustainable development of the sector.

7. Perspectives

At the end of this survey of olive growers and oil producers in the semi-arid region of Tiaret, the various elements of the olive sector were assessed. The economic analysis enabled to draw up some recommendations for improving the performance of olive growing in this semi-arid area:

Optimizing the performance of intensive production systems must involve modernizing farming techniques and equipment. Upgrading the irrigation network will reduce costs and rationalize the region's valuable water resources. The introduction of mechanized harvesting should help to reduce labor costs, which are increasingly onerous, particularly in steppe areas. The government needs to launch long-term strategic plans focused on the olive farms modernization and sustainable farming techniques. It is also crucial to train a more skilled workforce and improve farmers' technical and management capabilities, to provide the knowledge needed to optimize production systems and ensure sustainability. The development of olive growing in rural areas must be accompanied by a strengthening of processing capacity through the implementation of new programmes to revitalise the olive industry. The installation of new processing units in high-production areas is essential. This initiative will reduce the storage time of olives in the mills, and consequently, improve the quality of the olive oil produced and promote competitiveness. The region's olive growers need to join forces and organize themselves into cooperatives to deal with the different economic and technical constraints encountered. Policies should also support the sector by developing appropriate policies to encourage collaboration and create a stable and regulated environment to

promote more efficient market organization. It is also essential to assist the different players in organizing themselves to implement marketing strategies and improve quality and packaging to promote a more competitive olive oil that meets international marketing standards. In addition, a new, more effective policy via a geographical indication should help to enhance rural heritage and create an olive oil whose origin and production techniques are certified, thereby strengthening the reputation and sustainable development of arid areas. It is also necessary to sensitize the local population about the benefits of olive oil; in order to anchor new dietary habits which will boost the local market.

To diagnose the olive oil sector in the semi-arid zone of western Algeria, we adopted a case study of the value chain approach. However, the study has certain limits, due in particular to the reluctance of industrialists to provide quantified information and the difficulty of collecting viable data from consumers in the region. A complementary study on the various processing costs generated during the olive trituration would have been preferable. This information will enable an evaluation of the efficiency and profitability of the olive oil industry and a better understanding of the management of product pricing in the face of competition and the market. In addition, consumer surveys would have enabled insight into consumer preferences and perceptions of product quality and price. This information would have enriched the analysis of the sector in order to establish suitable strategies to better respond to market expectations. Finally, a comparative study with other regions will highlight the performance of agricultural techniques, economic models and regional policies in the country. The limitations identified may constitute new research perspectives providing a global overview of the Algerian olive sector.

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Explorer le comportement des consommateurs vis-à-vis des aliments agroécologiques en Algérie : Profil sociodémographique, motivations et contraintes à la consommation

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Abstract

The aim of this article is to analyse the behaviour of consumers of agroecological products in Algeria. The analysis is based on data from a direct survey of 40 consumers of agro-ecological products who are adherents of the solidarity initiative for authentic farmers in Algiers, and another online survey of 315 individuals. The main results show that: more than a third of those surveyed online regularly consume agroecological foods; consumption of these foods varied according to age, income level and household structure; the motivations are mainly linked to the expected health benefits and quality of the food; the constraints on consumption are the lack of availability and the high prices of these products on the domestic market. Despite the limitations to the generalisation of the results, this exploratory research provides useful information for economic operators to develop marketing strategies and indicates the action's levers of public authorities to design and implement policies to promote sustainable food.

Keywords*: Consumer behaviour, Agroecological products, Sustainable food, Algeria.*

1. Introduction

Les systèmes alimentaires conventionnels sont considérés comme l'un des principaux facteurs de mauvaise santé et de dégradation de l'environnement à l'échelle mondiale (Mooney *et al.*, 2021). Les consommateurs ont réalisé, au fil des années, que leurs comportements d'achat et de consommation alimentaire ont un impact direct sur l'atténuation des risques sanitaires et écologiques (Lema-Blanco *et al.*, 2023, Steen-Olsen & Hertwich, 2015). En effet, la croissance plus rapide de la demande d'aliments biologiques par rapport aux aliments conventionnels au niveau mondial (Willer *et al*., 2022), surtout dans les pays développés, illustre un changement significatif vers une alimentation saine et durable (Gar-

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cia Mira *et al.*, 2017 ; Castellini *et al.*, 2020). Bien qu'elle reste concentrée principalement en Amérique du Nord et en Europe, la demande d'aliments biologique[1] gagne peu à peu l'attention des consommateurs des économies émergentes, notamment d'Asie (Willer *et al.*, 2022 ; FiBL&IFOAM- Organics International, 2019) avec une énorme demande potentielle (Wang et *al.*, 2023 ; Kashani-Nazari et *al.*, 2016). Par contre, la consommation de ces aliments reste marginale dans les pays en développement alors que la production biologique de ces pays est orientée principalement vers l'exportation (Willer et *al.*, 2022).

En Algérie, les risques sur la santé humaine et sur l'environnement liés à l'agriculture conventionnelle intensive sont avérés par des analyses sur les résidus de pesticides dans quelques produits stratégiques (fruits et légumes et blé) (Mebdoua & Ounane, 2019 ; Mebdoua *et al*., 2017). Malgré cela, le pays a très peu développé l'agriculture biologique comparativement aux pays voisins d'Afrique du Nord (Willer *et al.*, 2022). Les rares initiatives de certification émanent exclusivement des producteurs privés et sont limitées à quatre principaux produits (olive de table, dattes, vins et huile d'olive), destinés exclusivement à l'exportation (Hadjou *et al.*, 2013 ; Benziouche, 2017). Pourtant le pays dispose d'un secteur agricole paysan important et diversifié qui peut être rapidement converti à l'agriculture biologique (Hadjou *et al.*, 2013). Le sous-développement de cette dernière est expliqué par le retard accusé à ce jour dans l'élaboration du cadre réglementaire, prévu par la loi d'orientation agricole de 2008 et par l'absence d'une véritable politique de soutien à cette forme d'agriculture durable (hormis quelques mesures incitatives néanmoins insuffisantes à la conversion au bio et à l'exportation prévues dans le cadre du Plan National de Développement Agricole 2000-2004) (Hadjou *et al.*, 2013 ; Abdellaoui, 2012).

Dans ce contexte, des organisations citoyennes, particulièrement le collectif Torba[2], s'efforcent, depuis une décennie, de concevoir et mettre en œuvre des innovations organisationnelles pour valoriser les produits agroécologiques locaux dont le mode de production est identique à l'agriculture biologique, mais ils ne sont pas labellisés, en offrant aux producteurs de nouveaux revenus, en renforçant les liens de proximité géographique et sociale (solidarité notamment) entre agriculteurs et consommateurs, en accompagnant le changement de pratiques agricoles et en promouvant le dialogue entre les parties prenantes en vue d'une transition agroécologique. Leurs actions pour la promotion de l'agroécologie portent notamment sur l'organisation des circuits courts « marchés paysans » l'aménagement de jardins partagés, les formations sur la permaculture et les pratiques agroécologiques, les forums d'échanges, les ateliers pour enfants, la collaboration avec des institutions de recherche-développement et la participation dans les programmes de coopération internationale (Collectif Torba, 2020).

Les statistiques officielles algériennes ne rendent pas compte de la consommation des aliments biologiques (segmentation de la consommation en fonction des signes de qualité) et les analyses empiriques sur la demande et la consommation sont rares sinon absentes. Partant de ce constat, l'objectif de cet article est d'explorer le comportement des consommateurs algériens à l'égard des aliments agroécologiques. Il s'agit précisément d'identifier les facteurs sociodémographiques déterminants de la décision de

[1] « L'agriculture biologique est un système de production qui maintient et améliore la santé des sols, des écosystèmes et des personnes. Elle s'appuie sur des processus écologiques, la biodiversité et des cycles adaptés aux conditions locales, plutôt que sur l'utilisation d'intrants ayant des effets adverses. L'agriculture biologique allie tradition, innovation et science au bénéfice de l'environnement commun et promeut des relations justes et une bonne qualité de vie pour tous ceux qui y sont impliqués » (https://www.ifoam.bio/why-organic/organic-landmarks/definition-organic).

[2] Le collectif Torba est une ONG dédiée à la promotion de l'agroécologie et qui vise à sensibiliser le consommateur algérien à revenir au respect de la terre, de la nature et de l'environnement. En plus du collectif Torba, on peut citer la ferme pédagogique de Zéralda (https://fermepedagogique-dz.com/; https://www.facebook.com/fermepedagogique.dz), l'association IwounacenAgrarDatamouht (Timimoune) et la ferme Djanatualarif de Mostaganem.

consommer ces aliments, les motivations et les freins à la consommation, de plus, d'appréhender la perception, les attitudes et les attentes des consommateurs vis-à-vis des aspects de l'offre de ces produits (disponibilité, qualité, prix…) et leurs perspectives par rapport au développement de la filière agroécologique en Algérie. L'analyse est basée sur l'exploitation des données issues de deux enquêtes par questionnaire : une enquête directe auprès d'un échantillon de consommateurs de produits agroécologiques adhérents à un dispositif visant le maintien de l'agriculture paysanne baptisé TAFAS[3]« solidarité paysanne» (inspiré du concept d'Association pour le Maintien de l'Agriculture Paysanne –AMAP), initié par le collectif Torba et adossé à un système participatif de garantie de la qualité des produits (SPG)[4]; et une enquête en ligne de quelques centaines de consommateurs, à travers les réseaux sociaux.

2. Revue de la littérature

En relation avec la croissance de la demande potentielle d'aliments biologiques et ses limitations, une importante littérature scientifique est consacrée pour analyser et comprendre les comportements des consommateurs dans les pays développés (surtout) et en développement. Cette littérature analyse le processus de choix des aliments en fonction des caractéristiques sociodémographiques ou socio-économiques, des attitudes, des motivations, des perceptions, des contraintes et des préférences du consommateur (Yadegari, 2022). La recherche sur le comportement d'achat des consommateurs dans les pays développés et en développement peut contribuer à l'élaboration des stratégies de marketing et à l'accroissement de la portée des aliments biologiques à l'échelle mondiale (Rana & Paul, 2017).

La théorie socio-psychologique du comportement planifié (TPB), qui est développée à partir de la théorie de l'action raisonnée (TRA), est souvent mobilisée pour analyser et comprendre les comportements alimentaires des individus et leurs choix d'achat d'aliments (Yazdanpanah & Forouzani, 2015). L'objectif de cette théorie est d'expliquer la variation des comportements individuels volontaires et réels (Ajzen, 1991). Selon ce modèle, c'est l'intention de l'individu qui contrôle principalement les comportements humains (Zhang *et al.*, 2019). Ce cadre théorique est largement utilisé pour comprendre le comportement d'achat et de consommation des aliments biologiques (Dorce *et al.*, 2021). Grimmer *et al*. (2016) démontrent que la relation entre l'intention et le comportement réel d'achat est néanmoins modérée par le contexte d'achat (disponibilité, distance à parcourir, prix, pouvoir d'achat).

Les études utilisant des profils démographiques montrent que la grande majorité des consommateurs de produits biologiques sont des personnes éduquées et jouissant d'une bonne situation économique (Yadegari, 2022 ; OFAG, 2022 ; Nikolić, 2018 ; Kashani-Nazari *et al.*, 2016 ; McCarthy & Murphy, 2013). Les femmes constituent la majorité des consommateurs, elles ont une attitude plus favorable vis-à-vis des produits bio et consentent de payer les prix élevés (Yazdanpanah & Forouzani, 2015 ; Li & Jaharuddin, 2020). Les jeunes ont une attitude plus positive due à leur prise de conscience sur les impacts négatifs de l'agriculture conventionnelle sur l'environnement. A l'inverse, les personnes âgées achètent plus les produits biologiques (Magnusson *et al.*, 2001) et sont plus disposés à payer les prix élevés à cause des bénéfices attendus sur la santé (Fotopoulos & Krystallis, 2002). Cependant, les résultats des études montrent que les variables démographiques ne prédisent pas

[3] TAFAS : en langue arabe « ***Ta****dhamoun maa el* ***F****allah el* ***As****li* » est une formule de vente directe entre producteurs et un collectif de consommateurs. Cette première AMAP est née à Alger le 25 septembre 2014. https://torba.dz/1ere-amap-a-alger/.

[4] Ce système de garantie participatif est adopté par le collectif Torba. C'est une démarche collective qui consiste à visiter et évaluer les producteurs de façon inopinée par rapport à deux critères importants : La provenance des produits et la non utilisation de pesticides ou engrais chimiques. Voir lien : https://torba.dz/torba-adopte-le-systeme-de-garantie-participatif/.

bien le comportement d'achat des aliments biologiques, lequel est plutôt liée aux systèmes de valeurs et au compromis entre les valeurs subjectives des consommateurs (Yadegari, 2022).

Un grand nombre d'études analysent les motivations des consommateurs pour l'achat des produits biologiques. Les résultats de ces recherches tournent en général autour des attitudes des consommateurs et de leurs motivations à l'égard de la santé, de l'environnement, du bien-être animal, de la nutrition, de la sécurité alimentaire, de l'attrait sensoriel, de la mode et de la nostalgie ainsi que la concurrence entre les besoins, les désirs et les préférences des consommateurs (Yadegari, 2022). La plupart de ces recherches confirment que les bénéfices perçus sur la santé, y compris les aspects nutritionnels, représentent la principale raison pour l'achat des produits biologiques (Mohammed, 2021 ; Patel *et al.*, 2021 ; Hoffmann *et al.*, 2015). De plus, les crises sanitaires récentes liées à l'alimentation et la propagation rapide des maladies causées par les additifs chimiques et les modes de production non biologiques conduisent les consommateurs à chercher la sécurité et des régimes alimentaires plus fiables, ces derniers semblent être disposés à payer davantage pour des aliments sains, qui ne contiennent pas des substances chimiques nocives (Basha *et al.*, 2015). En outre, d'autres études ont montré que les attributs qualitatifs de bon goût et de fraicheur constituent des critères importants dans l'achat des aliments biologiques (Kuhar et *al.*, 2012). Selon les analyses comparatives entre pays, il existe certaines similitudes dans les motivations des consommateurs à acheter des produits biologiques (Thøgersen *et al.*, 2015).

De nombreuses autres études considèrent que les normes subjectives (croyances comportementales ou normatives liées à l'influence sociale et culturelle) (Wang *et al*., 2023 ; Li & Jaharuddin, 2020 ; Castellini *et al*., 2020 ; Wang *et al*., 2019 ; Rohman *et al*., 2020 ; Zhang *et al*., 2019) les styles de vie (Castellini *et al*., 2020 ; Soroka et Wojciechowska-Solis, 2019 ; Garcia Mira & Dumitru, 2017) et/ou les attitudes à l'égard des questions de durabilité environnementale (Lema-Blanco *et al.*, 2023 ; Patel *et al*., 2021 ; Kusumaningsih *et al*., 2019 ; Monier-Dilhan&Bergès, 2016 ; Petrescu *et al*., 2017 ; McCarthy & Murphy, 2013) ont des effets importants ou déterminants sur la consommation des aliments biologiques dans différents contextes. Toutefois, certaines analyses concluent que les motivations altruistes liées à la perception des bénéfices environnementaux et des préoccupations relatives à la durabilité des systèmes de production constituent de meilleurs prédicteurs et ont une plus grande influence sur l'intention d'achat des consommateurs par rapport aux motivations égoïstes liées à la perception des bénéfices sur la santé et de la qualité des aliments (Shahriari *et al*., 2019).

En ce qui concerne l'analyse des contraintes à l'achat des denrées biologiques, un consensus général dans la littérature a été fait sur les prix élevés et la disponibilité ou l'accessibilité limitée de ces produits comme principaux obstacles (Pearson et *al*., 2011). Plusieurs études ont confirmé d'autres contraintes à l'achat des aliments biologiques comme le manque de connaissances sur les bénéfices de ces aliments, le manque de confiance dans les labels de certification Bio ou le manque de priorisation des critères de sécurité sanitaire des aliments (Hughner *et al*., 2007).

3. Matériel et Méthode

3.1. *Collecte des données*

La collecte des données primaires liées au comportement des individus à l'égard de la consommation des produits agroécologiques est effectuée par l'administration d'un questionnaire suivant deux types d'enquête:

- Une enquête directe exhaustive auprès des consommateurs de produits agroécologiques, adhérents au dispositif TAFAS. L'enquête effectuée durant le mois de juin 2021 a atteint un effectif de 40 individus disponibles, ce qui représente 80% des consommateurs inscrits au marché paysan « El Fayet » organisé chaque vendredi dans la banlieue ouest d'Alger (Commune d'Ouled Fayet).
- Une enquête en ligne, non représentative, à travers les réseaux sociaux auprès des consommateurs algériens (consommateurs

et non-consommateurs de produits agroécologiques), durant deux périodes - septembre 2021 et juillet 2022. Le nombre de répondants retenu est de 315 individus[5].

Le questionnaire est composé d'une vingtaine de questions réparties en cinq dimensions : i) les caractéristiques sociodémographiques des personnes (genre, catégorie d'âge, situation du ménage, catégorie socioprofessionnelle et catégorie de revenu); ii) les motivations liées à l'achat/la consommation des produits agroécologiques ; iii) le comportement d'achat/consommation ; iv) les perceptions, les attitudes vis-à-vis des problèmes liés à l'offre locale de produits agroécologiques, les attentes et les perspectives de développement de cette filière en Algérie ; v) les obstacles à la consommation des produits agroécologiques. Le questionnaire structuré est conçu dans Google form et un lien est partagé en ligne et à travers les réseaux sociaux. Les données des deux enquêtes ont été traitées à l'aide du logiciel SPSS.

3.2. *Méthodologie d'analyse des données*

L'analyse adopte l'approche descriptive. Plusieurs outils d'analyse statistique des données ont été mobilisés grâce au logiciel SPSS : tables de fréquences, tableaux croisés dynamiques, tests statistiques pour identifier les liens entre différentes variables (Khi-deux ou Coefficient de Corrélation de Pearson), comparaison graphique des sous-groupes, modèle de régression logistique.

- La régression logistique binaire est appliquée aux données de l'enquête en ligne dans l'objectif d'identifier les variables sociodémographiques ayant un effet significatif sur le comportement de consommation des produits agroécologiques. En effet, le modèle logit (fonction de régression logistique dichotomique) est approprié pour analyser le problème de choix dichotomique, soit d'estimer la probabilité de consommer ou non des produits agroécologiques (variable dépendante ou expliquée binaire) en fonction d'un certain nombre de variables indépendantes (explicatives). La relation logistique s'écrit :

$$Logit\ (P_{L1}) = In\left(\frac{P_{L2}}{1 - P_{L1}}\right) = In\ (e^{z}) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots$$

(Où P_{L2} représente la probabilité d'occurrence de la réponse positive (le fait de consommer le produit agroécologique) et P_{L1} désigne la probabilité de la réponse négative (le fait de ne pas consommer le produit agroécologique), tel que : $P_{L2}+ P_{L1}=1$, dès lors, $P_{L2}=1- P_{L1}$).

- La caractérisation des sous-groupes de consommateurs définis par leur motivation à consommer les produits agroécologiques repose sur des tests khi-deux pour identifier les liens de corrélation significatifs entre la variable motivation et les variables de plusieurs ordres : sociodémographique, attitude, perception, comportement et attentes des consommateurs par rapport au développement de la filière agroécologique. Cette caractérisation s'appuie aussi sur une comparaison de la distribution/la proportion de ces caractéristiques (ou modalités) dans les sous-groupes par rapport à leur distribution/proportion dans l'échantillon entier. L'analyse est faite pour chacune des deux enquêtes.

4. Résultats

4.1. *Profil sociodémographique des consommateurs de produits agroécologiques*

a) Caractéristiques sociodémographiques des consommateurs enquêtés

Les consommateurs adhérents au dispositif « TAFAS », directement enquêtés au niveau du marché paysan El Fayet, sont en majorité âgés de plus de 50 ans (60%), mariés avec enfants (60%) et presque à parité homme/femme. Plus

[5] Le nombre total des répondants est de 401 individus. Toutefois, l'effectif des répondants de la catégorie -étudiants- (au nombre de 86) a été éliminé à cause des biais ou confusions relevées dans les réponses apportées par cette catégorie entre, d'une part, leurs propres caractéristiques sociodémographiques et leurs opinions et d'autre part, les caractéristiques du chef du ménage et le comportement alimentaire du ménage familial.

Tableau 1 - Caractéristiques sociodémographiques des consommateurs de produits agroécologiques.

Caractéristique	*Modalité*	*Enquête directe*		*Enquête en ligne*	
		Effectif	*Taux*	*Effectif*	*Taux*
Genre	Femme	19	47,5%	57	48,3%
	Homme	21	52,5%	61	51,7%
Catégorie d'âge	20-30ans	4	10,0%	40	33,9%
	31-40ans	4	10,0%	19	16,1%
	41-50ans	8	20,0%	26	22,0%
	Age ≥51ans			33	28,0%
	Age 51-60ans	11	27,5%		
	Age ≥61ans	13	32,5%		
Catégorie socioprofessionnelle	Sans emploi	5	12,5%	18	15,3%
	Employé	10	25,0%	34	28,8%
	Cadre moyen	4	10,0%		
	Cadre supérieur	2	5,0%		
	Cadre Moyen ou Supérieur			25	21,2%
	Profession libérale	15	37,5%	32	27,1%
	Retraité	4	10,0%	9	7,6%
Structure du ménage	Vit seul	8	20,0%	36	30,5%
	Marié sans enfants	8	20,0%	19	16,1%
	Marié avec enfants	24	60,0%	48	40,7%
	Vit avec ses parents			15	12,7%
Catégorie de revenu mensuel	R≤20 000 DA	5	12,5%	7	5,9%
	20 000 <R≤ 30 000 DZD	2	5,0%	8	6,8%
	30 000 <R≤ 50 000 DZD	7	17,5%	24	20,3%
	50 000 <R≤ 70 000 DZD	8	20,0%	25	21,2%
	70 000 <R≤ 100 000 DZD	7	17,5%	29	24,6%
	R≥ 100 000 DZD	11	27,5%	25	21,2%
Consommateurs-adhérents au concept TAFAS, enquêtés directement		40			
Consommateurs de produits agro-écologiques (effectif total)				118	37,5%
Consommateurs enquêtés en ligne				315	

Source : Auteurs.

d'un tiers exercent une profession libérale (médecin, pharmacien, commerçant, ...) tandis que les catégories cadre supérieur ou moyen sont faiblement représentées. Ils font partie d'une catégorie sociale plutôt aisée (45% ont un revenu mensuel supérieur à 70 milleDZD/mois) suivie de la catégorie à revenu moyen (20% disposent d'un revenu mensuel entre 50 et 70 mille DZD).

Parmi les 315 participants retenus à l'enquête en ligne, 37,5% déclarent consommer des produits agro-écologiques. Ces consommateurs sont presque partagés à parité égale homme/femme, sont plutôt jeunes (un tiers ont entre 20-30 ans) suivis par les personnes plutôt âgées (28% ont plus de 50 ans), sont principalement mariés avec enfants (41%) ou vivent seuls (31%). Les catégories profession libérale et cadre supérieur ou moyen représentent ensemble près de la moitié de ces consommateurs. Les catégories de revenu mensuel supérieur à 70 mille DZD représentent 46% des consommateurs (même proportion trouvée pour l'enquête directe).

b) Les facteurs sociodémographiques déterminant de la consommation des produits agro-écologiques (l'enquête en ligne)

Pour déterminer les facteurs sociodémographiques ayant un effet significatif sur la consommation des produits agroécologiques, deux modèles de régression logistique ont été appliqués aux données issues de l'enquête en ligne :

- Modèle 1 basé sur la méthode pas à pas ascendante (Wald) avec une méthode de contraste dite Répété appliquée à toutes les variables catégorielles (Répété : Chaque catégorie de la variable de prédicteur, hormis la première catégorie, est comparée avec la catégorie précédente). Les variables indépendantes du modèle sont : catégorie de revenu, catégorie socioprofessionnelle, catégorie d'âge, genre, structure du ménage. Le modèle est significatif (0,001) et prévoit correctement 63,8% des observations. Au premier pas (Pas 1) et après 4 itérations, il fait ressortir la structure du ménage comme seule variable ayant un effet significatif (khi-deux = 0,001) sur la consommation des produits agroécologiques. La comparaison entre les modalités fait ressortir que

Tableau 2 - Déterminants sociodémographiques de la décision de consommer des produits agroécologiques par l'application de la régression logistique sur les données de l'enquête en ligne (Modèle 1).

Modèle 1 : *Méthode : Pas à pas ascendante (Wald)*						
Tests composites des coefficients du modèle :						
			Khi-deux	*Ddl*	*Sign.*	
	Pas 1	Pas	17,300	3	0,001	
		Bloc	17,300	3	0,001	
		Modèle	17,300	3	0,001	
Récapitulatif des modèles (l'estimation s'est arrêtée à l'itération n°4) :						
	Pas 1	Log de Vraissemblance-2	R-deux de Cox et Snell	R-deux de Nagelkerke		
		3,999	0,053	0,073		
Table de classification :						
	Observé		*Prévisions*			
			Consommez-vous des produits agroécologiques			
			Non	Oui	Pourcentage correct	
Pas 1	Consommez-vous des produits agroécologiques	Non	165	32	83,8	
		Oui	82	36	30,5	
		Pourcentage global			63,8	
Variables de l'équation :						
Variables au Pas 1	*B*	*E.S*	*(Wald)*	*Ddl*	*Sig.*	*Exp(B)*
Menage			(16,510)	3	0,001	
Menage (1)	*1,234*	0,359	(11,809)	1	0,001	*3,434*
Menage (2)	- 0,827	0,326	(6,453)	1	0,011	0,437
Menage (3)	*0,765*	0,356	(4,636)	1	0,031	*2,150*
Constante	- 0,585	0,126	(21,432)	1	0,000	0,557

Source : Auteurs.

Tableau 3 - Déterminants sociodémographiques dela décision de consommer des produits agroécologiques par l'application de la régression logistique sur les données de l'enquête en ligne (Modèle 2).

Modèle 2 *Méthode : Pas à pas ascendante (Wald)*						
Tests composites des coefficients du modèle :						
			Khi-deux	Ddl	Sign.	
	Pas 1	Pas	11,427	3	0,010	
		Bloc	11,427	3	0,010	
		Modèle	11,427	3	0,010	
	Pas 2	Pas	10,932	5	0,043	
		Bloc	22,360	8	0,004	
		Modèle	22,360	8	0,004	
Récapitulatif des modèles (l'estimation s'est arrêtée à l'itération n°4) :						
	Pas	Log de Vraissemblance-2	R-deux de Cox et Snell	R-deux de Nagelkerke		
	1	405,230	0,036	0,049		
	2	394,297	0,069	0,093		
Table de classification :						
			Prévisions			
			Consommez-vous des produits agroécologiques			
	Observé		Non	Oui	Pourcentage correct	
Pas 1	Consommez-vous des produits agroécologiques	Non	197	0	100	
		Oui	118	0	0,0	
		Pourcentage global			**62,5**	
Pas 2	Consommez-vous des produits agroécologiques	Non	187	10	94,9	
		Oui	94	24	20,3	
		Pourcentage global			**67,0**	
Variables de l'équation :						
	B	*E.S*	*(Wald)*	*Ddl*	*Sig.*	*Exp(B)*
Variables au Pas 1						
Age			(11,085)	3	0,011	
Age (1)	- 0,501	0,350	(2,057)	1	0,151	0,606
Age (2)	- 0,525	0,288	(3,323)	1	0,068	0,592
Age (3)	**0,639**	0,281	(5,158)	1	0,023	**1,894**
Constante	-0,509	0,121	(17,689)	1	0,000	0,601
Variables au Pas 2						
Age			(12,034)	3	0,007	
Age (1)	-0,479	0,358	(1,788)	1	0,181	0,619
Age (2)	-0,709	0,305	(5,393)	1	0,020	0,492
Age (3)	**0,566**	0,291	(3,795)	1	0,051	**1,761**
Rev			(10,654)	5	0,059	
Rev (1)	-1,282	0,782	(2,685)	1	0,101	0,278
Rev (2)	-0,595	0,466	(1,633)	1	0,201	0,551
Rev (3)	-0,389	0,370	(1,107)	1	0,293	0,678
Rev (4)	-0,142	0,325	(0,192)	1	0,661	0,867
Rev (5)	**0,737**	0,359	(4,205)	1	0,040	**2,089**
Constante	-0,354	0,160	(4,931)	1	0,026	0,702

Source : Auteurs.

(Tableau 2) : i) la catégorie « personnes mariées sans enfants (ménage 1) » a un effet positif sur la consommation des produits agroécologiques comparativement à la catégorie précédente « personnes vivant seul » ; ii) la catégorie « personnes mariées avec enfants (ménage 2) » a un effet plutôt négatif sur la consommation de ces produits comparativement à la catégorie précédente « personnes mariées sans enfants » ; iii) la catégorie « personnes vivant avec leurs parents (ménage 3) » a un effet plutôt positif sur cette consommation comparativement aux personnes mariées avec enfants. Les catégories « personnes mariées sans enfant » et « personnes vivant avec leurs parents » ont des effets significatifs (respectivement Sign.=0,001 et 0,031), positifs et très importants (respectivement Exp(B)=3,434 et 2,150) sur la consommation des produits agroécologiques.

- Modèle 2 basé sur la méthode pas à pas ascendante (Wald) avec une méthode de contraste dite Différence appliquée aux variables catégorielles – catégorie d'âge et catégorie de revenu – (Différence : Chaque catégorie de la variable de prédicteur – hormis la première catégorie – est comparée avec l'effet moyen des catégories précédentes. (Aussi connu sous le nom de contrastes inversés d'Helmert.) et une méthode de contraste dite Répété appliquée aux variables sexe et catégorie socioprofessionnelle (Répété : Chaque catégorie de la variable de prédicteur – hormis la première catégorie – est comparée avec la catégorie précédente). Les variables indépendantes du modèle sont : catégorie de revenu, catégorie socioprofessionnelle, catégorie d'âge et genre ; tandis que la variable structure du ménage a été enlevée de l'échelle. Le modèle est significatif (0,004) et prévoit correctement 67% des observations.

  Ce modèle fait ressortir au second pas (Pas 2) deux variables ayant un effet significatif sur la consommation des produits agroécologiques (Tableau 3) : catégorie d'âge (Sign. = 0,007 au pas 2) et catégorie de revenu (Sign. = 0,059 au pas 2). Pour la variable âge, le modèle indique que la catégorie plus de 50ans (modalité Age 3) a un effet positif significatif sur la consommation des produits agroécologiques (B = 0,566 ; sig. = 0,051<0,1 ; Exp(B) = 1,761) supérieur à l'effet moyen de l'ensemble des catégories d'âge inférieures. Concernant la variable revenu, le modèle fait ressortir que la catégorie supérieure à 100 mille DZD/mois (modalité revenu5) a un effet positif très significatif sur la consommation de ces produits (B = 0,737 ; sig. = 0,026<0,05 ; Exp(B)=2,089) par rapport à l'effet moyen de l'ensemble des catégories de revenu inférieures.

5. Motivations liées à la consommation des produits agroécologiques

En ce qui concerne les consommateurs enquêtés directement au marché paysan El Fayet, ils ont tous adhéré volontairement au dispositif TAFAS en étant membre du collectif Torba (58%), ou après avoir pris connaissance de ce dispositif par l'intermédiaire d'une tierce personne (22%), les 20% restants ont adhéré grâce aux réseaux sociaux. Trois quarts des personnes interrogées consomment plusieurs fois par semaine les produits agroécologiques. Elles sont motivées principalement par la qualité jugée meilleure de ces produits (goût, fraîcheur) suivie par la perception de leurs effets bénéfiques sur la santé humaine (32,5%). A l'inverse, les attributs environnementaux liés à ce type de produits constituent un motif très faible (5%) (*cf*. Annexe 1).

Quant aux consommateurs des produits agroécologiques enquêtés en ligne qui représente 37,5% du total des personnes enquêtées (*cf*. Annexe 2), ils sont répartis entre consommateurs réguliers consommant ces produits entre une fois (19,5%) à 2 ou 3 fois par semaine (60,2%) et consommateurs plutôt occasionnels avec une fréquence d'une fois par mois (5%) ou plutôt rare (12%). Les aliments consommés sont par ordre d'importance décroissant : les légumes (63,6%), les fruits (33,1%), les œufs et poulet (16,9%) et les produits laitiers (11,9%). Les motivations des consommateurs sont liées principalement à la perception des effets bénéfiques de ces produits sur la santé pour près de

la moitié des consommateurs (48,3%) suivie par la perception que ces produits sont de meilleure qualité (goût, et fraîcheur) (42,4%). Par contre, le motif environnemental lié à la consommation de ces produits est plutôt très faible (6,8%). La variable motivation n'est pas corrélée de façon significative avec les caractéristiques sociodémographiques des répondants au questionnaire.

5.1. *Comparaison entre sous-groupes de consommateurs définis par leur motivation*

Une caractérisation des sous-groupes de consommateurs, définis par leur motivation (meilleure qualité, bienfaits sur la santé, respect de l'environnement) à consommer les produits agroécologiques est faite par rapport aux variables sociodémographiques, leur perception de l'offre locale des produits agroécologiques, à leurs attentes et suggestions pour développer la filière agroécologique, à leurs consentement à payer ces produits et à leurs comportements de consommation/achat des aliments agroécologiques. Cette analyse descriptive a été effectuée pour les deux enquêtes : directe et en ligne.

a) Cas de l'enquête directe auprès des consommateurs adhérents au dispositif de solidarité avec les paysans

Les consommateurs enquêtés perçoivent en majorité que les produits agroécologiques sont peu disponibles (82,5%), leurs prix sont plutôt corrects (82,5%) et sont plutôt sûrs de la qualité des produits distribués au marché paysan « El Fayet » (72,5%). Compte tenu du coût de la certification, les personnes interrogées consentent de payer un prix plus élevé pour les produits certifiés « bio » (87%), cependant, pour (57,5%), cette augmentation doit être plutôt modérée (+25%). Pour les personnes qui refusent de payer plus cher, elles avancent l'argument du faible coût de ces produits car cultivés de façon traditionnelle sans recours aux produits chimiques (23,5%) et vendus en circuits courts (11,8%) ou doivent être, en principe, accessibles à toutes les catégories de revenu (23,5%). Tous les consommateurs enquêtés pensent à l'unanimité que la filière des produits agroécologiques présente un avenir prometteur en Algérie (*cf*. Annexe 1).

Le test Khi-deux de Pearson entre la variable motivation et les autres variables sociodémographiques, la perception, l'attitude et le comportement des consommateurs font ressortir les corrélations les plus significatives : catégorie d'âge (0,018), catégorie socioprofessionnelle (0,002), suggestion pour améliorer la disponibilité (0,075) et raisons de ne pas payer plus cher les aliments s'ils sont certifiés (0,012). La caractérisation des sous-groupes de consommateurs s'est appuyée aussi sur la comparaison de la distribution/proportion des caractéristiques (ou modalités des variables) dans les sous-groupes par rapport à leur distribution/proportion dans l'échantillon entier (pourcentage d'une modalité dans un sous-groupe par rapport au pourcentage de la même modalité dans l'échantillon total) qui a permis d'observer plusieurs différences:

- Les consommateurs *motivés par la qualité meilleure des aliments agroécologiques* sont caractérisés sur le plan sociodémographique par la prépondérance des catégories d'âges 40-50 et 50-60 ans, l'importance relative de la catégorie socioprofessionnelle « profession libérale », une diversité des catégories de revenu (30-50, 50-70 et 70-100 mille DZD/mois), une fréquence de consommation plutôt faible(1fois par semaine), une perception que les produits sont plutôt peu disponibles mais sont plutôt sûrs de la qualité des produits sur le marché El-Fayet. Par rapport aux problèmes liés à l'offre, ils proposent de multiplier les contrats de solidarité entre consommateurs et producteurs (exemple de TAFAS) pour accroître la disponibilité et préfèrent s'assurer de la qualité à travers les réseaux de relations de confiance entre producteurs et consommateurs. Ce sous-groupe de consommateurs n'est plutôt pas disposé à payer plus cher ces produits, justifiant ceci par leurs faibles coûts de production liés au mode traditionnel qui ne fait pas recours aux intrants chimiques. De plus, ils estiment que les produits agroécologiques doivent être en principe accessibles à tous.
- Les consommateurs *motivés par les bienfaits sur la santé des aliments agroécologiques* se distinguent principalement par la prépondérance des personnes âgées (61 ans et plus) et

corrélativement de la catégorie socio professionnelle de « retraités ». Leur comportement de consommation est caractérisé par des fréquences plutôt élevées (n fois par semaine), avec une perception que les produits sont plutôt disponibles mais ne sont plutôt pas sûrs de leur origine et leur qualité. Par rapport à ces problèmes, ils suggèrent plutôt la solution de la certification biologique et souhaitent une prise en charge de cette solution par l'Etat comme levier de croissance de l'offre des produits agroécologiques. D'ailleurs, ce sous-groupe perçoit que les prix pratiqués sont plutôt corrects et il est plutôt d'accord de payer une augmentation modérée des prix (+25%) si les produits seront certifiés. Quelques-uns ne consentent pas de payer plus cher car ils considèrent que la vente en circuit court, en éliminant les intermédiaires, devrait en principe permettre de réduire le coût de distribution.

- Les consommateurs *motivés par le respect de l'environnement lié au mode de production écologique* sont, comparativement aux autres sous-groupes, hétérogènes sur le plan sociodémographique (coprésence de catégories d'âge plutôt jeune (30-40 ans) et personnes âgée (61 ans et plus), catégories socioprofessionnelles « cadre supérieur » et « employé »), mais leur revenu mensuel est plutôt élevé (≥70 mille DZD, leur comportement de consommation est caractérisé néanmoins par une fréquence plutôt faible (1 fois par semaine), une perception que les produits sont peu disponibles mais ils sont plutôt sûrs de leur qualité. Pour résoudre le problème de disponibilité, le sous-groupe se distingue par la proposition de créer « une marque » commune pour une commercialisation plus large des aliments agroécologiques. Ces personnes considèrent que les prix pratiqués sont déjà élevés et ne sont plutôt pas disposés à payer plus cher les produits certifiés. La raison unique est qu'ils ont d'autres priorités de dépenses.

b) Cas de l'enquête en ligne

Sur le plan de la perception de l'offre locale des produits agroécologiques, les avis des consommateurs sont partagés entre l'offre plutôt peu disponible (50%) et disponible (47,5%). Les produits sont achetés directement chez les fermiers (63,6%), chez un magasin de proximité (13,6%) ou autoproduit (11,9%). Près de deux tiers des consommateurs considèrent les prix de ces produits plutôt corrects (61%) contre un tiers qui jugent les prix élevés (31,4%) ou très élevés (2,5%). La majorité des consommateurs sont plutôt sûrs de la qualité des produits distribués (58,5%). Plus de la moitié de ces derniers demandent la certification de la qualité (54,3%) tandis qu'un pourcentage important préfère le réseau de vente directe ou de proximité basé sur des relations de confiance (43,5%). Compte tenu du coût élevé de la certification, la majorité des consommateurs consentent de payer plus cher les produits certifiés (64,4%), néanmoins, ils acceptent une augmentation modérée du prix (+25% plus cher) (78,9%). En dernier, les consommateurs expriment deux attentes principales par rapport à l'offre locale de produits agroécologiques : une meilleure gamme de produits (50,8%) et des quantités plus importantes (45,8%) (*cf*. Annexe 2). En général, la grande majorité des répondants – consommateurs et non-consommateurs de produits agroécologiques – estime que la filière dispose potentiellement d'un avenir prometteur en Algérie (81%).

Le test Khi-deux de Pearson entre la variable motivation et les autres variables sociodémographiques et variables liées à la perception, l'attitude et le comportement et les attentes par rapport à l'offre locale font ressortir les corrélations les plus significatives : *la consommation des produits laitiers (khi-deux=0,003), source d'achat (0,055), perception de la disponibilité (0,002), attentes par rapport à l'offre locale (0,003)*. De plus, la comparaison de la distribution/proportion de ces caractéristiques ou modalités dans les sous-groupes de consommateurs par rapport à l'échantillon entier des enquêtés a fait ressortir les différences suivantes :

- Les consommateurs *motivés par la qualité meilleure des aliments* sont caractérisés par un effectif masculin prédominant, par une consommation relativement élevée de produits laitiers et par l'achat direct auprès des producteurs, par la perception que les ali-

ments agroécologiques sont peu disponibles, que leurs prix sont plutôt corrects, une attente d'améliorer la gamme (diversifier l'offre de produits), avec une proposition pour garantir la qualité des produits par le renforcement des réseaux de relation de confiance entre producteurs et consommateurs.

- Les consommateurs *motivés par les bienfaits sur la santé* sont caractérisés par une légère supériorité de l'effectif féminin, une importance relative de catégorie « retraité », par une consommation plutôt faible de produits laitiers, une autoproduction ou un achat dans les magasins de proximité ; une perception que les produits sont plutôt disponibles et leurs prix plutôt élevés, une attente d'accroitre la disponibilité des produits avec une suggestion de la certification pour s'assurer de leur qualité. Ils sont plutôt favorables de payer plus cher les produits certifiés si l'augmentation est modérée.
- Les consommateurs *motivés par les attributs liés au mode de production respectueux de l'environnement* sont caractérisés, sur le plan sociodémographique, par une prépondérance des femmes, et par une hétérogénéité des catégories d'âge et des catégories de revenu; sur le plan du comportement de consommation/achat, par l'absence de consommation de produits laitiers et de fruits, par l'achat plus important au niveau des grandes surfaces comparativement aux autres sous-groupes; par la perception que les produits sont disponibles et leurs prix plutôt très élevés, par l'attente d'améliorer la gamme des produits (diversifier l'offre), par la suggestion de certifier la qualité des aliments et, en dernier, une proportion relativement élevée des personnes sceptiques quant à l'avenir de la filière agroécologique en Algérie.

5.2. *Les obstacles à la consommation des produits agroécologiques*

L'enquête en ligne révèle que les non-consommateurs des produits agroécologiques avancent deux causes principales : la non disponibilité (51,3%) et les prix élevés de cette catégorie de produits (40,6%). Tandis qu'une minorité déclare ne pas être intéressée par ce type de produits (7,6%).

6. Discussion

Les résultats sont discutés et comparés à ceux des recherches empiriques antérieures selon trois aspects : la caractérisation de la demande de produits agro-écologiques et des facteurs sociodémographiques qui la déterminent ; le vecteur principal de motivation et les contraintes majeures à consommer ce type d'aliments :

6.1. *Une demande potentielle importante et régulière pour les produits agroécologiques modulée par des caractéristiques sociodémographiques : revenu, âge et structure du ménage*

Les résultats de l'enquête en ligne montrent que plus d'un tiers (37,5%) des répondants consomment les produits agroécologiques. Ce pourcentage avoisine les résultats des recherches empiriques sur la consommation des aliments biologiques menées en Tunisie, pays voisin, (Mtimet *et al.*, 2020 ; Callieris *et al.*, 2016). Dans notre cas d'étude, les consommateurs de produits agroécologiques enquêtés sont en majorité réguliers (80% déclarent en consommer une à trois fois / semaine). Les aliments consommés sont principalement les légumes et les fruits, et dans une moindre mesure, les produits de volaille et les produits laitiers. L'ordre dans la nature des aliments consommés correspond aussi à celui révélé par l'étude de Mtimet *et al.* (2020) que les fruits et légumes frais sont classés en tête tandis que les produits laitiers sont en queue du classement.

Sur le plan sociodémographique, les résultats de la régression logistique appliquée aux données de l'enquête en ligne démontrent le rôle important de la catégorie sociale à revenu élevé et, dans une moindre mesure, de la catégorie plutôt âgée dans la consommation des produits agroécologiques. Pour ce qui est de l'effet du revenu, l'étude de Mtimet *et al.* (2020), par exemple, a montré dans le contexte tunisien l'influence importante du revenu du ménage

sur la décision d'achat et de consommation des produits biologiques. Un grand nombre d'analyses dans différents contextes ont montré que la majorité des consommateurs des aliments biologiques jouissent d'une bonne situation économique (Yadegari, 2022 ; OFAG, 2022 ; Nikolić, 2018 ; Kashani-Nazari *et al.*, 2016 ; McCarthy et Murphy, 2013). En ce qui concerne l'effet de l'âge, selon Kashani-Nazari *et al.* (2016), des études pionnières sur le profil démographique ont montré que les consommateurs des produits biologiques sont généralement plutôt jeunes, par contre, des études plus récentes ont révélé que les consommateurs de ces produits tendent (depuis les années 1990) à être plus âgés.

En outre, les résultats de l'analyse révèlent que la consommation des produits agroécologiques est modulée par la structure/composition du « ménage » (personnes vivant sous le même toit) : les personnes vivant avec leurs parents âgés et les personnes mariés sans enfants ont un effet positif plus important par rapport respectivement aux personnes mariées avec enfants et les personnes vivant seules. Ces résultats contredisent quelques analyses qui ont révélé l'effet positif des personnes mariées avec enfants sur la consommation des aliments biologiques dans les pays développés (McCarthy & Murphy, 2013). Ces résultats renvoient néanmoins aux autres analyses qui ont démontré l'effet de l'âge et du revenu élevé sur la consommation des aliments biologiques (Kashani-Nazari *et al.*, 2016 ; Mtimet *et al.*, 2020).

6.2. *Le facteur santé humaine, un vecteur principal de la motivation pour consommer les produits agroécologiques*

En ce qui concerne les motivations des consommateurs, l'analyse des données des deux enquêtes révèlent qu'elles sont principalement liées à la perception des bienfaits des produits agroécologiques sur la santé humaine et à la perception que ces produits sont de meilleure qualité (goût, fraicheur). Ces résultats correspondent à ceux révélés par de nombreuses analyses dans différents contextes (Nikolić, 2018). En outre, les résultats des deux enquêtes montrent que l'argument environnemental reste un motif de consommation très faible (6,8% des consommateurs d'aliments écologiques enquêtés en ligne et 5% des consommateurs enquêtés directement). Ce résultat confirme les analyses antérieures qui ont démontré que les consommateurs sont motivés plus par leurs intérêts égoïstes (bénéfices sur la santé et qualité des aliments) comparativement aux considérations altruistes liées au respect de l'environnement et de bien-être animal ou de développement durable (Magnusson *et al.*, 2003).

La synthèse des résultats de la comparaison entre sous-groupes de consommateurs définis par leurs motivations à consommer les produits agroécologiques permet de faire ressortir des différences saillantes :

1. Le sous-groupe de consommateurs *motivé par la qualité meilleure des produits agroécologiques* par rapport aux produits conventionnels est caractérisé par la prépondérance du genre masculin, la perception que les produits sont peu disponibles et sont plutôt favorables à la multiplication des dispositifs de distribution basés sur les réseaux sociaux de confiance entre producteurs et consommateurs (vente directe, circuits courts ; ...);
2. Le sous-groupe de consommateurs *motivé par les bienfaits sur la santé* est caractérisé par une prépondérance du genre féminin, des personnes plutôt âgées et corrélativement de la catégorie socioprofessionnelle de retraités et une fréquence de consommation relativement élevée. Ce sous-groupe est plutôt favorable à la certification biologique de la qualité des produits et disposé à payer une augmentation modérée des prix;
3. Le sous-groupe de consommateurs *motivé par les attributs environnementaux des produits agroécologiques* est très hétérogène sur le plan sociodémographique avec néanmoins une supériorité du genre féminin par rapport au taux moyen des femmes dans l'échantillon, et se distingue par la perception que les prix des produits agroécologiques sont plutôt élevés. Les résultats relatifs au fait que les femmes sont plus motivées par les bienfaits des aliments écologiques sur la santé et sur l'environnement, comparativement aux hommes, sou-

tiennent les analyses antérieures qui ont révélé une différence d'attitude et d'intention pour l'achat des produits biologiques entre les hommes et les femmes, que ces dernières tendent à porter plus d'attention pour la santé et l'environnement, et par conséquent, à avoir une attitude et une intention positives pour acheter les produits biologiques (Irianto, 2015).

6.3. *Des contraintes à la consommation liées à la structure de l'offre et de la demande des produits agroécologiques*

Quant aux contraintes à la consommation, les non-consommateurs des aliments écologiques évoquent principalement la non-disponibilité de ces produits (insuffisance de l'offre) et les prix élevés de cette catégorie d'aliments. Ces résultats sont largement démontrés par une multitude d'analyses sur les limitations à la consommation des aliments écologiques dans différents contextes (Nikolić, 2018). Par ailleurs, les données de l'enquête révèlent l'existence d'une catégorie de personnes, néanmoins de faible pourcentage, non intéressée par les aliments écologiques/biologiques (7,6% des non-consommateurs). Cette dernière catégorie correspondrait à celle des « anti-green consumer » décrite par Boukhedimi (2021) et Boukhedimi (2022).

7. Conclusion

Cette recherche empirique révèle que plus d'un tiers des personnes enquêtées consomment des produits agroécologiques, de façon plutôt régulière. En outre, elle montre l'influence des catégories à revenu élevé et des catégories âgées sur la consommation des produits agroécologiques. Les motivations des consommateurs sont principalement liées aux bienfaits sur la santé et à la qualité meilleure de ces produits, avec une tendance particulière des femmes à porter plus d'attention pour la santé et l'environnement comparativement aux hommes. Par contre, les contraintes majeures de non-consommation sont liées à au manque de disponibilité et aux prix élevés des produits agroécologiques sur le marché domestique. Ces différents résultats correspondent à ceux issus de nombreuses recherches antérieures menées dans les différents contextes socioéconomiques des pays développés ou en développement.

Cependant, cette recherche exploratoire présente plusieurs limites à la généralisation des résultats obtenus qui sont liées, notamment à la méthode de collecte des données en ligne basée sur un échantillon de convenance, au lieu d'un échantillon aléatoire stratifié représentatif de la population de consommateurs, et au fait de regrouper l'ensemble des produits agroécologiques dans une variable dépendante unique au lieu de différencier les catégories de produits. Néanmoins, cette recherche exploratoire s'inscrit dans la perspective d'approfondir les analyses pour permettre une meilleure compréhension du comportement du consommateur algérien vis-à-vis des produits agroécologiques.

Les implications des analyses du comportement d'achat et de consommation des produits agroécologiques sont multiples : contribuer sur le plan scientifique à identifier le profil sociodémographique du consommateur et vérifier la théorie du comportement planifié dans le contexte algérien ; offrir aux acteurs économiques les éléments de connaissance pour concevoir des stratégies de marketing ; indiquer aux pouvoirs publics les leviers d'action en vue d'une transition vers une alimentation saine et durable. A ce titre, les éléments de résultats de cette recherche empirique permettent d'identifier au moins quatre leviers d'action : la sensibilisation des consommateurs (en particulier des jeunes) sur les bienfaits des produits agroécologiques principalement sur la santé humaine ; la promotion et la généralisation des circuits courts à l'échelle des territoires pour un rapprochement entre producteurs et consommateurs (organisation de marchés paysans et multiplication des points de vente) ; la certification de la qualité des produits agroécologiques pour les différencier et les valoriser ; l'intervention des pouvoirs publics pour soutenir ces actions et pour lever les contraintes structurelles à la consommation et au développement des filières agroécologiques.

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Annexes

Annexe 1 - Caractéristiques sociodémographiques, perception et attitude des consommateurs en fonction de leur motivation à consommer les aliments agroécologiques – enquête directe des consommateurs adhérents au dispositif TAFAS, 2021.

Caractéristique	*Modalité*	*Motivation de consommer les produits agroécologiques*			*Effectif total*
		Meilleure qualité	*Bienfaits sur la santé*	*Respect de l'environnement*	
Genre	F	10	8	1	19
	H	15	5	1	21
Catégorie d'âge	Age 20-30ans	4	0	0	4
	Age 31-40ans	3	0	1	4
	Age 41-50ans	6	2	0	8
	Age 51-60ans	9	2	0	11
	Age +60ans	3	9	1	13
Structure du ménage	Vit seul	5	3	0	8
	Marié sans enfant	6	2	0	8
	Marié avec enfant	14	8	2	24
Catégorie socioprofessionnelle	Sans emploi	1	4	0	5
	Employé	7	2	1	10
	Cadre moyen	3	1	0	4
	Cadre supérieur	1	0	1	2
	Profession libérale	13	2	0	15
	Retraité	0	4	0	4
Catégorie de revenu	Rev< 20 000 DZD	1	4	0	5
	Rev 20-30 000 DZD	2	0	0	2
	Rev 30 – 50 000 DZD	6	1	0	7
	Rev 50 – 70 000 DZD	5	3	0	8
	Rev 70 – 100 000 DZD	5	1	1	7
	Rev+100 000 DZD	6	4	1	11
Fréquence de consommation par semaine	1 fois	7	2	1	10
	n. fois	18	11	1	30
Comment jugez-vous la disponibilité des produits sur le marché « Souk El Fayet »	Disponibles	3	4	0	7
	Peu disponibles	22	9	2	33
Que suggérez-vous pour améliorer la disponibilité des produits agroécologiques ? (sur 33 qui jugent peu disponible les produits agroécologiques)	-Multiplier les contrats de solidarité avec les agriculteurs (exemple : TAFAS)	15	5	1	21
	-Prise en charge de la certification par le Ministère de l'agriculture	6	4	0	10
	-Créer une marque commerciale pour une diffusion plus large de ces produits	1	0	1	2

Etes-vous sûr de l'origine/ qualité des produits agroécologiques ?	Sûr	19	8	2	29
	Pas sûr	6	5	0	11
Quelle solution proposez-vous pour s'assurer de la qualité des produits ? (sur 11 pas sûr sur la qualité)	-Certification des produits agroécologiques	4	5	0	9
	-Réseau de relations -confiance	2	0	0	2
Comment jugez-vous le prix des produits sur ce marché ?	Correct	21	11	1	33
	Elevé	4	2	1	7
Acceptez-vous de payer plus cher ces produits s'ils sont certifiés ?	D'accord	13	9	1	23
	Pas d'accord	12	4	1	17
Si d'accord de payer plus cher les produits certifiés, jusqu'à quel niveau pourriez-vous payer ? (Sur 23)	+25%	11	8	1	20
	+50%	2	0	0	2
	Sans réponse	0	1	0	1
Si pas d'accord, quelles sont les raisons de ne pas payer plus cher les produits certifiés ? (Sur 17 pas d'accord de payer plus cher)	-Ces produits doivent être accessibles à tout le monde	4	0	0	4
	-Produits cultivés de façon traditionnelle ou ancestrale, ne coûtent pas cher	3	0	0	3
	-Les produits sont vendus en circuits courts (pas d'intermédiaires), donc pas cher	1	1	0	2
	-Ces produits n'utilisent pas des produits chimiques (moins de dépenses)	1	0	0	1
	-J'ai d'autres besoins dans la vie	0	0	1	1
	-Sans réponse	3	3	0	6
Pensez-vous que cette filière aura un avenir prometteur en Algérie ? (sur 40 consommateurs)	Oui	25	13	2	40
	Non	0	0	0	0
Effectif total		25	13	2	40

Source : Auteurs.

Annexe 2 - Caractéristiques sociodémographiques, perception et attitude des consommateurs en fonction de leur motivation à consommer les aliments agroécologiques – enquête en ligne 2021-2022.

Caractéristique	*Modalité*	*Motivation de consommer les produits agroécologiques*			*Effectif total*
		Meilleure qualité	*Bienfaits sur la santé*	*Respect de l'environnement*	
Genre	F	22	29	5	56
	H	28	28	3	59
Catégorie d'âge	Age 20-30ans	16	20	3	39
	Age 31-40ans	7	8	3	18
	Age 41-50ans	11	14	0	25
	Age +51ans	16	15	2	33
Structure du ménage	Vit seul	11	21	3	35
	Marié sans enfants	10	8	1	19
	Marié avec enfants Vit avec les parents	21 8	21 7	4 0	46 15
Catégorie socioprofessionnelle	Sans emploi	5	11	1	17
	Employé	15	17	2	34
	Cadre moyen-supérieur	11	10	3	24
	Profession libérale	16	13	2	31
	Retraité	3	6	0	9
Catégorie de revenu	Rev< 20 000 DZD	1	5	1	7
	Rev 20-30 000 DZD	4	3	1	8
	Rev 30 – 50 000 DZD	10	11	2	23
	Rev 50 – 70 000 DZD	13	10	0	23
	Rev 70 – 100 000 DZD	14	13	2	29
	Rev+100 000 DZD	8	15	2	25
Fréquence de consommation par semaine	Occasionnellement 1 fois /mois 1 fois /semaine	6 3 10	8 3 9	0 0 4	14 6 23
	2à3 fois par semaine	30	37	4	71
Produits consommés	Fruits	19	20	0	39
	Légumes	34	35	6	75
	Œufs et poulet	10	9	1	20
	Produits laitiers	12	2	0	14
Où achetez-vous ces produits ?	Autoproduction	4	10	0	14
	Achat directe à la ferme	39	31	5	75
	Magasins de proximité	3	12	1	16
	Grande surface	4	4	2	10
Comment jugez-vous la disponibilité des produits sur le marché « Souk El Fayet »	Disponibles	15	36	5	56
	Peu disponibles	35	21	3	59

Attentes par rapport à l'offre locale de produits agroécologiques	Une quantité plus importante	21	31	2	54
	Une meilleure gamme	29	26	5	60
	Sans réponse	0	0	1	1
Comment jugez-vous les prix des produits agroécologiques ?	Prix faible Prix correct Prix élevé Prix très élevé	1 37 12 0	1 30 23 2	0 5 2 1	2 72 37 3
Etes-vous sûr de l'origine/ qualité des produits agroécologiques ?	Sûr	30	34	5	69
	Pas sûr	20	23	3	46
Quelle solution proposez-vous pour s'assurer de la qualité des produits ? (sur 11 pas sûr sur la qualité)	-Certification des produits agroécologiques	10	13	2	25
	-Réseau de relations -confiance	10	9	1	20
Acceptez-vous de payer plus cher ces produits s'ils sont certifiés ?	D'accord	32	38	6	76
	Pas d'accord	18	18	2	38
Si d'accord de payer plus cher les produits certifiés, jusqu'à quel niveau pourriez-vous payer ? (Sur 23)	+25%	27	32	4	63
	+50%	5	3	1	9
	+100%	1	5	1	7
Pensez-vous que cette filière aura un avenir prometteur en Algérie ? (sur 40 consommateurs)	Oui	46	54	7	107
	Non	4	3	1	8
Effectif total		50	57	8	115

Source : Auteurs.

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