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

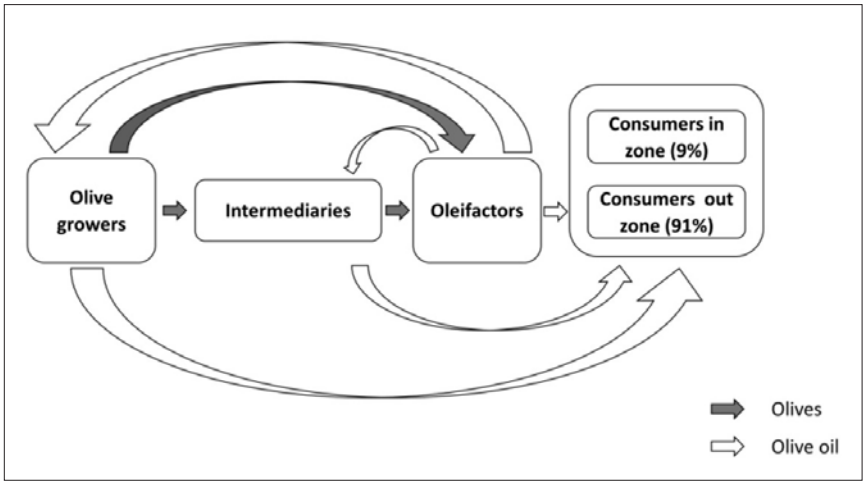


Figure 1 - Olive oil value chain map.

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

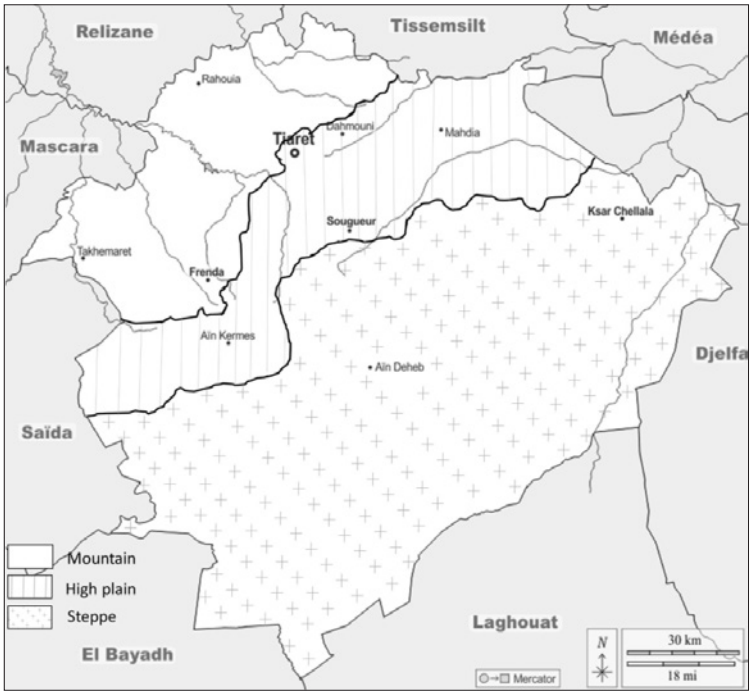


Figure 2 - Geographical location of the Tiaret region and the relief-based boundaries of the study areas.

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.

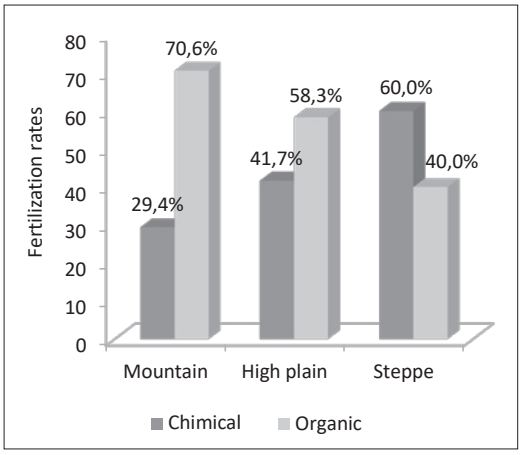
		Mountain	*High plain*	*Steppe*
Irrigation	*Drip system*	08.64%	42.14%	40.45%
	Gravity fed	72.77%	40 .36%	45.64%
	Spray irrigation	18.52%	17.51%	13.91%
Fertilization		72.22%	77.78%	80.00%
Phytosanitary traitement		50.00%	66.67%	80.00%
Soil management		83.33%	90.00%	75.00%

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

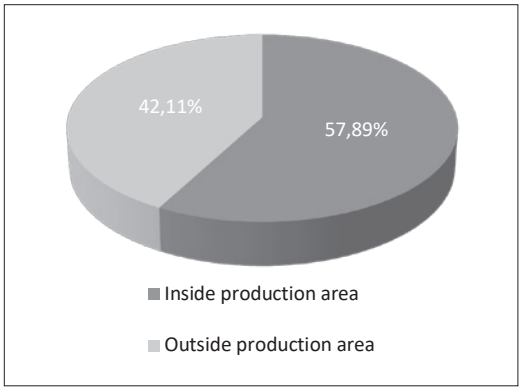
The Tiaret region has two modern, automatic processing units with a three-stage crushing system. One is located in the mountainous region, with a crushing capacity of 30 q/day, and the other in the steppe region with a higher capacity of 240 q/day. The total milling capacity for the region is 270 q/day, 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

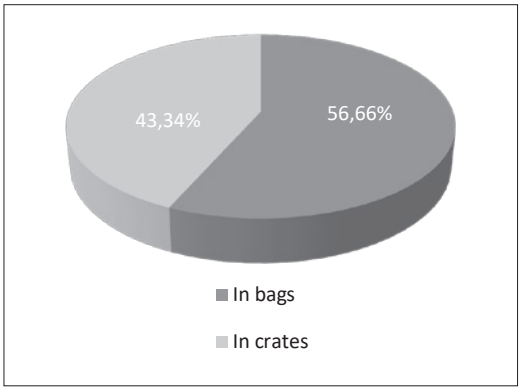
Source: Survey, 2019/2020.

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.

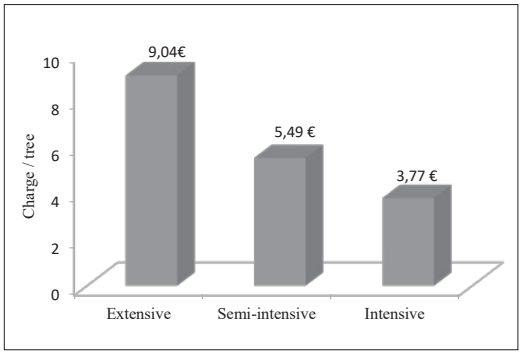
4.3. *Economic analysis of the olive oil value chain*

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

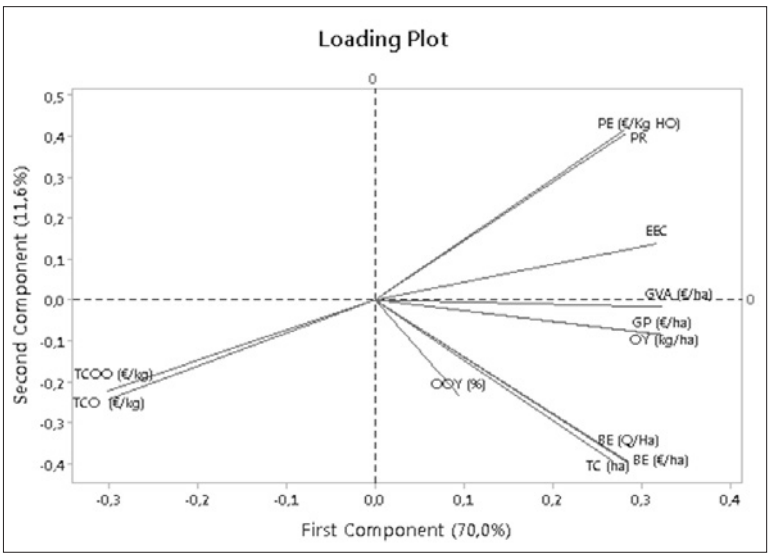


Figure 7 - Loading plot graph.

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

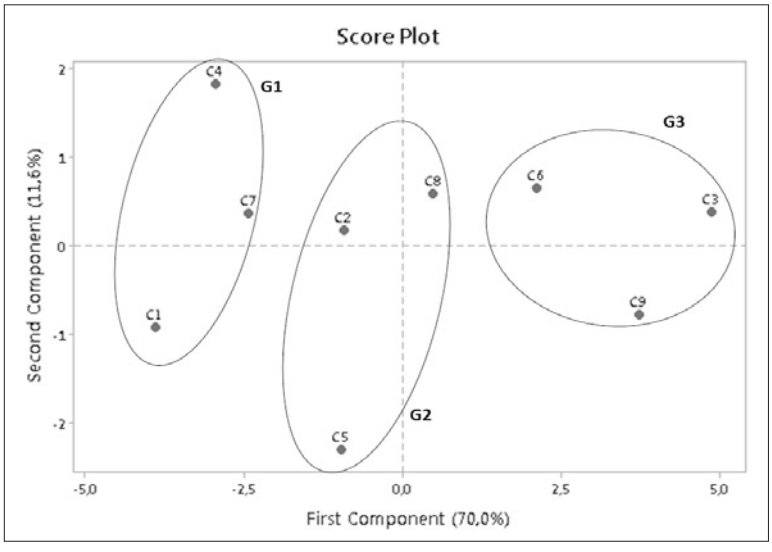


Figure 8 - Score plot graph.

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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