

Dietary patterns and socioeconomic factors affecting Mediterranean diet adherence in Tunisia

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> DOI: 10.30682/nm2502f JEL codes: I9, I18, Q17, Q18, R18, R21

Abstract

This study aims to assess Tunisian consumers' adherence to the Mediterranean diet (MD) and identify socioeconomic factors influencing this adherence. A national survey involving 600 individuals is performed and data are analyzed. The results of the Mediterranean Diet Adherence Screener (MEDAS) score calculation allowed the classification of consumers into three groups: moderate adherence group (68.7% of the total population), high adherence (5%) and low adherence group (26.3%). The Probit model results showed that individuals with high adherence to the Mediterranean diet primarily consume olive oil, fruits, legumes, and fish and that region is negatively associated with low adherence. In addition, a higher adherence was observed in a higher socio category professional like executive senior. These findings highlight the need for targeted promotion and marketing strategies to raise awareness of the Mediterranean diet's benefits and the health risks associated with modern diets.

Keywords: Mediterranean Diet (MD), Survey, Adherence, MEDAS score, Qualitative research, Probit model, Tunisia.

1. Introduction

Over the last few decades, the term "diet" has become extraordinarily popular all over the world. It refers to the style of eating normally adopted by an individual or a community. One of the most famous and widely studied diets is the Mediterranean one. This is a tradition to which the inhabitants and peoples of the Mediterranean basin add or revoke practices, knowledge, products, tastes, appreciations and many other components. According to study carried out in the 1960s (Cresta *et al.*, 1969), Mediterranean diet is characterized by high consumption of cereals, fruit, vegetables, herbal foods and olive oil as the main source of monounsaturated fats and fish, combined with low consumption of potatoes, meat, dairy products, eggs and sweets.

The Mediterranean diet has long been recognized as a healthy dietary pattern associated with numerous health benefits. Several recent epidemiological studies in different countries confirmed

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that adherence to the traditional Mediterranean diet is always linked to a significant reduction in the risk of cardiovascular accidents, the development of certain types of cancer, neurodegenerative diseases such as Parkinson's and type 2 diabetes (Feart *et al.*, 2010; Kastorini *et al.*, 2011; Kesse-Guyot *et al.*, 2012; Martínez-González *et al.*, 2008; Angel *et al.*, 2009, Vernele *et al.*, 2010). However, adherence to this diet can vary considerably from one population to another.

Recently, food consumption was influenced by a number of factors, including availability, climate change, food accessibility, income, socio-economic status, urbanization, globalization and marketing strategies (Kearney, 2010) these changes have led people to move away from the traditional Mediterranean diet, resulting in the emergence of chronic diseases (Sahar *et al.*, 2002) and to adopt an unhealthy diet.

In this context, in Tunisia, the consumption pattern has changed in recent years, (following the increase in prices of some products, notably olive oil, Fish and Nuts. Today, Tunisia imports an average of 160,000 tonnes of seed oils a year. The bulk of these are crude soybean and rapeseed oils (80%), considered to be necessities. In terms of value, these imports are estimated at 533 MD in 2022, broken down into 339 MD for imports of subsidized consumer vegetable oils (soybean oils), 95 MD for non-subsidized consumer vegetable oils (corn and sunflower oils) and 98 MD for other types of vegetable oils. (NSI, 2023). This is strongly expected to have influenced Tunisians' eating habits towards olive oil. In addition, according to data from surveys conducted by the National Institute of Statistics, the Average annual consumption per capita (in kilograms) of olive oil decreased from 8.2 kilograms in 2000 to 7.4 kilograms in 2015. This threat is at the root of the increase in diet-related diseases (60% of causes of death): type II diabetes, obesity, and cardiovascular diseases (Sahar et al., 2002).

In this context, the study of adherence to the Mediterranean diet proved necessary to understand Tunisian preferences and suggests appropriate policies. This work aims to investigate the level of adherence of the Tunisian consumer to the MD and to identify the socio-economic factors determining this behaviour. In a first step, the level of adherence to the Mediterranean diet is carried out on the basis of the calculation of the MEDAS score according to its 14 evaluated criteria. Secondly a Probit model is employed to determine the categories of food products that characterize the consumption of the different groups identified according to their level of adherence to the DM. The data used in this work come from a national survey of food consumption according to the Mediterranean diet. Finally, a conclusion is presented, including some policy implications.

2. Methodology

2.1. Selection of participants and questionnaire design

The study was carried out by the research team of the Laboratory of Research in Technological Innovation and Food Safety, LR22-AGR01-ESIAT.

A Google Forms questionnaire was distributed to the Tunisian population aged from 18 to 67 through social networks (Facebook) as well as institutional and private mailing lists. Part of the survey was conducted in the field to obtain a more representative and diverse sample. Participation in the study was entirely free, voluntary and anonymous, with participants' providing informed consent for data sharing and privacy policy. No personal data was collected, in compliance with laws on the protection of personal data and the guarantee of digital rights. Consequently, this survey did not require the intervention of an ethics committee.

The first section was dedicated socioeconomic characteristics and anthropometric parameters. the second included questions regarding food consumption based on the PREDIMED method's recommendations, while the third section covered dietary habits.

Weight and height are declared by participants and used to calculate body mass index (BMI), expressed in

$$\frac{weight (kg)}{Height (m)2}$$

In the second section, to assess adherence to the Mediterranean diet (MedDiet), participants

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were given a validated 14-item questionnaire (Schröder *et al.*, 2011; Afonso *et al.*, 2014).

The assessment was based on the MEDAS score (Mediterranean Diet Adherence Screener), which was initially developed as part of the PREDIMED (Prevención con Dieta Mediterránea) study designed to evaluate the cardiovascular effects of the Mediterranean diet.

This validated survey consisted of 12 questions on food consumption frequency and 2 questions on eating habits considered characteristic of the Mediterranean diet (Do you use olive oil as the main source of fat for cooking? and Do you prefer eating chicken, turkey, or rabbit instead of beef, pork, hamburgers, or sausages?)

Based on responses to the MEDAS questionnaire, a MEDAS score is calculated, ranging from 0 to 14. Each question received a score of 0 if the condition was not met, or 1 if the condition was met. According to this score, respondents are divided into three categories: (1) low adherence to MD for scores ranging from 0 to 5 (2) medium adherence to DM for scores ranging from 6 to 9, (3) high adherence to DM for scores above 10.

Participants completed the forms directly connected to the Google platform. Once completed, each response was transmitted to this platform and the final database was downloaded as a Microsoft Excel spreadsheet. The questionnaire was disseminated over 3 years from 2021 to 2023.

2.2. Analysis of adherence to Mediterranean diet

2.2.1. Chi-square test

The Chi-square test is used to test hypotheses to determinate whether data conform to expectations. The basic idea behind the test is to compare the observed values in data with the expected values if the null hypothesis is true. In this study, this test is used to determinate the Percentage of Adherence to the Mediterranean Diet according to Socioeconomic Characteristics.

2.2.2. Probit model

Since our explained variable (adherence to the Mediterranean diet) is dichotomous, it requires us to choose an appropriate analysis model. With this in mind, Hurlin (2003) points out that Logit and Probit dichotomous models admit as explained variable, not a quantitative coding associated with the realization of an event (as in the case of linear specification), but the probability of occurrence of this event, conditional on exogenous variables.

The Probit model is a statistical method used in binary classification, which is a type of regression analysis employed to model a binary outcome variable. In the Probit model, the dependent variable is binary, taking on one of two possible values (usually 0 or 1), and the model estimates the probability that the dependent variable is equal to 1 as a function of one or more predictor variables. The dependent variables used are low adherence which takes values of 1 if respondents adhere to a low adherence Mediterranean diet with a score between 0 and 5, and 0 if not. The medium adherence variable takes a value of 1 if respondents adhere to a medium adherence Mediterranean diet, with a score between 6 and 9, and 0 if not. The variable high adherence takes a 1 if participants adhere to a Mediterranean diet with a score above 10.

The independent variables are:

Age, Region, Education level, Socio economic professional, income, olive oil, vegetable, fruit, Meat, Fat, legume, carbonated beverage, Fish and nuts consumption.

 $P (Adhérence = 1) = \varphi (\beta 0 + \beta 1 * Age + \beta 2 * re$ $gion + \beta 3 * Education level + \beta 4 * category + \beta 5 *$ $Income + \beta 6 * Olive oil + \beta 7 * vegetable + \beta 8 *$ $Fruit + \beta 9 * Meat + \beta 10 * Fat + \beta 11 * carbonated$ $Beverage + \beta 12 * legume + \beta 13 * Fish consump$ $tion + \beta 14 Nuts consumption +$

2.3. Statistical analysis

Statistical analysis was performed using SPSS (Statistical Package for the Social Sciences) version 11.0. Results are expressed as mean ± standard deviation or frequency (%). the distribution of selected characteristics is compared between groups, using chi-square x2 tests for categorical variables or Student's t-tests. The significance level was set at 0.05. Probit model and marginal effects were estimated using STATA.

3. Results

3.1. Characteristics of the participants of study

A total of 598 participants from different regions in Tunisia (5 respondents were eliminated because they did not indicate their region), aged from 18 to 75, were selected in the survey, including (179) 29.9% men and 70.1% (419) women with an average of 28.8 old. This over-representation of women in the survey population does not necessarily influence the results of the survey, given that in most Tunisian households, women are responsible for errands and purchases. The demographic and anthropometrics characteristics of the persons interviewed showed a normal BMI was found for 48.8% of the survey sample, 4.8% were classified as underweight, 30.8% as overweight, and 15.5% as obese (moderate and severe) (Table 1).

3.2. Mediterranean diet adherence

3.2.1. Calculate score

26.3% of the total population had low adherence (<5 points) to the MD, while 68.7% had moderate adherence (between 6 and 9 points), and only 5% had high adherence (>10 points) to the MD according to the calculated MEDAS score.

3.2.2. Factors influencing adherence to the Mediterranean diet

Results mentioned in Table 2 showed that the older respondents registered the highest adherence to the MD, while adherence was lower among younger participants. The residents of Sehel (Center East) tend to have a higher adherence to the Mediterranean diet 11.5% compared to the residents of the Greater Tunis region which 71.3% follow a diet with moderate adherence. Income is proportional to MD adherence. Most participants with low adherence are from Greater Tunis and the northern region, particularly Bizerte, have a secondary school education level, and earn less than 500 dinars. In contrast, participants earning over 1500 dinars are more likely to adhere to the Mediterranean diet compared to the rest of the participants. Just one parTable 1 - Characteristics of the population study. The demographic and anthropometrics characteristics of the subjects who answered the questionnaire.

Sociodemographic Variable	Percentage % (n)			
Gender				
Men	29.9 (179)			
Women	70.1 (419)			
Age Group (years)				
18 to 24	25.8 (154)			
25 to 30	31.4 (188)			
31 to 44	29.9 (179)			
45 to 75	12.9 (77)			
Adherence score mean	6.6			
Mean Age (years)	31.73			
Region				
Greater Tunis %	26.8 (160)			
North % (Bizerte + other governorates)	36.6 (219)			
Sehel: Central East %	16.1 (96)			
Central West %	7.9 (47)			
South %"	12.7 (76)			
Educational Level				
Secondary	8.5 (51)			
Higher"	91.5 (547)			
Categories				
Student	26.1 (156)			
Employee	22.2 (133)			
Senior Executive	26.6 (159)			
Other (Retired and jobless): Retired = 8%(12), Jobless: 92% (138)	25,1 (150)			
Income				
Less than 500 dinars	40 (239)			
Between 500 and 1000 dinars	15.4 (92)			
Between 1000 and 1500 dinars	20.4 (122)			
More than 1500 dinars	24.2 (145)			
BMI				
BMI<18.5	4.8 (29)			
18,5 <bmi<24,9< td=""><td>48.8 (292)</td></bmi<24,9<>	48.8 (292)			
25 <bmi <29.9<="" td=""><td>30.8 (184)</td></bmi>	30.8 (184)			
30 <bmi<34.9< td=""><td>10.7 (64)</td></bmi<34.9<>	10.7 (64)			
BMI≥35	4.8 (29)			

Source: our calculation from SPSS.

		Score d'adhérence		
	≤ 5	6-9	≥10	
All population %	26.3 (157)	68.7 (411)	5 (30)	
Gender				
Men	28.5 (51)	64.8 (116)	6.7 (12)	
Women	25.3 (106)	70.4 (295)	4.3 (18)	
Age %				
18-24 years	35.7 (55)	62.3 (96)	1.9 (3)	
25-30 years	29.8 (56)	67 (126)	3.2 (6)	
31-44 years	21.2 (38)	72.6 (130)	6.1 (11)	
45-75 years	10.4 (8)	76.6 (59)	13 (10)	
Region %				
Greater Tunis	26.3 (42)	71.3 (114)	2.5 (4)	
North	35.6 (78)	60.7 (133)	3.7 (8)	
Sehel: Central East	18.8 (18)	69.8 (67)	11.5 (11)	
Central West	12.8 (6)	80.9 (38)	6.4 (3)	
South	17.1 (13) 77.6 (59)		5.3 (4)	
Educational Level %				
Secondary	45.1 (23)	54.9 (28)	0 (0)	
Higher	24.5 (134)	70 (383)	30 (5.5)	
Categories %				
Student	26.9 (42)	70.5 (110)	2.6 (4)	
Employee	24.8 (33)	70.7 (94)	4.5 (6)	
Senior Executive	22 (35)	69.8 (111)	8.2 (13)	
Other (Retired and jobless)	31.3 (47)	64 (96)	4.7 (7)	
Income %				
Less than 500 dinars	31.8 (76)	64.9 (155)	3.3 (8)	
Between 500 and 1000 dinars	30.4 (28)	67.4 (62)	2.2 (2)	
Between 1000 and 1500 dinars	22.1 (27)	73 (89)	4.9 (6)	
More than 1500 dinars	17.9 (26)	72.4 (105)	9.7 (14)	
Class IMC				
BMI<18.5	31 (9)	69 (20)	0 (0)	
18,5 <bmi<24,9< td=""><td>29.5 (86)</td><td>65.8 (192)</td><td>4.8 (14)</td></bmi<24,9<>	29.5 (86)	65.8 (192)	4.8 (14)	
25 <bmi<29.9< td=""><td>22.8 (42)</td><td>71.7 (132)</td><td>5.4 (10)</td></bmi<29.9<>	22.8 (42)	71.7 (132)	5.4 (10)	
30 <bmi<34.9< td=""><td>23.4</td><td>68.8 (44)</td><td>7.8 (5)</td></bmi<34.9<>	23.4	68.8 (44)	7.8 (5)	
BMI ≥ 35	17.2 (5)	79.3 (23)	3.4 (1)	

Table 2 - Percentage of Adherence to the Mediterranean Diet According to Socioeconomic Characteristics.

Source: our calculation from SPSS.

ticipant with severe obesity shows adherence to the Mediterranean diet.

3.2.3. *Compliance Test Results for the Mediterranean Diet*

An analysis of the degree of compliance to the MD with each recommendation of the PRED-

IMED questionnaire was conducted. Table 3 showed a low consumption of olive oil (33%), fruits (18.4%), legumes (27.9%), nuts (12.6%), and fish (7.7%). High consumption of white meat (86.8%), moderate consumption of pasta, rice, vegetables, and other dishes accompanied by sofrito (47%) were observed.

	N	%
1. Using olive oil as the principal source of fat for cooking	439	73.4
2. \geq 4 T (1 T ¹ / ₄ 13.5 g) of olive oil/d (eg, used in frying, slads)	198	33.1
3. 2 or more servings of vegetables/d	342	57.2
4. 3 or more pieces of fruit/d	110	18.4
5. <1 serving of red meat or sausages/d (1portion =	357	59.7
6. <1 serving of animal fat/d	510	85.3
7. < 3 serving / wk of sweets, commercial cakes	428	71.6
8. ≥7 servings of red wine/wk	-	-
9. ≥3 servings of legumes/wk	167	27.9
10. ≥3 servings of fish/wk	46	7.7
11. <1 sweet or carbonated beverages per day?	477	79.8
12. ≥3 servings of nuts/wk	75	12.6
13. Preferring white meat over red meat?	517	86.8
14. ≥2 servings/wk of a dish with a traditional sauce of tomatoes, garlic, onion, leeks sautéed in olive oil	281	47
Mean Score adherence	6.6	

Table 3 - Overall Results Mediterranean Diet Predimed recommendations.

Source: our calculation from SPSS.

3.3. Food habits

The study provides key insights into the dietary and lifestyle habits of the surveyed population. 64.9% of respondents are unfamiliar with the Mediterranean diet, highlighting a gap in awareness of this health-promoting eating pattern. Regarding physical activity, 48.3% of the population engages in sports, indicating a moderate level of exercise participation.

Regarding mealtimes, while 4.3% of respondents spend less than 10 minutes eating their meals, the majority (65.1%) take between 10 and 20 minutes. Additionally, 29.6% allocate 20 to 30 minutes to their meals, and only 1% take more than 30 minutes. Dining location preferences reveal that 88.1% of individuals prefer eating at home, whereas only 15.2% choose to dine at restaurants.

Snacking is prevalent, with 63.1% of respondents reporting regular snacking, while 36.9% do not. The consumption of ready-to-eat meals is also notable, with 58% of individuals incorporating them into their diets. Among them, 13.7% consume these meals more than three times a week, reflecting a shift toward ease foods.

Regarding food purchasing decisions, health impact is the most influential factor, considered

by 45% of respondents. Price is the second most important factor, influencing 41.1% of consumers, while 40.9% consider nutritional composition as a factor in their decision-making. The least important factor is ease of preparation, suggesting that health and nutrition are prioritized over convenience. Additionally, 39.9% of participants consistently use thyme and spices when preparing meals, reflecting a preference for traditional flavors.

Despite the recognized benefits of Mediterranean products such as olive oil, fish, legumes, vegetables, and fruits, their consumption is hindered by key barriers. The most significant reasons are their limited availability (52.5%) and high cost (46.5%). Addressing these challenges through improved accessibility and affordability could play a crucial role in encouraging healthier eating habits within the population.

3.4. Probit model: Association socioeconomic factors and food products with Mediterranean diet according PREDIMED

The accuracy of predictions serves as an indicator of the model's capability to forecast outcomes accurately, and it demonstrates high performance across all three models. Specifically,

		N	%
I tellingtion plice of the mineral for far applies	yes	439	73.4
Othization onve on like principal lat for cooking	No	159	26.6
	Less than one tablespoon	64	10.7
Consumption alive ail (tablespaces) per dev	1 to 2 tablespoons	172	28.8
Consumption onve on (tablespoons) per day	2 to 4 tablespoons	164	27.4
	4 tablespoons or more	198	33.1
	0	25	4.2
Consumption vegetables units per day	1	231	38.6
	2 or more	342	57.2
	0	30	5
Concumption Empits non day	1	234	39.1
Consumption Fruits per day	2	224	37.5
	3 or more	110	18.4
Consumption most nor day	Less than 1	357	59.7
Consumption meat per day	1 or More	241	40.3
Consumption fat per day	Less than 1	510	85.3
(1 unit = 12 g)	1 or more	88	14.7
Consumption beverages per day	Less than 1	477	79.8
Consumption beverages per day	1 or more	121	20.2
Consumption Legumes per week $(1 \text{ portion} = 150 \text{ g})$	Less than 2	439	72.1
Consumption Legumes per week (1 portion = 150 g)	3 or more	167	27.9
	Less than 2	398	65.1
Consumption fish per week (1 portion = 100-150 g fish)	2	163	27.3
	3 or more	46	7.7
Consumption sweets	Less than 3	428	71.6
	More than 3	170	28.4
	Less than 2	390	65.2
Consumption nuts	2	133	22.2
	3 or more	75	12.5
Consumption white meat	yes	517	86.5
Consumption white meat	No	81	13.5
	Never	60	10
Consumption pasta or rice with sofrito	1 or 2 times per week	257	43
	2 or more	281	47

Table 4 - Description variables of food consumption by MEDAS.

Source: our calculation from SPSS.

the correct prediction rate stands at 98.2% for low adherence, 78.2% for moderate adherence, and 94.2% for high adherence.

As shown in Table 10, the LR Chi-square (LR-Chi2) values and their highly significant P-values (p<0.001) provide strong evidence for the validity of the Probit model across all adherence levels. These findings suggest that

the model reliably captures the variability in adherence levels, providing indirect evidence of its robustness. The bootstrap method was applied to confirm these results and to further test the robustness of the model. The bootstrap analysis validated the consistency and significance of the model coefficients across all adherence categories. The agreement between

Food Habits		N	%
Knowledge_ Mediterraneen	Yes	207	34.6
diet	No	388	64.9
Physic activity	Yes	289	48.3
practice	No	308	51.5
Speaking	Yes	382	63.9
Shacking	No	216	36.1
Place of esting	Home	526	88.1
Place of eating	Restaurant	91	15.2
Consumption	Yes	319	53.3
prepared meals	No	279	46.7
	0	228	38.1
Times of	1 time	172	28.8
consumption of	2 times	90	15.1
prepared meals	3 times	82	13.7
	4 times or more	26	4.3
	composition	245	41.1
Food abaiaas	price	244	40.9
rood choices	preparation	111	18.6
	effect on health	268	45
	less than 10 min	26	4.3
Time of eating in	10 to 20	389	65.1
minutes	20 to 30	177	29.6
	more than 30	6	1

Table 5 - Food habits for 598 respondents.

Table 6 - Cultural factors and food consumption (198 respondents added).

N 0/

		1 V	>0
	sometimes	33	16.7
Frequency of	rarely	7	3.5
oil	often	67	33.8
	always	91	46
	never	1	0.5
	sometimes	42	21.2
Consumption of dairy products	rarely	16	8.1
F	often	75	37.9
	always	64	32.3
	sometimes	117	59.1
Consumption of fish	rarely	33	16.7
Consumption of fish	often	38	19.2
	always	10	5.1
	sometimes	29	14.6
Consumption of fruits	rarely	2	1
and vegetables	often	80	40.4
	always	87	43.9
	never	3	1.5
Using thyme and	sometimes	38	19.2
spices when preparing	rarely	12	6.1
meals	often	66	33.3
	always	79	39.9
Reasons of not	availability	104	52.5
Mediterranean	price	92	46.5
products (olive	multimedia	6	3
vegetables and fruit)	substitution	37	18.7

Source: our calculation from SPSS.

the original and bootstrap-estimated results reinforces the reliability of the probit model in explaining adherence behavior. The consistently high and significant LR Chi2 values, together with the validation provided by the bootstrap method, demonstrate the stability and robustness of the model.

Our Probit analysis, exploring influential factors and products related to adherence across low, moderate, and high levels, reveals no noteworthy correlation between age, education level and adherence to the Mediterranean diet.

The Tables 7, 8 and 9 presented the results of Probit estimations on adherence to the Med-

Source: our calculation from SPSS.

iterranean diet. Socioeconomic factors had a significant impact on adherence to the Mediterranean diet.

Region demonstrated a negative effect on low adherence, ($\beta = -0.18$, p-value = 0.008, which explains why residents in the central and southern regions are more likely to adhere to the Mediterranean diet compared to those in the north. The socio-professional Category positively affect-

Variables	Coefficient	Std error	Z statistic	Sig	Interval 195% cl		Effet marginal	P_value marginal effect
Intercept: low adherence (cste)	2.007987	.7385652	2.72	0.007	0.5604257	3.455548		
Predictor 1: age	0.0979505	0.1056409	0.93	0.354	-0.1091018	0.3050027	0.0173806	0.353
Predictor 2: region	-0.1617973	0.0606075	-2.67	0.008	-0.2805858	-0.0430087	-0.0287098	0.007
Predictor 3: education level	-0.1479368	0.2645182	-0.56	0.576	-0.666383	0.3705094	-0.0262503	0.576
Predictor 4: categoy	-0.0025022	0.0709116	-0.04	0.972	-0.1414863	0.1364819	-0.000444	0.972
Predictor 5: income	0.0127136	0.0823209	0.15	0.877	-0.1486323	0.1740595	0.0022559	0.877
Predictor 6: cons_olive oil	-0.6482937	0.0837254	-7.74	0.000	-0.8123925	-0.4841949	-0.1150351	0.000
Predictor 7: cons_vegetables	-0.7122491	0.132871	-5.36	0.000	-0.9726714	-0.4518268	-0.1263836	0.000
Predictor 8: cons_fruits	-0.1884572	0.1006616	-1.87	0.061	-0.3857504	0.0088359	-0.0334404	0.059
Predictor 9: cons_meat	0.9344009	0.1581792	5.91	0.000	0.6243753	1.244427	0.1658028	0.000
Predictor 10: cons_fat	1.222604	0.2157803	5.67	0.000	0.7996826	1.645526	0.2169425	0.000
Predictor 11: cons_beverage	0.9240357	0.176815	5.23	0.000	0.5774846	1.270587	0.1639636	0.000
Predictor 12: cons_legumes	-1.332946	0.2195373	-6.07	0.000	-1.763231	-0.9026609	-0.2365219	0.000
Predictor 13: cons_fish	-0.2741812	0.1291255	-2.12	0.034	-0.5272626	-0.0210998	-0.0486515	0.032
Predictor 14: cons_nuts	1915687	0.1203207	-1.59	0.111	-0.4273929	0.0442555	-0.0339925	0.110

Table 7 - Results of Probit model in the case of low Adherence.

Source: results from STATA.

ed high adherence ($\beta = 0.44$, p-value = 0.046), this suggest that individuals move from lower socio-professional categories (e.g., students) to higher ones (e.g., employees, senior executives), their likelihood of adherence increases.

Consumed food products significantly influenced adherence to the Mediterranean diet.

Olive oil consumption has a positive and significant effect on moderate ($\beta = 0.361$, P-value = 0) and high adherence ($\beta = 1.32$, p-value = 0.000). Conversely, it has a negative impact on low adherence with $\beta = -0.648$, p-value = 0.000 and marginal effect of -0.1151 indicates that increased olive oil consumption lowers the probability of low adherence by 11.51%.

This result demonstrates that olive oil is a key

component of the Mediterranean diet. The other products that have a positive and significant effect on moderate adherence are vegetables with a coefficient of 0.374 The products that have a significant negative impact on moderate adherence are meat (β = -0.26, p = 0.029, ME = -0.07), fat (β = -0.546, p = 0.001, ME = -0.16), and carbonated beverages (β = -0.59, p = 0.000, ME = -0.177). These findings explain that individuals with moderate adherence consume more olive oil and vegetables, while reducing their intake of red meat, fat, and carbonated beverages.

For high adherence, we find that olive oil consumption has a significant and positive effect with a high coefficient of 1.32. Additionally, the consumption of fruits, legumes, and fish also has

Variables	Coefficient	Std error	Z statistic	Sig	Interval 195% cl		Effet marginal	P_value marginal effect
Intercept: moderate adherence (cste)	0.3917553	0.6114361	0.64	0.522	-0.8066375	1.590148		
Predictor 1: age	073448	0.0833041	-0.88	0.378	-0.236721	0.0898249	-0.0218584	0.377
Predictor 2: region	.0627457	0.0474431	1.32	0.186	-0.0302411	0.1557325	0.0186733	0.185
Predictor 3: education level	0581609	0.2224853	-0.26	0.794	-0.4942241	0.3779023	-0.0173089	0.794
Predictor 4: categoy	0406859	0.0569563	-0.71	0.475	-0.1523181	0.0709463	-0.0121083	0.474
Predictor 5: income	0159696	0.064966	-0.25	0.806	-0.1433007	0.1113615	-0.0047526	0.806
Predictor 6: cons_olive oil	0.3619611	0.0631213	5.73	0.000	0.2382457	0.4856765	0.1077209	0.000
Predictor 7: cons_vegetables	0.3748955	0.1091703	3.43	0.001	0.1609257	0.5888652	0.1115702	0.000
Predictor 8: cons_fruits	0.0182628	0.0765441	0.24	0.811	-0.1317609	0.1682864	0.0054351	0.811
Predictor 9: cons_meat	-0.2601704	0.1195045	-2.18	0.029	-0.4943949	-0.0259459	-0.0774276	0.028
Predictor 10: cons_fat	-0.5477106	0.1658577	-3.30	0.001	-0.8727856	-0.2226355	-0.1630006	0.001
Predictor 11: cons_beverage	-0.5974356	0.1451423	-4.12	0.000	-0.8819092	-0.3129619	-0.1777989	0.000
Predictor 12: cons_legumes	0.202791	0.1342068	1.51	0.131	-0.0602494	0.4658315	0.0603513	0.131
Predictor 13: cons_fish	-0.0871756	0.0931067	-0.94	0.349	-0.2696614	0.0953103	-0.0259438	0.348
Predictor 14: cons_nuts	-0.0091607	0.0862765	-0.11	0.915	-0.1782596	0.1599381	-0.0027263	0.915

Table 8 - Results of Probit model in the case of moderate Adherence.

Source: results from STATA.

a significant positive effect on high adherence. Red meat has a negative effect on high adherence to the Mediterranean diet. Olive oil, fruits, legumes, and fish characterize the diet of Tunisians who exhibit high adherence.

For low adherence, the consumption of olive oil, vegetables, fruits, legumes and fish has a significant negative effect.

The consumption of red meat, fats and carbonated beverages has a positive effect on low adherence. Participants showing low adherence tended to consume red meat, fats, carbonated drinks, and sweets, while avoided consuming olive oil, vegetables, fruits, legumes, fish, and nuts.

4. Discussion

Our research emphasized the significance of the Mediterranean diet, a culinary heritage shared by Tunisia and other Mediterranean nations, which is gradually fading in favor of a more contemporary dietary regimen. The present study described the patterns of the MD in a sample survey of adult Tunisian population and its association with socioeconomic factors using the MEDAS screener and the Probit model. This method has been recently validated as a reliable tool for assessing adherence to the Mediterranean diet across various countries in the Mediterranean regio (García-Conesa, 2020; Cíntia

Variables	Coefficient	Std error	Z statistic	Sig	Interval 195% cl		Effet marginal	P_value marginal effect
Intercept: high adherence (cste)	-12.78445	2.936294	-4.35	0.000	-18.53948	-7.029419		
Predictor 1: age	223026	.2665797	-0.84	0.403	7455126	.2994606	0152156	0.401
Predictor 2: region	.21312	.1583303	1.35	0.178	0972016	.5234417	.0145398	0.170
Predictor 3: education level	0	(omitted)					0	
Predictor 4: categoy csp	0.4471832	.2242672	1.99	0.046	.0076277	.8867388	.0305084	0.040
Predictor 5: income	0.5131645	.2104712	0.54	0.049	2993515	.5256806	.0077205	0.591
Predictor 6: cons_olive oil	1.325415	.3433408	3.86	0.000	.6524793	1.99835	.0904243	0.000
Predictor 7: cons_vegetables	0	(omitted)					0	
Predictor 8: cons_fruits	0.9482344	.2764718	3.43	0.001	.4063596	1.490109	.0646918	0.000
Predictor 9: cons_meat	-1.803861	.4621507	-3.90	0.000	-2.70966	8980626	1230655	0.000
Predictor 10: cons_fat	0	(omitted)					0	
Predictor 11: cons_beverage	-1.554809	1.202846	-1.29	0.196	-3.912344	.8027265	1060743	0.192
Predictor 12: cons_legumes	2.537323	.5267845	4.82	0.000	1.504844	3.569802	.1731047	0.000
Predictor 13: cons_fish	1.402682	.3273239	4.29	0.000	.7611391	2.044225	.0956957	0.000
Predictor 14: cons_nuts	.1863832	.2128783	0.88	0.381	2308507	.6036171	.0127157	0.380

Table 9 - Results of probit model in the case of high adherence.

Source: results from STATA.

Ferreira-Pêgo *et al.*, 2019; Hidalgo Mora, 2020). Among the various adherence scores developed, the 14-item MEDAS screening tool, initially validated for the Spanish population in the PREDIMED study (Schröder *et al.*, 2011), has been widely studied for its applicability in several countries worldwide (Hebestreit *et al.*, 2017; Bottcher *et al.*, 2018; Papadaki *et al.*, 2018; Know *et al.*, 2020). The PREDIMED score derived from the MEDAS differs slightly from those used in other studies. It establishes specific cutoff points for the intake of key Mediterranean diet components, such as nuts, legumes, and olive oil, while also considering the consumption of non-traditional Mediterranean foods, including sugary soft drinks and pastries (Schröder *et al.*, 2011). The use of MEDAS in research in Tunisia is not yet widely adopted, and this method is among the first applications of its kind in this study. One of the limitations attributed to the 14-MEDAS is that, in most studies, this score was validated for a specific sample population (i.e., individuals aged 55 to 80 years at high risk of coronary heart disease), meaning the results cannot be generalized to the broader population. However, the validity of the 14-MEDAS has also been analyzed in other studies, such as the one by García-Conesa *et al.* (2020), which assessed it in a general adult population (>18 years old) across various Southern European countries. In our study, the 14-MEDAS questionnaire is also used for a general adult population, without specific age restrictions, there by broadening the scope of the results and providing a better understanding of Mediterranean diet adherence in a more general context. Another limitation is that the MEDAS primarily focuses on specific components of the diet. For this reason, we have integrated questions regarding dietary factors and eating habits to obtain a more comprehensive assessment of Mediterranean diet adherence, as well as the impact of socio-economic, cultural factors, and eating behaviors.

The results of MEDAS showed that the majority of the participants have a moderate adherence to traditional Med Diet. Approximately 26.3% of the total population exhibited poor adherence to the Mediterranean diet, scoring at least 5 points on the 14-point questionnaire, while 68.7% displayed moderate adherence, and only 5% had high adherence, scoring 10 points or more.

In the Probit model findings, high adherence to the MD is characterized by high intake of fruits, fish, olive oil and legumes according to the MD score, and by the absence of meat consumption. The parametric terms found to be significant predictors of moderate adherence in this study were olive oil consumption and vegetable consumption with positive effect, meat consumption, fat intake, and the consumption of carbonated beverages with negative effect.

Among the factors and products influencing positively the probability of having a low score of adherence to MD were meat consumption, fat consumption and carbonated beverage. Region, olive oil consumption, vegetable consumption, fruit consumption, legume consumption fish consumption had a significantly negative impact on low adherence.

Results showed that high adherence rate was observed among participants, primarily concentrated in the Central East Sehel governorate and that the majority of adherents to the mediterranean diet in this region are aged between 45 and 75, with a university education, holding senior positions, and earning an income exceeding 1500 dinars. This can be explained by the fact that this region is renowned for its high production of seafood and olive oil. (Arfaoui *et al.*, 2022).

Olive oil consumption in the Center-East region was the highest compared to other regions, with an average of 12.6 kg per capita per year, compared to the national average of 7.4 kg per capita in 2015 (NSI). This disparities between coastal and continental Tunisian inhabitants of fish and sea food consumption depending on the availability and supply of fish products, consumption habits and product quality are proven by the finding of Dhehibi et al., 2005. The average fish consumption in the Center-East region is 16.5 kg per capita per year, compared to a national average of 9.3 kg per capita per year, according to the Tunisian statistics of the National Institute of Statistics in 2015 and that older individuals maintain loyalty to traditional lifestyles and dietary habits acquired during their upbringing, leading them to eschew modern dishes and fast foods also taking into account that the majority are farmers of these products. This shift is characterized by a decreased intake of essential MD foods like fruits, vegetables, and legumes, coupled with an increased consumption of fats and proteins (Naska and Trichopoulou, 2014; Sahingoz and Sanlier, 2011). Similarto the Casa Blanca (Mohtadi et al., 2020) study and the work of El Rhazi and colleagues (El Rhazi et al., 2012). However, they examined sociodemographic factors related to Mediterranean diet adherence in a Moroccan population and found no correlation between age and adherence to the Mediterranean diet.

In the other hand, it has been reported that age was predictive factor of MD adherence in most Mediterranean regions as in Spain (Arcila-Agudelo *et al.*, 2019; Buckland *et al.*, 2011), Italy (Grosso *et al.*, 2013), and Greece (Kontogianni *et al.*, 2008; Kyriacou *et al.*, 2015), it is believed that younger people are more likely to adopt western dietary patterns.

It should be also taken into account the effect of advertising and the media, and the promotion of industrialized, sweetened products, more than fresh produce, since the latter do not generally belong to recognized brands and are not widely available in supermarkets.

The bootstrap method was used, a widely recognised resampling technique, to ensure the reliability of our results. This approach involves generating multiple random samples with replacement from the original data set, recalculating the probit model coefficients for each sample, and deriving robust confidence intervals. The bootstrap method is particularly advantageous as it does not rely on strong parametric assumptions about the error distribution or explanatory variables, making it well suited to complex data structures. Our results showed consistent coefficients and significance levels across bootstrap iterations, confirming the robustness and stability of the estimates.

Results of Probit model confirmed that residents who tend to adhere to the Mediterranean diet consume olive oil, fish, fruits and legumes at a high frequency. These foods are fundamental components of traditional Tunisian cuisine, reflecting a dietary pattern rich in healthy fats, high-quality proteins, and essential nutrients. This finding improve the importance of following traditional Tunisian eating habits which present a strong case for encouraging their adoption as part of a balanced and sustainable diet. Residents of the central, western, and southern regions are those most attached to their culinary traditions. This can be attributed to the fact that the lifestyle in these areas has not been as heavily influenced by urbanization compared to the northern regions and Greater Tunis. According to the results of the Probit model, residents of the north and Greater Tunis tend to have lower adherence to the Mediterranean diet. They consume more meat, fats, carbonated beverages, and sweets. This is due to the lack of time for cooking, especially because of women's work, and the availability of processed foods. The residents of the center west and south represent the highest percentage of those with moderate adherence to the Mediterranean diet. The people in these regions are attached to their culinary traditions, but their issue lies in the high consumption of meat, due to the limited availability of fish in these areas. The Central West, Southwest, and Northwest regions recorded the lowest average fish consumption, with an average intake of less than 4 kg per person per year (NSI, 2015). These differences between regions influence the eating habits in each region. Improving the availability of high-quality fish could boost consumption in these regions. Promoting better packaging and transportation methods would ensure a consistent supply of fish to interior regions. Given the importance of fish in the Mediterranean diet, these measures are essential for maintaining a healthy and balanced diet in these regions. (Barhoumi *et al.*, 2024).

Tunisia is in the early stages of a nutritional transition, where traditional dietary practices remain prominent but are starting to be influenced by Western food patterns, particularly among the younger population. In addition, no significant differences in MD adherence according to education level because the majority of participants have a university education level. In fact, the interviewees who showed a high level of adherence represent different educational levels, this is explained by the fact that the respondent could be a manufacturer of the product in concern or have a high income (trader, farmer) without necessarily having a university level of education, or it could also depend on family habits where pupils and children will adhere or not to the MD.

The dependence of income on adherence to Mediterranean Diet could suggest that the cost of Mediterranean products acts as a barrier for individuals with lower incomes in adopting the Mediterranean diet compared to those with higher incomes. Indeed, Tunisia has opted to import seed oils in order to release larger quantities of HO for export, needed to increase foreign exchange earnings and meet the needs of a growing population. This policy has had a significant impact on olive oil cost and the structure of edible oil consumption, which is now dominated by seed oils (72% of total oil demand), compared with 28% for olive oil, which was the main oil consumed in 1970. This explain lower adherence to the Mediterranean diet among people with low and middle incomes according to the National Observatory of Agriculture (NOA). In the other hand, fish consumption has risen significantly, climbing from 6.1 kg to 9.3 kg per capita annually between 1985 and 2015 (NSI., 2015). Despite this overall growth, there exists a pronounced disparity in consumption patterns between coastal and inland regions highlighting the influence of geographical factors on dietary habits (Barhoumi et al., 2024). The residents of the Central-East region show the highest adherence to the Mediterranean diet, which is not influenced by the high prices of Mediterranean diet products such as fish and olive oil. This is primarily due to the availability of these products, as the region is a major producer of both. Additionally, most of the population in this area consists of farmers and fishermen, and their food culture places great importance on these products. In addition, Senior executives show the highest adherence to the Mediterranean diet. This socio-professional category benefits from financial independence, a high income, and a high level of education, along with greater awareness of the health benefits of the Mediterranean diet. All these factors contribute to encouraging them to adopt healthy eating habits.

These results tend to be in line with some studies that have shown like González and colleagues (Gonzalez *et al.*, 2002) who concluded that Mediterranean diet adherence in Spain was lower in young individuals those with higher incomes and in females. The same results were found in other Mediterranean countries (Katsarou *et al.*, 2010; Panagiotakos *et al.*, 2008).

Overall results on the Mediterranean diet adherence test showed a preference for white meat consumption: 84.8% of the population prefers white meat, high consumption of animal fat, sweets, a moderate consumption of pasta, rice, and vegetables, a low consumption of fruits, nuts, legumes and fish. These results similar to this study realized by Aounallah-Skhiri et al., 2011. Since the 1980s, the Tunisian government has actively promoted the production of poultry and similar products as part of a strategic effort to enhance food security and meet growing demand. This initiative led to a significant boost in poultry production, which was further amplified by a shift in consumption patterns following the 2011 revolution. With the rising cost of red meat, poultry emerged as a recommended alternative by nutritionists and a direct substitute for red meat in the Tunisian diet (Boudiche et al., 2022). As a result, per capita poultry consumption increased from 5.3 kg to 20.6 kg per year between 1985 and 2015, while beef consumption dropped from 7.6 kg to 4.9 kg in the same period (NSI, 2015).

Furthermore, adherence and BMI are inversely proportional, this is explained by the fact that the Mediterranean diet does not include high-calorie foods, and this has been shown by several research. A study conducted by Damigou et al. in 2022 assessed changes in adherence to the Mediterranean-type diet (MTD) and their impact on body weight over a 20-year follow-up period. The findings revealed an inverse relationship between MTD adherence, changes in adherence, and both BMI at 20 years and the average BMI during the follow-up. Maintaining consistent adherence to MTD over the 20-year period was linked to a more than 90% reduction in the risk of sustaining overweight or obesity. The Mediterranean dietary pattern contributes to obesity prevention and weight management through several key components. These include the high polyphenol content found in extra virgin olive oil (EVOO), fruits, vegetables, herbs, spices, whole grains, legumes, and nuts.

Despite the widely touted health benefits of the Mediterranean diet and its rich cultural heritage, Mediterranean populations, particularly the younger generations, have been gradually moving away from this traditional dietary pattern over the past few decades. Factors such as urbanization, population growth, and the increasing globalization of the food supply have been identified as potential causes for this shift (Vernele et al., 2010). It is crucial to raise awareness among the youth and encourage them to enhance their eating habits, as dietary behaviors are established early in life and significantly impact the quality of life in adulthood. Early interventions of this nature can play a substantial role in preventing chronic diseases and fostering sustainable lifestyle habits rooted in balanced nutrition and regular physical activity (Hachem et al., 2016).

Paradoxically, while the Mediterranean diet is gaining global popularity and receiving increasing recognition from the international scientific community, Studies have shown a decline in this dietery model across various regions of the Mediterranean (Lacirignola and Capone, 2009; Naja *et al.*, 2021). Dernini and Capone (2021) called for the revitalization of the Mediterranean diet by enhancing its current perception, particularly among the younger generation, not just as a healthy diet but also as a model for a sustainable lifestyle.

In this context, the studies conducted by Capone et al. (2021) and Ridolfi et al. (2020) provide an in-depth analysis of the challenges and perspectives of food systems in the region, further highlighting this trend. These works highlight the importance of collaboration between the Mediterranean sustainable food systems (SFS-Med) Platform, developed by CIHEAM, FAO, and the Union for the Mediterranean (UfM) to promote the transition of food systems towards sustainability and accelerate the achievement of the Sustainable Development Goals (SDGs) in the region. The platform provides a unique opportunity to unite various technical, scientific, and political mandates, fostering stronger partnerships aimed at creating more resilient and sustainable food systems in the Mediterranean.

The promotion of the Mediterranean diet, recognized globally as a model of sustainable diets, represents a concrete step in advancing sustainability in the region. The unsustainability of food systems within the Mediterranean is contributing to the erosion of the cultural food heritage, represented by the Mediterranean diet. Furthermore, transforming food systems in the Mediterranean necessitates the formation of multi-stakeholder partnerships, with collaboration between intergovernmental organizations, governments, academia, the private sector, and civil society. In light of the heterogeneity of food systems across Mediterranean countries, adopting a context-specific yet integrated approach is critical to gain a holistic understanding of food systems. This approach should focus on addressing all components within the entire food system, rather than viewing them separately, to assess their impacts and trade-offs comprehensively. Transitioning towards sustainable food systems involves addressing issues in the consumption side of the food chain while considering the connections between production and consumption. Therefore, a comprehensive strategy is essential to ensure that all stages of the food system are aligned to promote sustainability (Capone et al., 2021). The authors highlight the need to better understand food-related choices and the drivers behind them in relation to their cultural, social, economic, and environmental circumstances (Ridolfi *et al.*, 2020).

Establishing a greener, bluer, and more circular economy are three key concepts of the SFS Med food systems transformation aimed at promoting sustainable development and improving the quality of life for the population. It is crucial to support the position of farmers and fishers within the value chain, promote "green" and "blue" growth, foster a circular economy, and encourage sustainable food consumption while ensuring access to healthy and affordable food for everyone (Ridolfi *et al.*, 2020).

This study focused on quantitative methods, specifically the probit model and the chi-square test, to identify statistical associations between dietary habits and socio-demographic factors in Tunisia. These methods allowed us to analyse broad patterns and associations at the population level. However, it's recognized that a qualitative approach, such as in-depth interviews or focus groups, could provide deeper insights into the motivations, cultural influences and individual perceptions behind the dietary behaviors observed. While our research was designed to provide a quantitative overview of dietary patterns, future studies could benefit from integrating qualitative methods to explore the underlying reasons for certain dietary choices, the role of social norms and personal experiences that influence adherence to diets such as the Mediterranean diet.

5. Conclusion

In conclusion, two-thirds of the Tunisian population show moderate adherence to the Mediterranean diet, while only 5% exhibit high adherence. This highlights a significant deviation from the traditional Tunisian dietary pattern associated with the Mediterranean diet. There is a notable shift away from the characteristic consumption model of the Mediterranean diet in Tunisia.

Studying the factors influencing adherence to the Mediterranean Diet in Tunisia socio-professional category (SPC), and region have proven to be determining factors of the Tunisian behavior consumer. The lifestyle, particularly in the capital, and low purchasing power have negatively impacted adherence to the Mediterranean diet. While Tunisia has successfully controlled communicable diseases, the prevalence of food-related chronic diseases is on the rise, accounting for 60% of deaths. Obesity now affects half of the population, with 33.7% classified as overweight and 26.2% as obese (Ministry of Health, 2019; Dogui et al., 2021), which is double the global average of 11.7% (FAO, 2014). Additionally, the high prevalence of diabetes underscores a growing public health concern, with around 15.1% of the adult population currently affected, according to the latest national health statistics. This rising prevalence of chronic diseases is strongly associated with shifts in dietary habits, marked by a move away from traditional diets toward more processed and high-calorie foods. To encourage healthier eating habits, it is essential to offer breakfast options that are not only nutritious but also convenient and easy to prepare. A Mediterranean diet-inspired breakfast, rich in essential nutrients like healthy fats, fiber, and protein, can be a practical solution. For instance, incorporating nuts, Greek yogurt, and fresh fruits create a balanced breakfast.

The increase of the agri-food industry, with its growing supply of industrialized foods and ready-made meals, are causing the decline in traditional mediterranean diet style. This shift towards processed and ultraprocessed products is partly replacing the consumption of fresh, whole foods that are central to the Mediterranean diet, including fruits, vegetables, legumes, whole grains, and healthy fats such as olive oil and nuts.

Increases in the prices of cereals, fish and fruit, and fluctuating olive oil prices, which are essential components of the Mediterranean diet, have the potential to influence food choices and adherence to the Mediterranean diet in Tunisia. Agricultural policies play a crucial role in mitigating the effects of these price rises, in particular by ensuring that Mediterranean staple foods remain affordable and accessible. While these price changes reflect broader global trends, they also underline that a dynamic and transparent agricultural policy that adapts to international changes and includes all categories of farmers is crucial to ensuring sustainable agricultural development and food security in Tunisia, focusing on local production to reduce import dependency and ensure the sustainability of key Mediterranean foods (Thabet *et al.*, 2024).

On a practical level, marketing campaigns to raise consumer awareness of the benefits of the main staples of the Mediterranean diet could be a solution to improve adherence to this regime. On a national level, subsidizing olive oil could minimize the consumption of vegetable oils and reduce the cost of olive oil. It would also be advisable to organize supply chains between regions to balance consumption somewhat better.

Additionally, this work could be supplemented by surveys by periods of time (summer/winter), or 5 years ago and the current year to highlight the evolution of consumption over time.

A more in-depth study could be carried out to better understand the reasons for consumer choice, for example conducting a survey of farmers and non-farmers, or in urban and rural regions.

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