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Research article

Consumption of fruits and vegetables in two European countries: Results from a survey in France and Portugal

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Abstract: Presently, there is a huge burden on public health due to a very high incidence of chronic diseases like cardiovascular diseases, diabetes, and obesity, among others. The modern lifestyle, with inadequate diets and insufficient physical activity, is one of the most important factors contributing to this situation. Therefore, a healthy diet can have a very positive impact on global population health. Fruits and vegetables are staple foods with a typically low caloric value that still contribute to an adequate ingestion of the necessary macro and micronutrients and bioactive compounds, with a beneficial effect on health. This study aimed to investigate the knowledge about the consumption of fruits and vegetables in two countries, Portugal and France. A questionnaire survey was carried out on a sample of 639 adult participants (382 French and 257 Portuguese). The results revealed significant differences in knowledge between countries, sexes, level of education, body mass index, satisfaction with body weight, reasons for dissatisfaction with weight, and having a chronic disease. The most influential sociodemographic variable was the country, while the most influential behavioral variable was practicing a varied diet. Factor analysis identified two factors, one accounting for items in the scale that were true, and the other accounting for false items; both factors had acceptable internal consistency. Finally, cluster analysis showed three clusters of participants: The first included individuals with high knowledge of both factors, the second included individuals with low or very low knowledge, and the third cluster included individuals with partial knowledge, who only knew about true items. These results are relevant for planning educational measures aimed at improving knowledge and thus helping to promote healthier diets.

Keywords: healthy diet; consumer study; questionnaire survey; factor analysis; cluster analysis

1. Introduction

Many studies in scientific literature have confirmed the benefits of healthy eating and plant-based dietary patterns on human health. Although guaranteeing the necessary ingestion of plant-based foods is necessary at all ages and stages of development, this is even more relevant for the elderly, as it helps to reduce the risk of chronic diseases such as diabetes, high cholesterol, and cardiovascular diseases, and all-cause mortality rates in general [1–3].

The Southern European Atlantic Diet (SEAD) comprises dietary patterns traditional to the North-East regions of the Iberian Peninsula (Spanish region of Galicia and North of Portugal) [4]. Due to specific geographical and climatic conditions, a particular food pattern was established, based on the consumption of local, fresh, and seasonal products. This dietary pattern is based on a high intake of fish and seafood from the Atlantic Ocean, together with cereals, potatoes, legumes, fruits, dairy products, and vegetables cultivated locally. This diet also includes the consumption of meat, especially lean meat, and a moderate consumption of eggs and wine [4]. Although the SEAD dietary pattern is characterized by specific eating practices, it comprises more than just a way of eating, also including lifestyle factors such as regular physical exercise, simple cooking techniques, compliance with traditions, and socially pleasurable eating [4]. A study by Agostinis-Sobrinho [5] investigated the adherence to the SEAD diet among Portuguese adolescents and concluded that this dietary pattern associated with physical exercise contributes to a reduced risk of cardiometabolic diseases. Similar benefits for heart health were observed by Oliveira et al. [6] for a sample of Portuguese participants. Carballo-Casla et al. [7] conducted a multicohort study in some European countries to investigate the relation between SEAD and all-cause and cause-specific mortality. Their research included subjects from Spain, Czechia, Poland, and the United Kingdom. The SEAD dietary pattern, which is traditional of the Iberian Peninsula (northwestern Spain and northern Portugal), was also reported to have some similarities to the patterns of central, eastern, and western European countries. This pattern has been reported to diminish the risk of myocardial infarction and mortality in older adults; the study by Carballo-Casla et al. [7] confirmed that the SEAD in fact reduced mortality due to multiple causes, cardiovascular diseases, and cancer. Some staple foods of this pattern include fish, meat, dairy, and plant-based foods (cereals, fruits, and vegetables, these frequently consumed in soup) [8].

Another dietary pattern characteristic of some countries around the Mediterranean Sea has been pointed out as a traditional eating pattern with particularities and benefits. Seven countries (Cyprus, Croatia, Spain, Greece, Italy, Morocco, and Portugal) submitted a proposal for the "Mediterranean Diet" (MD) to UNESCO, who inscribed it on the Representative List of the Intangible Cultural Heritage of Humanity. Besides food, the MD involves a set of knowledge, expertise, rituals, symbols, and traditions on agricultural techniques, fishing, cattle breeding, conservation, processing, preparation, and especially food sharing and consumption [9,10]. The MD is characterized by high consumption of dietary fiber and low consumption of saturated fatty acids. It typically includes a generous amount of vegetables, legumes, whole cereals, fruits, and nuts. It also includes moderate quantities of dairy products, fish, eggs, wine, and olive oil, which is the primary source of fat [11]. Olive oil has important nutritional benefits owing to its fatty acids composition, where monounsaturated predominate over saturated fatty acids [12]. Fruits and vegetables (F&V) are also

essential elements of the MD, assuming particular nutritional relevance due to their low caloric value but high content of dietary fiber, vitamins, minerals, and bioactive compounds. Also, the MD has been associated with several health benefits, reducing inflammation [13], cardiovascular diseases [14], diabetes [15], obesity [16], cancer [17], and depression [18], and benefitting patients with multiple sclerosis [19]. Despite such health benefits of consuming fruits and vegetables regularly, consumption ratios are, in many cases, lower than recommended. A study by Dela Cruz et al. [20] revealed a low frequency of F&V intake among Chinese children. Fleary et al. [21] suggested that information and motivation could positively influence adolescents to increase their consumption of F&V. Tami and Alshrihi [22] reported a very low consumption of F&V among Saudi University Students, but a proper nutrition intervention could contribute to effectively increasing consumption.

A study conducted by Pérez-Flores et al. [23] evaluated the consumption of organic vegetables and fruits in two Mediterranean countries, considering that the organic production system bears additional health benefits apart from their richness in nutrients and bioactive compounds. In fact, organic foods are pesticide-free and their production does not use synthetic growth stimulants, thus being healthier. The study revealed that sociodemographic factors like education level, income, and environment are influential factors in determining the profile of consumers of organically produced fruits and vegetables in Spain and Portugal. In another study [24], the consumption of organic foods was studied in Portugal and Turkey, showing a similar consumption pattern in both countries. Additionally, it was concluded that consumers are motivated to choose organic foods due to their benefits for human health and the environment, while their higher cost was seen as the strongest factor impeding higher consumption [24].

Gaining a deeper understanding of consumers' knowledge about the dietary significance of F&V is essential in fostering healthier eating habits and preventing chronic diseases associated with consumption. Hence, the present study aimed to investigate the awareness and comprehension regarding consumption of fruits and vegetables, integral elements of a healthy diet, among populations in Portugal and France. Specific objectives included the evaluation of factors influencing the level of knowledge, the application of factor analysis to the items used in the questionnaire to assess knowledge, and the application of cluster segmentation to the participants, thus obtaining a grouping structure according to their perceptions.

2. Materials and methods

2.1. Instrument for data collection

This is a transversal descriptive study that targeted adult individuals aged 18 years or older. The instrument was a questionnaire developed to collect the necessary information, consisting of the following five parts: 1. Sociodemographic characteristics, 2. anthropometric and behavioral aspects, 3. consumption habits and lifestyle, 4. health problems, and 5. knowledge about the consumption of vegetables and fruits. The full version of the questionnaire is presented in Appendix A. The last part of the questionnaire (part V) contained 11 items for which the participants expressed their agreement using a 5-point Likert scale (1 = Strongly disagree, 2 = Disagree, 3 = Indifferent, 4 = Agree, 5 = Strongly agree) [25]:

1. Fruits and vegetables are foods poor in vitamins and minerals that are important to the good functioning of the human body (false).
2. The regular consumption of vegetables and fruits results in higher and better longevity.

3. By consuming fruits and vegetables on a daily basis, your body cells will be unprotected (False).
4. Vegetables and fruits are low-calorie foods and can contribute to a healthy weight reduction.
5. Green leaves, beans, broccoli, cabbage, cauliflower, and vegetables with a yellow-orange coloration like carrots are more effective in the reduction of cancer incidence.
6. Some vegetables such as spinach or cabbage are rich in iron and can help cure anemia.
7. Neither vegetables nor fruits contain sugars (False).
8. Both vegetables and fruits constitute a good source of dietary fiber.
9. Some vegetables and legumes can be irritating to the intestine.
10. The regular consumption of vegetables and fruits can protect against type-2 diabetes, cardiovascular diseases, hypertension, and cancer.
11. A high ingestion of fruits and vegetables can reduce obesity, cholesterol, and lower blood pressure.

2.2. Participants and ethical considerations

The questionnaire was translated into the two native languages before being distributed to the participants from both countries included in the study: Portugal and France. These two countries were selected for the study based on an ongoing bilateral partnership resulting from ERASMUS collaboration between both countries. The survey was applied through the Google Forms® online platform. The invitation to participate in the study was disseminated on social networks and by email with the link from September 2020 to May 2021. Individuals aged under 18 years old and with any nationality other than French or Portuguese were excluded from the survey. Only those who manifested voluntary agreement to participate accessed the questionnaire. All of the 639 individuals who accessed the questionnaire platform completed the survey, and from those, 382 were French and 257 were Portuguese. All ethical considerations were taken into account when designing the questionnaire and collecting the data, namely those from the American Psychological Association (APA) Ethical Guidelines for Research Involving Human Subjects and the Declaration of Helsinki. The Polytechnic University of Viseu Ethics Committee approved the ethical aspects of this study (No. 10/SUB/2020).

2.3. Data analysis

Data were analyzed using basic descriptive statistics such as frequency, mean, and standard deviation. For all items used to evaluate knowledge, indices were calculated as the mean value between the scores attributed by all participants. Nonetheless, prior to the calculation of the mean value, the scores of the three false items were reversed, to get all the items in the same measuring scale. Another step included the redefinition of the scale, eliminating the effect of the participants who scored 3 (indifferent). Apart from the item indices, the level of knowledge for each participant was also calculated as the average of the scores for all items given by that participant. Finally, the level of knowledge was allocated according to the following classes: very low knowledge ($-2 \leq$ value < -1), low knowledge ($-1 \leq$ value ≤ 0), high knowledge ($0 <$ value < 1), and very high knowledge ($1 \leq$ value ≤ 2).

The relative influence of the sociodemographic variables and the anthropometric and behavioral variables on the level of knowledge was assessed through tree classification analysis. For this, a classification and regression trees (CRT) algorithm with cross-validation [26] was used. The minimum change in improvement was equal to 0.001 and the minimum number of cases for parent and child nodes was established as 20 and 10, respectively.

To validate the scale, factor analysis (FA) was carried out, using the method of principal component analysis (PCA) that identifies grouping structures between the items. Once again, before applying FA, data were evaluated to assess the suitability to this kind of statistical treatment, namely: a) The correlation matrix between the variables was analyzed to identify possible correlations; b) The Kaiser-Meyer-Olkin (KMO) measure of the adequacy of the sample was calculated, and c) Bartlett's test was performed to evaluate correlations between variables [27]. The following reference values were used to analyze the KMO: Excellent for $0.9 \leq KMO \leq 1.0$, Good for $0.8 \leq KMO < 0.9$, Acceptable for $0.7 \leq KMO < 0.8$, Tolerable for $0.6 \leq KMO < 0.7$, Bad for $0.5 \leq KMO < 0.6$, and Unacceptable for $KMO < 0.5$ [28].

Just like in the previous analysis, FA was applied after reversing the false items (1, 3, and 7) so that the measuring scale would be uniform, i.e., higher value meaning higher knowledge. After verification of the suitability of the data, FA was applied with extraction using PCA and Varimax rotation with Kaiser normalization. Eigenvalues greater than 1 were used to determine the number of components to extract. The calculation of the communalities informed about the percentage of variance explained by the factors extracted [27]. In the analysis, due to low relevance, items with low factor loadings (absolute value lower than 0.4) were excluded [29,30]. After identifying the factors extracted, the Cronbach's alpha (α) was used to determine the internal consistency of each of them [27,31]. Reference values for alpha used were the following: a value of 0.7 or above was good, but a value higher than 0.8 could be considered very good, although some authors propose a different classification, defending that values over 0.5 are acceptable [32–34].

After this, the factors identified in FA were used as variables to submit to cluster analysis; in the first step, hierarchical methods were applied, establishing the most appropriate number of clusters. Seven hierarchical methods were used: within groups linkage (WGL), between groups linkage (BGL), nearest neighbor (NN), furthest neighbor (FN), centroid (CE), median clustering (MC), and ward (WA); in all cases, the squared Euclidean distance was the measure considered. The coefficients from the agglomeration schedule indicated that the optimal number of groups that should be formed was three, based on the results of the majority of tested methods. After the number of clusters was established as three, the seven methods were run again with this number of clusters. The seven solutions obtained were compared using contingency tables (crosstabs) to evaluate stability. In the later phase, the stable solutions were used as initial solutions to carry out the analysis using the partitive method of k-means, which is particularly recommended and frequently used in CA [35].

The software used for data analysis was SPSS (Version 28) from IBM Inc. (Armonk, NY, USA), and the level of significance considered was 5% ($p < 0.05$).

3. Results

3.1. Sample characterization

Figure 1 shows the sociodemographic characteristics according to the variables age, sex, occupation, and education. Most of the participants were young adults (n = 248 French and n = 181 Portuguese) and a great majority were female (290 and 150 for French and Portuguese samples, respectively). A high number were students (n = 233 and n = 182 for French and Portuguese participants, respectively) and most had completed university studies (292 French and 196 Portuguese participants).

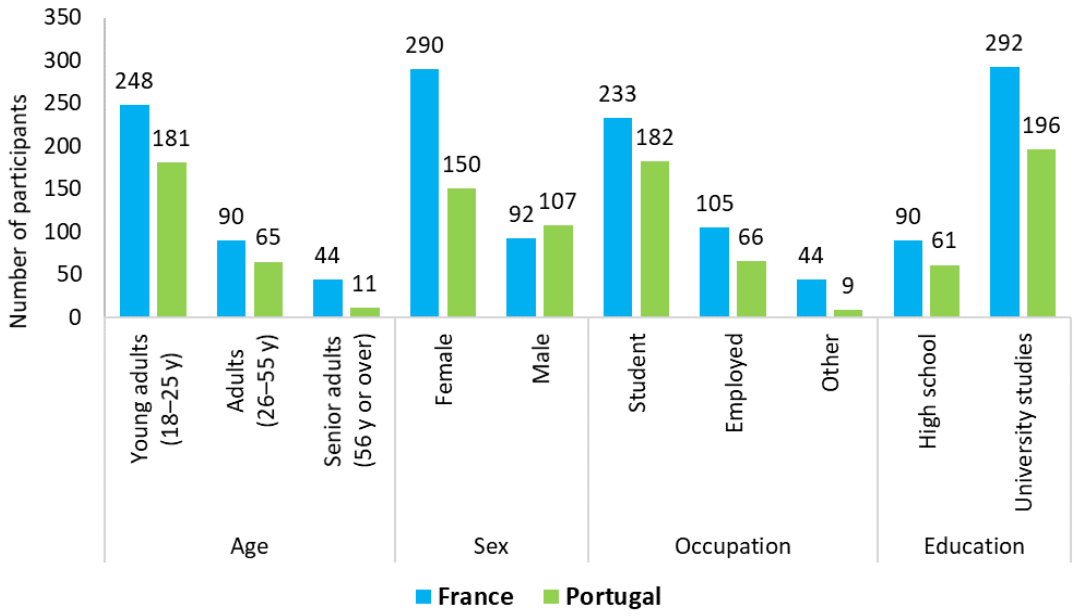

Figure 1. Sociodemographic characteristics of the participants [N = 639 participants; $N_{(France)}$ = 382; $N_{(Portugal)}$ = 257].

Concerning the anthropometric characteristics of weight, height, and body mass index (BMI) presented in Table 1, it was observed that weight varied from 34.0 to 164.0 kg with a mean value of 62.18 ± 14.46 kg for the global sample, with an average weight higher for the French participants (64.64 ± 13.12 kg). The height varied between 1.20 and 1.95 m, with a mean value of 1.65 ± 0.10 m, the average value again higher for the French participants (1.67 ± 0.09). The BMI ranged in the global sample from 12.64 to 61.72 kg/m^2, with a higher average BMI (22.95 ± 3.85 kg/m^2) in the French participants. These value means are within the normal weight class based on the classification of the World Health Organization [36]; the results in Table 3 for the BMI classes confirm that a high percentage of the participants had normal BMI, i.e., between 18.5 and 25.0 kg/m^2 (67.4% for the global sample and 67.0% and 67.9% for the French and Portuguese participants, respectively). Still, a relevant percentage of participants were overweight (11.9% and 20.6% for the Portuguese and French, respectively) or obese (5.0% and 5.4% for the Portuguese and French participants).

Figure 2 presents the results for the BMI class and the personal and behavioral aspects of the participants from both countries. The graph shows that a high fraction of the participants in both countries had normal weight (165 and 250 participants for Portugal and France, respectively). Concerning satisfaction with body weight, a high number of participants in both countries were not satisfied; the most frequent reason for the Portuguese participants was being overweight (n = 116), while for the French was low weight (n = 82). Regarding physical exercise, once or two to three times per week was the most frequent response for the participants from both countries. A high number of participants in both countries said they sometimes practiced a varied diet; there was a prevalence of the French over the Portuguese for practicing a varied diet several times per week (n = 146 and n = 66, respectively). Regarding the global health status, a great majority said they were in good health (n = 146 and n = 204 for French and Portuguese participants, respectively).

Table 1. Anthropometric characteristics of the participants.

Sample	Parameters	Weight (kg)	Height (m)	BMI[(1)] (kg/m^2)
France	N	373	377	373
	Min–Max[(2)]	42.0–130.0	1.45–1.95	16.71–46.06
	Mean ± SD[(3)]	64.64 ± 13.12	1.67 ± 0.09	22.95 ± 3.85
Portugal	N	243	249	243
	Min–Max[(2)]	34.0–164.0	1.20–1.90	12.64–61.72
	Mean ± SD[(3)]	58.40 ± 15.59	1.62 ± 0.11	22.16 ± 5.28
Global	N	616	626	616
	Min–Max[(2)]	34.0–164.0	1.20–1.95	12.64–61.72
	Mean ± SD[(3)]	62.18 ± 14.46	1.65 ± 0.10	22.64 ± 4.48

[(1)]BMI = body mass index (BMI = weight/height^2); [(2)]minimum and maximum values; [(3)]SD = standard deviation.

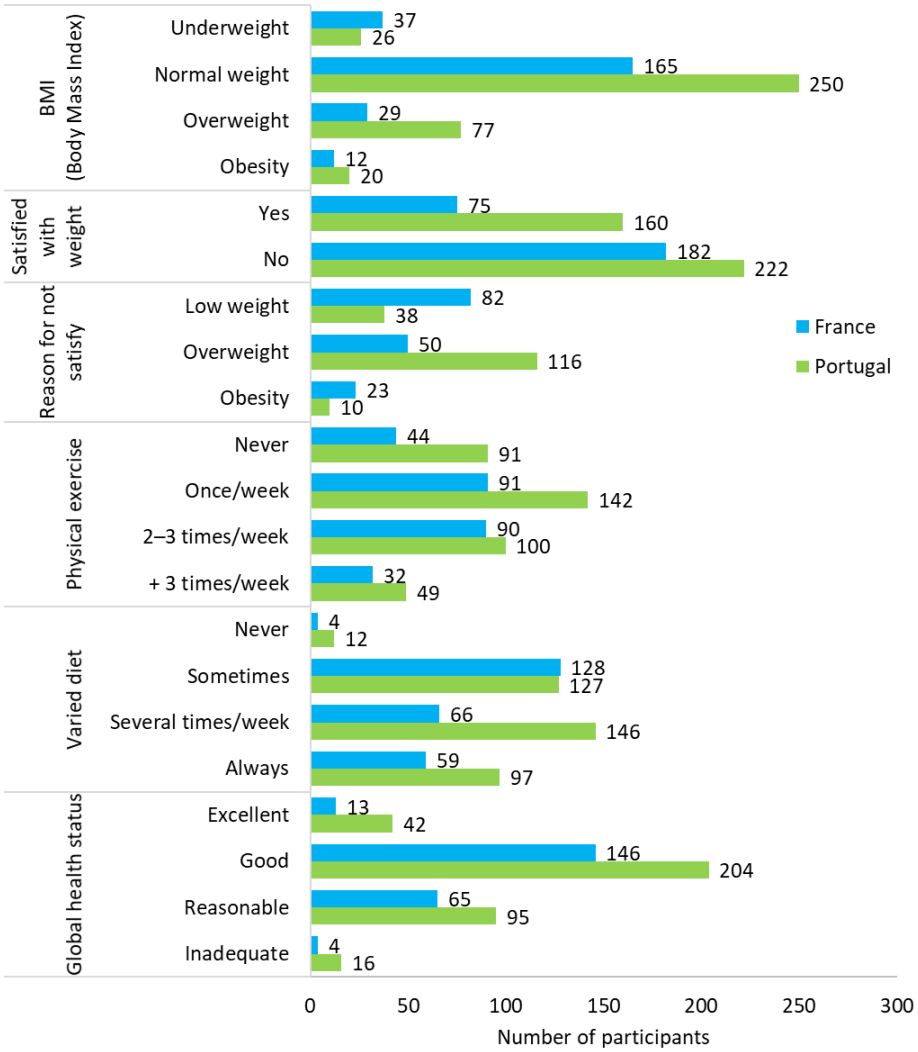

Figure 2. Behavioral characteristics of the participants [N = 639 participants; $N_{(France)}$ = 382; $N_{(Portugal)}$ = 257; Underweight = BMI < 18.5 kg/m^2; Normal weight = 18.5 < BMI ≤ 25.0 kg/m^2; Overweight = 25.0 < BMI ≤ 30.0 kg/m^2; Obesity = BMI ≥ 30.0 kg/m^2].

3.2. Scale validation through factor analysis

According to the values of the correlation matrix, there were some correlations between the variables, since there were 11 values of the correlation above 0.5, thus making it appropriate to apply factor analysis (FA). The highest correlation was found between items It.10 and It.11 ($r = 0.675$). This was corroborated by the results of Bartlett's test, leading to the rejection of the null hypothesis "H0: The correlation matrix is equal to the identity matrix" ($p < 0.0005$). Based on the classification of Kaiser and Rice [28], the obtained value of KMO (0.869) can be considered very good, once again confirming the suitability for the application of the intended statistical analysis. All the values of MSA (measure of sampling adequacy) in the anti-image matrix were higher than 0.5, thus confirming that all 11 items were adequate to include in the analysis. The lowest value of MSA was 0.649 for item It.3 and the highest was 0.941 for item It.4.

Table 2. Solution obtained through factor analysis.

Factor (%VE[1])	Items	Loadings	Factor name	Cronbach's Alpha (α)
F1 (38.1%)	It.2. The regular consumption of vegetables and fruits results in higher and better longevity.	0.790	Statements presented as True to the participants (TRUE)	0.866
	It.4. Vegetables and fruits are low-calorie foods and can contribute to a healthy weight reduction.	0.618		
	It.5. Green leaves, beans, broccoli, cabbage, cauliflower, and vegetables with a yellow-orange coloration like carrots are more effective in the reduction of cancer incidence.	0.692		
	It.6. Some vegetables such as spinach or cabbage are rich in iron and can help cure anemia.	0.733		
	It.8. Both vegetables and fruits constitute a good source of dietary fiber.	0.761		
	It.9. Some vegetables and legumes can be irritating to the intestine.	0.532		
	It.10. The regular consumption of vegetables and fruits can protect against type 2 diabetes, cardiovascular diseases, hypertension, and cancer.	0.813		
	It.11. A high ingestion of fruits and vegetables can reduce obesity, cholesterol, and lower blood pressure.	0.799		
F2 (17.9%)	It.1. Fruits and vegetables are foods poor in vitamins and minerals that are important to the good functioning of the human body (Reversed).	0.822	Statements presented as False to the participants (FALSE)	0.692
	It.3. By consuming fruits and vegetables on a daily basis, your body cells will be unprotected (Reversed).	0.796		
	It.7. Neither vegetables nor fruits contain sugars (Reversed).	0.716		

[1]VE = Variance explained.

The solution obtained by FA with PCA and Varimax rotation retained two components with eigenvalues higher than one (4.225 and 1.932). The global percentage of variance explained (VE) for this solution was 56.0% (38.1% for factor F1 and 17.9% for factor F2). The item with higher communality was It.1 (0.677 corresponding to 67.7% VE), and the item with the lowest variance explained by the solution was It.9 (communality = 0.304, 30.4% VE). Three iterations were enough to achieve conversion; Table 2 presents the obtained FA solution.

The two factors in Table 2 clearly separate the statements based on the way they were presented to the participants, i.e., one factor containing all the true statements (Factor F1) and the other accounting for the three false statements (Factor F2). All item loadings were high in both factors, varying from 0.532 to 0.816 in factor F1 and from 0.716 to 0.822 in factor F2. High loadings indicate that the items contribute to a high extent to the definition of the factors. Items with the highest loadings are item It.10 in factor F1 (0.816) and item It.1 in factor F2 (0.822), indicating that these items are the most strongly associated with the corresponding factors.

The solution was validated by calculation of the values of Cronbach's alpha (α) as a way to measure the internal consistency of each factor [27]. The results in Table 2 show that the value of Cronbach's alpha for factor F1 (TRUE) was 0.866 and for factor F2 (FALSE) was 0.692. Based on these values, the internal consistency of the scale can be considered very good for factor F1 and good for factor F2 [32–34].

Figure 3 shows the graphical representation of the solution obtained through FA, whereby the two factors are clearly identified as two separate groups of items according to each of the factors F1 and F2.

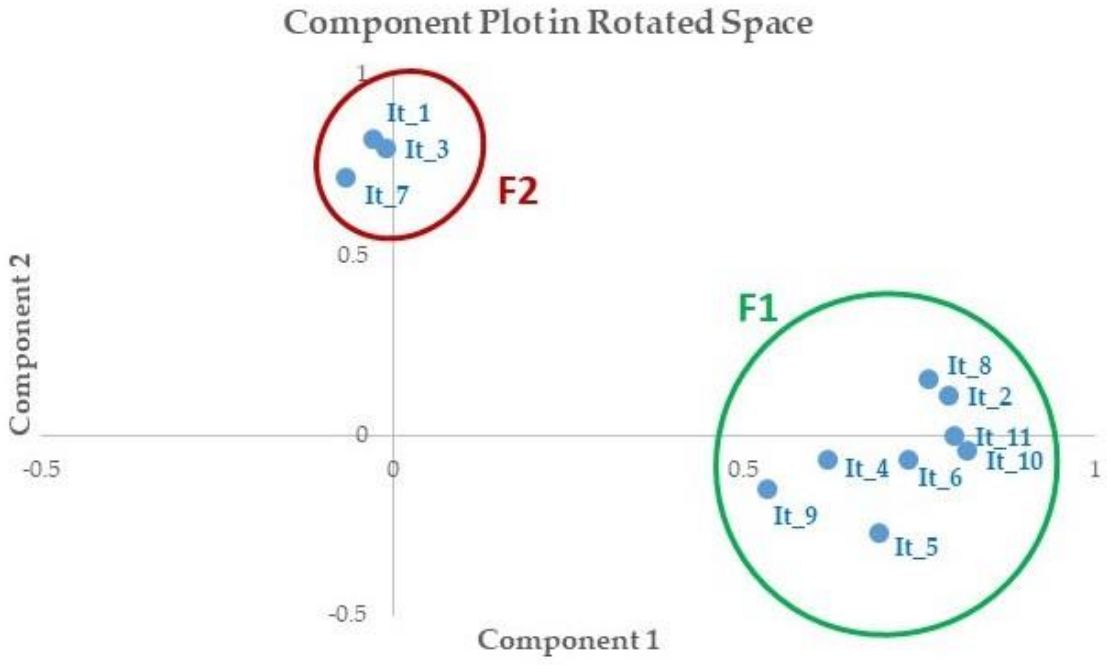

Figure 3. Rotated component plot resulting from factor analysis.

3.3. Cluster analysis

The first phase of the analysis started with the hierarchical methods to establish the optimum

number of clusters, which was fixed in three based on the agglomeration schedule, as shown in Figure 4 for the Ward method, as an example.

Table 3 shows the comparison through contingency tables (crosstabs) of the solutions obtained with the seven hierarchical methods tested. Some of the pairs of solutions showed a possible similarity of over 90% (94% WA-BGL, 95% WA-WGL, 95% BGL-WGL, 98% CE-NN), a strong indicator of potential stability. Hence, the two clustering solutions with the highest percentage (CE and NN) were used as initial solutions to carry out the final analysis using the partitive method of k-means, which is particularly recommended and frequently used in CA [35].

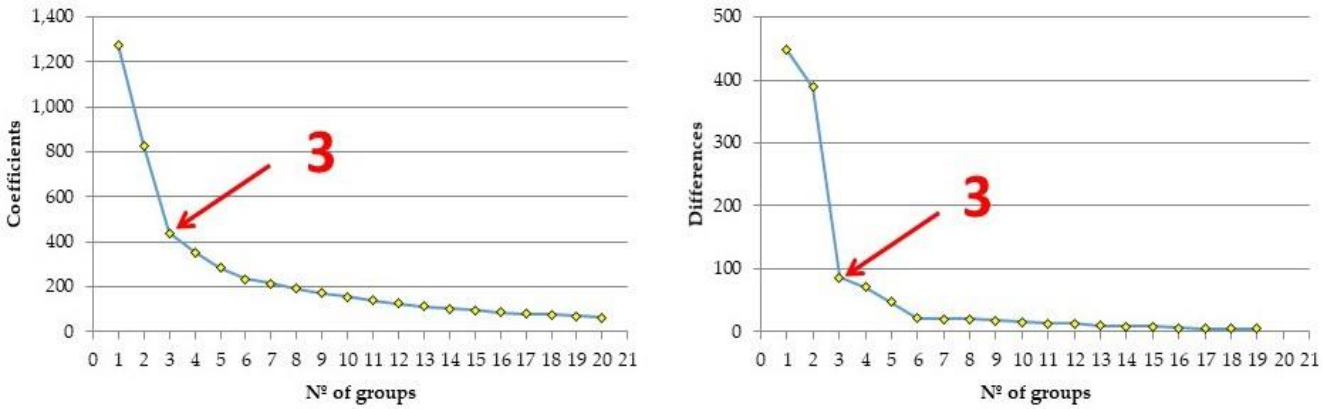

Figure 4. Definition of the number of clusters based on the Ward method.

Table 3. Similarity between the solutions obtained through hierarchical clustering methods.

Methods[1]	BGL	WGL	NN	FN	CE	MC	WA
BGL	100%						
WGL	95%	100%					
NN	71%	68%	100%				
FN	87%	83%	79%	100%			
CE	72%	68%	98%	81%	100%		
MC	75%	78%	46%	67%	47%	100%	
WA	94%	95%	65%	83%	66%	76%	100%

[1]BGL = between groups linkage, WG = within groups linkage, NN = nearest neighbor, FN = furthest neighbor, CE = centroid, MC = median clustering, WA = ward.

Table 4 presents the results of the k-means clustering for the two initial solutions; a convergence to the same final solution is evident, i.e., identical cluster centers and the same percentage of cases in each of the clusters. Based on the ANOVA results, the clusters' differentiation is significant ($p < 0.001$), and the values of the test statistic (F) are high, indicating similarity between the cases within the clusters and differentiation between clusters.

Table 4. Results for the k-means clustering.

		Initial solution NN[1]		Initial solution CE[2]	
		Factor F1 (True)	Factor F2 (False)	Factor F1 (True)	Factor F2 (False)
ANOVA	F	568.49	768.70	568.49	768.70
	p-value	< 0.001	< 0.001	< 0.001	< 0.001
Cluster 1	PC[3]	59 %		59 %	
	FCC[4]	0.421	0.556	0.422	0.556
Cluster 2	PC[3]	19%		19%	
	FCC[4]	−1.668	0.074	−1.668	0.074
Cluster 3	PC[3]	22%		22%	
	FCC[4]	0.276	−1.528	0.276	−1.528

[1]NN = nearest neighbor, [2]CE = centroid. [3] PC = percentage of cases in the cluster. [4]FCC = final cluster centers.

Considering the final solution, it was concluded that cluster 1 gathers most of the participants (n = 377, 59%), while clusters 2 and 3 have the lower numbers of members (n = 119, 19% for cluster 2 and n = 143, 22% for cluster 3). When analyzing the cluster centers, the interpretation of the cluster membership is suggested as follows:

- Cluster 1: Individuals who know about the true and false statements (positive values in both factors: 0.421 and 0.556).
- Cluster 2: Individuals who do not know about the true statements (negative value: −1.668) and have very low knowledge about the false statements (positive value but close to zero: 0.074).
- Cluster 3: Individuals who know about the true statements (positive value: 0.276) but who failed to correctly identify the false statements (negative value: −1.528).

3.4. Level of knowledge

The knowledge classes [very-low knowledge ($-2 \leq$ value < -1), low knowledge ($-1 \leq$ value ≤ 0), high knowledge ($0 <$ value < 1), and very high knowledge ($1 \leq$ value ≤ 2)] were used as the input variable for the tree classification, first considering the sociodemographic variables (country, age class, sex, occupation, education) and also considering the anthropometric and behavioral variables (BMI, satisfaction with weight, physical exercise, varied diet, global health status). The obtained trees are in Figures 5 and 6, respectively.

The model for the tree in Figure 5 is four levels deep with 19 nodes, from which 10 are terminal. Of the five independent variables included in the analysis, all of them were explicative, i.e., were found to influence the level of knowledge, so they had discriminating ability. The risk estimate was 0.509 with a standard error of 0.020 for resubstitution and 0.576 with a standard error of 0.020 for cross-validation. The model's overall prediction capacity accounts for a 49.1% probability of correctly predicting the cases according to the class of knowledge. In the first node, corresponding to the whole sample, there is evidence that about 80% have a high or very high knowledge (42.3% for high and 41.9% for very high knowledge). The first discriminating variable was Country, clearly evidencing a higher knowledge for the French sample (49.0% with very high knowledge) than for the Portuguese (31.5% with very high knowledge). For the French participants, the next discriminating variable was education level, while for the Portuguese it was sex. In the third level of depth, occupation was the

discriminating variable for practically all cases, except for the Portuguese male participants, for which the discriminating variable was age. In the last level of depth, the discriminating variables were occupation and education.

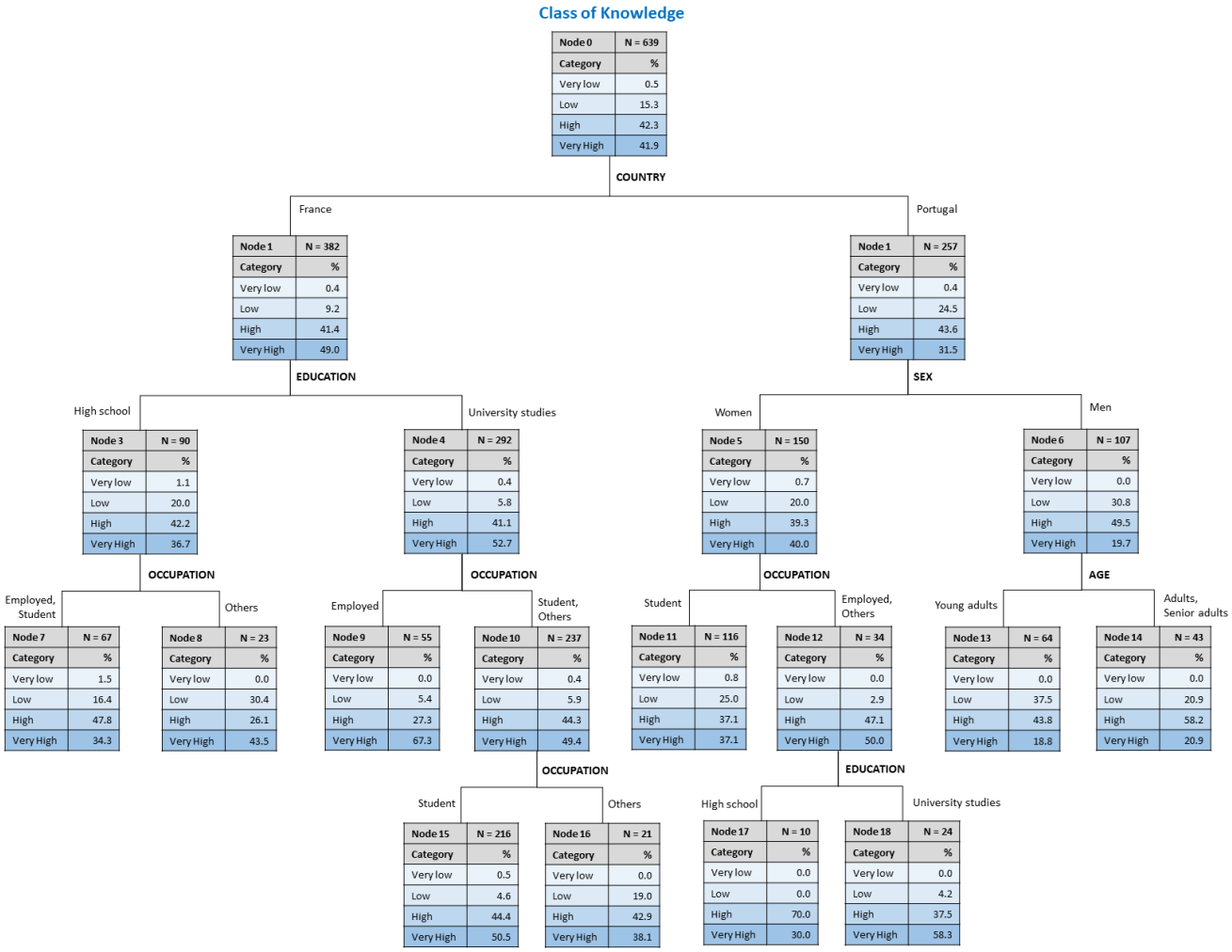

Figure 5. Tree classification for the level of knowledge according to sociodemographic variables.

The tree model in Figure 6 is five levels deep and has 17 nodes, of which 9 are terminal. Again, it was found that all five independent variables included in the analysis were explicative. The risk estimate was 0.491 with a standard error of 0.020 for resubstitution and 0.554 with a standard error of 0.020 for cross-validation. The model's overall prediction capacity is slightly higher than in the previous case, with a 50.9% probability of correctly predicting the cases according to the class of knowledge. In this tree, the first discriminating variable was the practice of a varied diet, separating those participants who do it several times per week or always from those who do it only sometimes or never, these last with a lower level of knowledge (32.5% of very high knowledge against 48.9% of those who do it more frequently—this being a terminal node). For those participants who never or seldom practice a varied diet, the next discriminating variable was health status, separating those participants with excellent health status from the rest, those having a lower level of information. In the third level of depth, the discriminating variable was again health status, and in the following level the

variables were physical exercise and BMI class. In the last level of depth, BMI and satisfaction with weight were the discriminating variables.

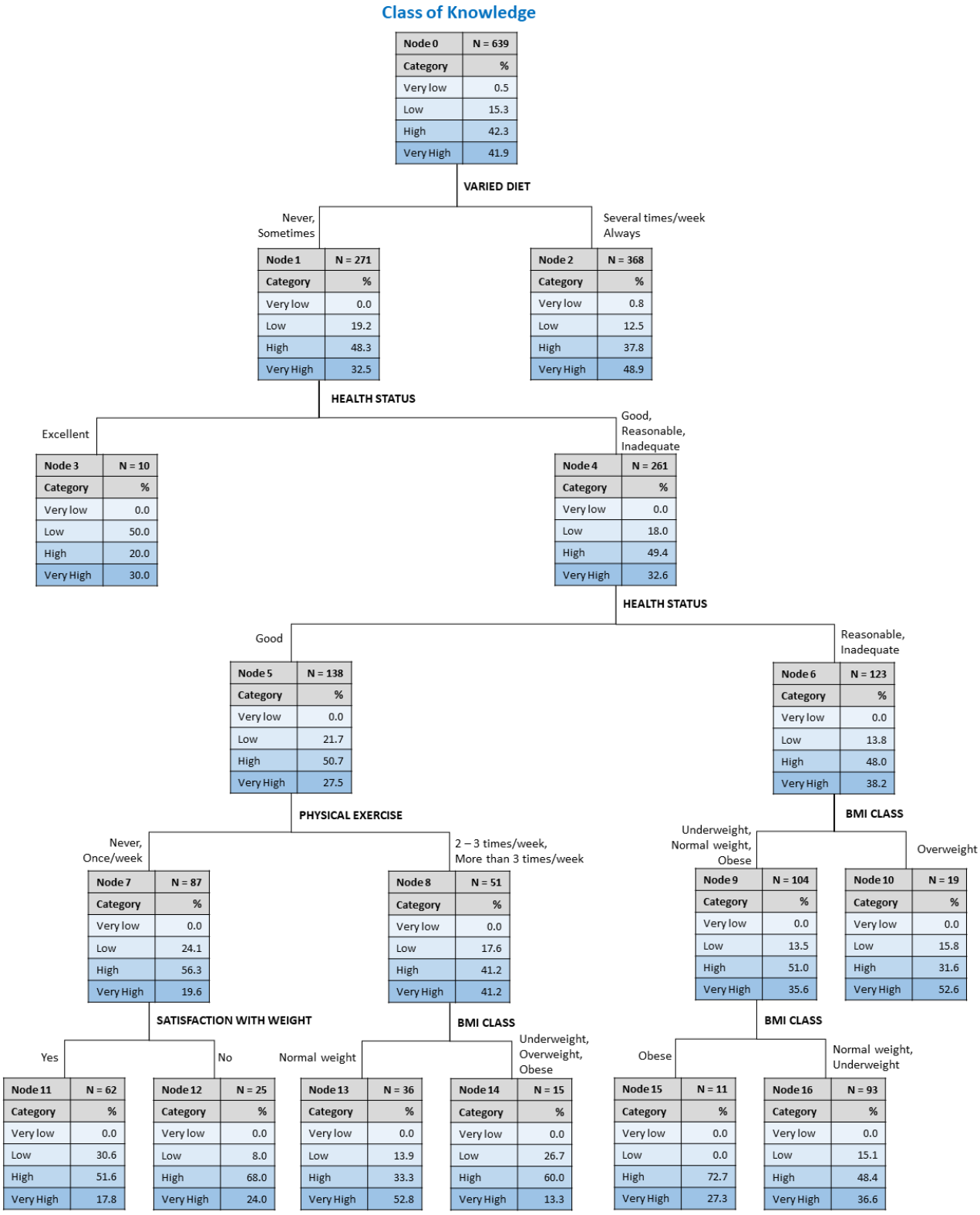

Figure 6. Tree classification for level of knowledge according to anthropometric and behavioral variables.

4. Discussion

This study enhances the general understanding of the diverse factors shaping consumer knowledge about the importance of F&V in the diet, offering valuable implications for public health initiatives and educational interventions tailored to specific demographic and behavioral profiles.

The high consumption of plant foods such as F&V constitutes one of the characteristics of Mediterranean dietary patterns, together with whole-grain products, fish and seafood, dairy products, olive oil, and others, making this kind of diet one with many health benefits [37–43]. Also, changing current diets is indispensable to make them more sustainable, which in turn requires knowledge about possibilities for improvement, since consuming higher amounts of fruits, vegetables, and fish has a positive effect on this balance [44]. Diet variety is a pillar of a healthy diet, and one strategy to improve health can be through the utilization of native F&V [45]; but modifications in the consumption of traditional F&Vs may be dependent on social norms and cultural values [46]. Differences in traditional F&V intake may be explained by differences in availability (i.e., amount) and accessibility (i.e., cost) of imported foods. High-economic income-level jurisdictions are more developed and have better infrastructure, allowing for greater means to import goods, including food [47].

F&V remain essential components of a healthy life, providing a rich array of vitamins, minerals, phytochemicals, and fiber, which strengthen the immune system, fight malnutrition, help prevent non-communicable disorders, and increase well-being at all ages [48]. Together with malnutrition, unhealthy diets are among the top ten risk causes for disease worldwide. The ingesting of these nutrient-intensive foods has been associated with a lower risk of chronic diseases, like for example cardiovascular diseases, certain cancers, and obesity [39,41–43]. However, despite the well-established benefits, many individuals still fall short of meeting the recommended daily intake of fruits and vegetables, and studies addressing this theme and its influencing aspects are still scarce in the literature. The low consumption of vegetables and fruits may not only be due to insufficient knowledge about their benefits for human health but also due to a lack of available funds to buy fresh foods (vegetables and fruits), often more expensive than cereal-based foods or even sweets. A study by Colabianchi et al. [49] revealed that higher neighborhood prices and poverty were associated with lower consumption of fruits and vegetables. This is even worse in the case of fruits and vegetables produced in organic farming, which are free from pesticides and therefore healthier but even more expensive than those coming from conventional agriculture. In a study with Portuguese and Turkish consumers, price was pointed out as the most limiting factor for not buying organic fruits and vegetables [24]. According to Powell et al. [50], taxation policies like subsidies to fruits and vegetables can contribute to an increased intake of these foods, especially among young adults and people with lower incomes.

One essential factor influencing F&V consumption is consumer knowledge about their dietary relevance. Understanding the nutritional value, health benefits, and the finest consumption strategies for these plant-based foods empowers individuals to make informed choices and effectively integrate them into their daily diets [51]. Consequently, stimulating consumer knowledge about the dietary impact of fruits and vegetables is vital for improving public health outcomes and preventing nutrition-related diseases, namely in younger generations; the earlier they start to have healthy habits, the less likely they are to become adults with chronic diseases [52]. Furthermore, misunderstandings and inadequate perceptions of portion sizes, preparation methods, and optimal cooking techniques [53] may impede individuals from making the most of these dietary possibilities. The World Health

Organization (WHO) recommends the combined consumption of 400 g per day of F&V (equivalent to five servings per day) as one of the 25 indicators of its Global Action Plan for the Prevention and Control of NCDs 2013–2020 [54] and emphasizes "5 a Day" type programs worldwide [41]. Besides, F&V must be wholesome and safe for consumers.

Factors such as French nationality, female gender, higher education, and frequent practice of a varied diet were found in this study to correlate strongly with higher levels of knowledge. The country of origin was in fact the most influential of the sociodemographic variables studied, while the practice of a varied diet was the most influential among the behavioral variables. The dietary recommendations in Portugal and France are based on the latest scientific reports and in line with the WHO recommendations [55–57]. Both French and Portuguese diets exhibit an appreciation for fresh, flavorful ingredients and traditional culinary techniques, yet they showcase distinct flavors, ingredients, and cultural influences reflective of their respective regions. The most recent dietary recommendations for the Portuguese population are delineated in the Portuguese Food Wheel Guide. Nonetheless, there is a troubling pattern of insufficient adherence to these guidelines, particularly evident in the lower consumption of fruits and vegetables, which fall below the recommended values [55]. Similarly, the French population also demonstrates a subpar intake of vegetables and fruit, which registers below the national dietary recommendations [57].

These results indicate some useful trends for public bodies in Portugal and France to plan actions to further increase knowledge about the consumption of healthy foods such as fruits and vegetables, as part of a healthy lifestyle, with important economic and social impacts. Additionally, by increasing awareness of nutritional composition, health benefits, and optimal consumption practices, individuals can make informed choices and effectively integrate these nutrient-dense foods into their daily diets. This study indicated that the level of understanding about the consumption of F&V is generally good. Furthermore, significant differences were found in the level of knowledge across groups for most of the studied sociodemographic and behavioral variables. However, a collective effort implicating public health campaigns, nutrition education programs, healthcare professionals, and digital platforms is essential to empower consumers to make informed choices with the awareness they need to improve healthier eating habits and ameliorate their health and well-being.

5. Conclusions

Although this study presents some limitations regarding sample and data collection, it still allowed drawing some trends on the topic, namely:

1. Validation of the scale by factor analysis showed two factors, one accounting for the true statements and the other for the statements that were given to the participants as false.
2. Cluster analysis allowed the identification of three clusters: cluster 1 included individuals who knew about the true and false statements, cluster 2 included individuals who did not know about the true statements and had very low knowledge about the false statements, and cluster 3 included individuals who knew about the true statements but failed to correctly identify the false statements.
3. Tree classification showed that the country was the variable most influencing the level of knowledge, followed by education and sex.
4. Considering the anthropometric, personal, and behavioral variables, the most important determinant for the level of knowledge was a varied diet.

In conclusion, this pioneering study, comparing consumer knowledge about the dietary relevance

of fruits and vegetables in France and Portugal, provides valuable insights into the cultural and behavioral influences shaping dietary perceptions. The findings reveal differences in knowledge levels and highlight the impact of socio-demographic and behavioral factors on this awareness.

6. Limitations and future work

Because the data collection followed a snowball methodology, with invitations sent by internet tools, we obtained a convenience and not a probabilistic sample. Therefore, the representativeness of the two countries was not even or proportional, and the same was verified for the other sociodemographic groups, with a lower representativeness of senior adults, men, and people with a level of education lower than university studies. For this reason, the confusions presented must be seen as those observed for the sample in the study, which could represent some trends for the population of the two countries, but not necessarily.

As a continuation of this work, it could be implemented in other countries of the Mediterranean surroundings to detect similarities or differences, bearing in mind their common typology of adherence to the MD. It would also be interesting to get additional financial support to undertake a similar study based on a probabilistic sample, with proportional representativeness of the different sociodemographic groups, to better extend possible conclusions to the whole population in the countries involved.

7. Guidelines for policymakers

Knowledge is fundamental to help shape people's eating habits. In the case of foods with a beneficial impact on an individual's health, the awareness of that positive impact can lead to higher consumption. This is precisely the case with fruits and vegetables, whose health benefits are well documented, but whose consumption is still not as desirable in many populations, particularly among the younger generations, who tend to consume more snacks and fast food as more trendy foods. Therefore, policymakers should plan initiatives to increase knowledge about the positive effects of consuming more vegetables and fruits in schools, health centers, or communities but also among the media channels used by the younger generations, like interesting innovative videos on TikTok or Instagram, for example. Also, launching apps and games to make the consumption of fruits and vegetables trendy would be a suitable way to increase the adoption of healthy foods. Finally, governments should implement policies to support the sale of healthy fruits and vegetables at affordable prices, cheaper than sugary sweets or other less recommended foods.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

The authors declare no conflicts of interest.

Authors contributions

Conceptualization: R.P.F.G.; methodology: R.P.F.G. and E.T.-L.; software: R.P.F.G.; validation: R.P.F.G.; formal analysis: R.P.F.G.; investigation: E.T.-L., and R.P.F.G.; resources: R.P.F.G. and E.T.-L.; data curation: R.P.F.G.; writing—original draft preparation: R.P.F.G., S.G.F., J.C.G., E.T.-L. and M.J.L.; writing—review and editing: R.P.F.G.; visualization: R.P.F.G. and S.G.F.; supervision: R.P.F.G.; project administration: R.P.F.G.; funding acquisition: R.P.F.G.. All authors have read and agreed to the published version of the manuscript.

Supplementary

Appendix A. Complete Questionnaire.

I-Sociodemographic and anthropometric characteristics
1. Gender: Male ☐$_1$ Female ☐$_2$
2. Age: ____years
3. Education level: Up to high school ☐$_1$ University studies ☐$_2$
4. Marital status: Single ☐$_1$ Married ☐$_2$ Divorced ☐$_3$ Widowed ☐$_4$
5. Professional status: Student ☐$_1$ Unemployed ☐$_2$ Public worker ☐$_3$ Employed ☐$_4$ Businessman ☐$_5$ Other ☐$_6$ Which?_____
6. Dimension of the household: 1–2 persons ☐$_1$ 3–5 persons ☐$_2$ 6–9 persons ☐$_3$ 10+ persons ☐$_4$
II-Anthropometric and behavioral characteristics
7. Weight ____kg
8. Height _____meters
9. Physical exercise? Never ☐$_1$ 1x/week ☐$_2$ 2–3x/week ☐$_3$ +3x/week ☐$_4$
10. Do you believe you have a varied diet? Never ☐$_1$ Sometimes ☐$_2$ Several times/week ☐$_3$ Always ☐$_4$
11. How do you rate your health status? I don´t want to report ☐$_1$ I don´t know ☐$_2$ Bad ☐$_3$ Moderate ☐$_4$ Good ☐$_5$ Excellent ☐$_6$
12. Are you satisfied with your weight? Yes ☐$_1$ No ☐$_2$
13. If you answered *No* in the previous question, what is the reason for dissatisfaction? Low weight ☐$_1$ Obesity ☐$_2$ Excess of weight ☐$_3$
III-Lifestyle
14. How many times have lunch or dinner away from home? Less than once/month ☐$_1$ 2–4x/month ☐$_2$ 1–3x/week ☐$_3$ 4–7x/week ☐$_4$
15. What kind of food do you usually eat outside from home? Normal food ☐$_1$ Vegetarian food ☐$_2$ Detox food ☐$_3$ Other☐$_4$ Which?_____

16. Do you like to eat vegetables?
Yes ☐$_1$ No ☐$_2$

17. If you answered *Yes* in the previous question, which do you consume most (you may select more than one option)
Peas/beans ☐$_1$ Tomato ☐$_2$ Bell pepper ☐$_3$ Aubergine ☐$_4$ Artichoke ☐$_5$ Cauliflower ☐$_6$ Carrot ☐$_7$ Beetroot ☐$_8$ Lettuce ☐$_9$ Broccoli ☐$_{10}$ Cabbage ☐$_{11}$ Watercress ☐$_{12}$ Spinach ☐$_{13}$

18. What is the frequency of vegetable consumption in a week?
Never ☐$_1$ 1–2x/week ☐$_2$ 3–5x/week ☐$_3$ Every day ☐$_4$

19. What amount of vegetables do you consume in a week? (please express it in number of teacups)
_____

20. If you answered *Yes* in question 16, which type do you consume more in a week?
Raw vegetables ☐$_1$ Cooked vegetables ☐$_2$

21. How many pieces of fruit do you consume on average in a week?
Zero ☐$_1$ 1–3 pieces/week ☐$_2$ 4–7 pieces/week ☐$_3$ 1–2 pieces/week ☐$_4$

22. Which fruit type of consumption do you prefer?
Fresh natural ☐$_1$ Natural juice ☐$_2$ Smoothie ☐$_3$ Other ☐$_5$ Which_____

23. If you selected natural juice/smoothie in the previous question, which amount to you consume in a week? (teacups) _____

24. Do you like to eat soup?
Yes ☐$_1$ No ☐$_2$

25. If you answered *Yes* in the previous question, which soup do you prefer?
Chicken soup ☐$_1$ Soup with vegetables pieces ☐$_2$ Soup with minced vegetables ☐$_3$

26. How many times do you consume soup in a week?
Never ☐$_1$ 2–3x/week ☐$_2$ once/week ☐$_3$ Everyday ☐$_4$

IV-Health problems

27. Do you have any disease?

Disease	**Yes**	**No**	**I don't know /I don´t remember**	**I don't want to report**
Diabetes	☐$_1$	☐$_2$	☐$_3$	☐$_4$
Obesity	☐$_1$	☐$_2$	☐$_3$	☐$_4$
Cardiovascular diseases	☐$_1$	☐$_2$	☐$_3$	☐$_4$
High cholesterol	☐$_1$	☐$_2$	☐$_3$	☐$_4$
Constipation	☐$_1$	☐$_2$	☐$_3$	☐$_4$
Cancer	☐$_1$	☐$_2$	☐$_3$	☐$_4$

V-Knowledge about the consumption of vegetables and fruits

28. Give your opinion to each statement in the scale: 1 = Strongly disagree, 2 = Disagree, 3 = Indifferent, 4 = Agree, 5 = Strongly agree.

Knowledge	**1**	**2**	**3**	**4**	**5**
Fruits and vegetables are foods poor in vitamins and minerals that are important to the good functioning of the human body	☐	☐	☐	☐	☐
The regular consumption of vegetables and fruits results in higher and better longevity.	☐	☐	☐	☐	☐

By consuming fruits and vegetables on a daily basis, your body cells will be unprotected.	☐	☐	☐	☐	☐
Vegetables and fruits are low-calorie foods and can contribute to a healthy weight reduction.	☐	☐	☐	☐	☐
Green leaves, beans, broccoli, cabbage, cauliflower, and vegetables with a yellow-orange coloration like carrots are more effective in the reduction of cancer incidence.	☐	☐	☐	☐	☐
Some vegetables such as spinach or cabbage are rich in iron and can help cure anemia.	☐	☐	☐	☐	☐
Neither vegetables nor fruits contain sugars.	☐	☐	☐	☐	☐
Both vegetables and fruits constitute a good source of dietary fiber.	☐	☐	☐	☐	☐
Some vegetables and legumes can be irritating to the intestine.	☐	☐	☐	☐	☐
The regular consumption of vegetables and fruits can protect against type 2 diabetes, cardiovascular diseases, hypertension and cancer.	☐	☐	☐	☐	☐
A high ingestion of fruits and vegetables can reduce obesity, cholesterol, and lower blood pressure.	☐	☐	☐	☐	☐

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