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Shellfish consumption preferences in an oceanic archipelago

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A survey on shellfish consumption preferences was conducted in the Eastern Atlantic archipelago of Madeira. A total of 402 valid questionnaires were collected from locals older than 15 years old. Gender, age, highest education level, work status and salary were considered in the sample composition. Participants were inquired about frequency, amount and risks associated with consumption, as well as concerns regarding the freshness of seafood. Shellfish appears to be consumed less than once a week, and 79.1% of these consumers prefer limpets. GLM analysis showed that total salary amount was the demographic variable which most affects seafood consumption. The results indicated that the majority of the respondents consume limpets less than once a week, in an amount that varies between a quarter and a half dose. With regard to health concerns, most respondents are conscious of the importance of products' freshness and approximately half of them are aware of the existence of risks associated with consumption. In general, the awareness about freshness and possible risks of consumption is dependent on the level of education. Limpets are preferably consumed during summer, both grilled and cooked, respectively. The present study provides preliminary information on shellfish consumption trend in the archipelago of Madeira. Raising the awareness of seafood consumers in line with a health surveillance network in preparation in Macaronesia could be an important tool for spreading information related to the risks associated to its consumption.

KEYWORDS

seafood consumption, demography, limpets, awareness, Madeira archipelago

1 Introduction

Seafood is broadly recognized as an important component of a healthy diet (Minnens et al., 2020). It is pivotal for body functions and promotes proper brain and nervous system development during gestation and infancy. Additionally, it helps to prevents cardiovascular disease in adults and has anticancer properties (Liao and Chao, 2009). However, concerns about shellfish consumption have risen over the risks associated with contaminants such as toxic metals, dioxins and polychlorinated biphenyls (Minnens et al., 2020). Nevertheless, several studies have shown that the health benefits far outweigh the potential risks for the general population (EFSA, 2012; Hellberg et al., 2012).

Seafood is of high nutritional value and is especially important in oceanic islands, where marine organisms are a more accessible source of protein (Sousa et al., 2019). They provide high-quality proteins rich in essential amino acids, a wide variety of minerals, including iron, calcium, zinc, phosphorus, magnesium and selenium, vitamins A, B, and D and polyunsaturated fatty acids particularly omega-3 (Cardoso et al., 2013; Nesheim et al., 2015; Chen et al., 2022).

Portugal has the second highest fish consumption per capita in the European Union per year (*ca*. 60.62 kg) (European Commission, 2020). Seafood consumption is not only associated with the intrinsic features of fishing resources (appearance, taste, smell and texture), but also with the economic, cultural and heritage characteristics of consumers. These socio-demographic features are in turn related to place of residence, health, wellbeing, tradition and religion (Almeida et al., 2015; Murray et al., 2017; Govzman et al., 2021).

In the archipelago of Madeira, shellfish consumption is part of the region's gastronomic heritage and dates back to the fifteenth century when the Portuguese discovered and colonized the archipelago (Silva and Menezes, 1921). The accessibility to rocky shores and coastal settlement prompted the exploitation of these resources along the coast over the years (Henriques et al., 2017). This activity is of high importance for the region's small-scale fisheries, directly benefitting coastal communities and indirectly providing for the whole community (Sousa et al., 2020). The economic impact of harvesting limpets has gradually increased over the years, marked by annual catches of up to 88 tonnes and yielding a first value of *ca*. 0.5M€ in 2021 (Regional Directorate for Fisheries, 2022).

There are few studies reported in the literature on fish consumption preferences in Portugal. Fish consumption preferences in the archipelago of Madeira were addressed by Hermida and Costa (2020). Lourenço et al. (2021) studied the preferences on the consumption of sea urchins which were stated as valuable seafood to be consumed in restaurants. The present work details the preferences associated with the consumption of limpets in this archipelago.

The present characterization intents to provide readers with a comprehensive outlook on shellfish consumption preferences for locals aged 15 years and older in the archipelago of Madeira. This study was based on a questionnaire survey carried out in Madeira and Porto Santo Islands considering demographic features such as gender, age group, level of education, occupation, preferences and associated consumption risks linked to heavy metals, toxins, food poisoning among others.

2 Materials and methods

2.1 Survey design

The archipelago of Madeira has a resident population of 250744 inhabitants (INE, 2022). As such, and in order to obtain a precision of ± 5% at a 95% confidence level, a minimum of 400 valid questionnaires were performed (Israel, 1992). These were designed to obtain information on the population's seafood consumption preferences and on the communities' awareness of the possible risks associated with consumption.

The survey was carried out randomly in both in-person interviews and online forms in order to reach the study's target population, which included locals aged 15 years and older. In-person interviews and online forms were conducted in the islands of Madeira and Porto Santo between October 2021 and March 2022. Information on the study's purpose and data confidentiality was provided to all participants before starting the questionnaire.

There were 14 questions in total, including both open and closed questions to allow a more comprehensive data collection. The questionnaire also included dependent questions or contingent to the previous one. Questions were divided into three sections: sociodemographic characterization, shellfish consumption and health concerns (Supplementary material).

Sociodemographic characterization considered place of residence, gender, age group, level of education, work status and salary. Work status was organized in three groups: "Employed", "Unemployed" and "Not in the labour force". Options were codified as 0, 1 and 2. Regarding salary amount, options were "<500€", "501-750€", "751-1500" and ">1500€". When the respondents did not answer, the attributed code was 0. Options were codified as 1, 2, 3 and 4.

The main part of the questionnaire was dedicated to shellfish consumption preferences considering the frequency of weekly intake for limpets, and the options "Do not consume", "Less than 1", "1 to 3", "4 to 6" and "More than 6" were included. In order to calculate proportions, options were codified as 0, 1, 2, 3 and 4, respectively. The approximate amount of consumption for each time, in doses, provided the options "Do not consume", "1/4", "1/2", "1" and "More than 1", which were codified as 0, 1, 2, 3 and 4. A dose of limpets includes approximately 20 limpets with an average size of 55 mm, corresponding to an edible portion of approximately 80 g.

The question regarding the preferable place of consumption contemplated the options "Do not consume", "Domestic" and "Restaurants", codified as 0, 1 and 2. In addition, participants were asked about the preferred season for consuming shellfish, ("Do not consume", "Winter", "Spring", "Summer" or "Autumn") and favourite cooking method ("Do not consume", "Raw", "Cooked", "Grilled" or "Other").

In order to infer about respondents' awareness on the potential risks associated with seafood consumption, the question "Do you consider that there is some risk associated with consumption?

("Yes", "No")" was added. If yes should be the response, the participant was then directed to a question regarding the nature of the potential risks ("Allergies", "Food poisoning", "Presence of toxins", "Presence of heavy metals", "Presence of bacteria", "Presence of viruses", "Other").

2.2 Statistical analysis

Statistical analysis was performed using R Statistical Software (version 1.4.1006; R Foundation for Statistical Computing, Vienna, Austria). A Chi-square test was used for comparing variances between and within groups for each variable. For each consumption measure, the influence of each demographic variable was evaluated by applying a General Linear Model (GLM) with a Poisson distribution. Gender, age group, level of education, work status and total salary amount were considered as explanatory variables. For all tests, statistical significance was accepted when $p<0.05$.

3 Results

A total of 441 questionnaires were randomly distributed, 402 of which were considered as valid after a preliminary analysis. The majority of the survey participants (94.2%) was from Madeira archipelago ($\chi 2$ = 327.80; $p<0.05$). Surveys assigned to participants under 15 years old and non-residents in Madeira archipelago were discarded from the study.

3.1 Socio-demographic characterization

A general socio-demographic characterization of the survey participants is presented in Table 1 (n=402), adjacent to a comparison with official data (INE, 2022). The group was characterized by a higher percentage of women (54.2%) (χ^2 = 2.88; p>0.05), and a significant majority of participants was aged between 25 and 64 years old (χ^2 = 597.33; p<0.05). Regarding education level, there was an unintentional deviation from the official data, with a higher representation of people with both a high school and university education (42.5% and 43.8%, respectively) (χ^2 = 214.42; p<0.05).

Considering employment, the majority of participants were employed (79.1%), followed by not in the labour force (16.2%) and unemployed (4.7%) (χ^2 = 420.10; p<0.05). Furthermore, it was verified that income significantly differs among groups and that most participants earn between € 751-1500 a month (37.6%) (χ^2 = 96.44; p<0.05).

3.2 Seafood consumption

79% of the inquired reported consuming limpets (χ^2 = 15.1; p<0.05). Among these, the majority (55%) has never harvested limpets for their own consumption.

When asked about frequency of seafood consumption, 61.9% of participants stated that they consume less than a portion of limpets (χ^2 = 68.8; p<0.05) per week (χ^2 = 491.3; p<0.05). With regards to consumption preferences, limpets are preferably consumed grilled

TABLE 1 Demographic characteristics of surveys sample, in comparison with official data for Madeira archipelago population.

	Survey sample	Madeira Island population
Gender[a]		
Female	54.2% (n=218)	53.1% (n=133059)
Male	45.8% (n=184)	46.9% (n=117685)
Age group[a]		
15 – 24 years	16.4% (n=66)	11.2% (n=28189)
25 – 64 years	78.9% (n=317)	56.1% (n=140557)
65 years and over	4.7% (n=19)	20.0% (n=50060)
Level of education[a]		
Did not complete basic education	4.2% (n=17)	14.6% (n=36485)
Basic education	9.5% (n=38)	50.3% (n=126148)
High school	42.5% (n=171)	20.7% (n=52015)
University education	43.8% (n=176)	14.4% (n=36096)
Work status[a]		
Employed	79.1% (n=318)	40.6% (n=100642)
Unemployed	4.7% (n=19)	5.5% (n=13810)
Not in the labour force	16.2% (n=65)	54.4% (n=136292)

[a]– Census INE 2021

($\chi2$ = 198.6; p<0.05) in restaurants ($\chi2$ = 34.6; p<0.05) during summer ($\chi2$ = 799.8; p<0.05) (Figure 1 and Table 2).

The majority of both male and female consume between a quarter and a half dose (p<0.05) of limpets at a frequency inferior to once a week (p<0.05). Consumption is preferred at restaurants (females χ^2 = 6.600; p<0.05 and males χ^2 = 0.509; p=0.467), grilled (p<0.05) and during summer (p<0.05). No significant differences were observed between genders (p>0.05) for all questions, with the exception of consumption frequency (χ^2 = 12.750; p<0.05).

Results show that the age group between 25-64 years old presented the highest proportion of consumers. Analysis also revealed that most participants consume limpets less than once a week, regardless of the age group (χ^2 = 8.942; p=0.347). Contrarily to participants older than 24 years old, young adults demonstrated a preference for consuming limpets at home (χ^2 = 1.143; p=0.285).

Concerning education level, participants prefer to consume limpets less than once a week (p<0.05). However, this trend was not statistically significant for those without a basic education (χ^2 = 1.529; p=0.465). Responders with a basic education or less (p<0.05), as well as unemployed (despite with no statistical significance: χ^2 = 1.667; p=0.197), prefer to consume limpets at home. It was also found that an increase in salary leads to a preference for consumption in restaurants (χ^2 = 12.820; p<0.05).

Total salary amount is the demographic feature with more influence in the results in all consumption measures (Table 3).

3.3 Health concerns

Approximately 80% of the inquired have concerns about the freshness of the consumed seafood (χ^2 = 229.9; p<0.05), and 62.2% consider that there is some risk associated with consuming limpets (χ^2 = 23.9; p<0.05). From those that acknowledge risk, 48% pointed out food poisoning as the major menace. It was also considered that seafood consumption could promote the development of allergies, the bioaccumulation of heavy metals and illnesses caused by the presence of toxins, bacteria and virus (χ^2 = 285.9; p<0.05).

Regarding the risks associated with allergies and heavy metals, analysis among groups showed statistically significant differences between genders (χ^2 = 6.013; p<0.05 and χ^2 = 4.304; p<0.05, respectively). Concerning food poisoning and the presence of
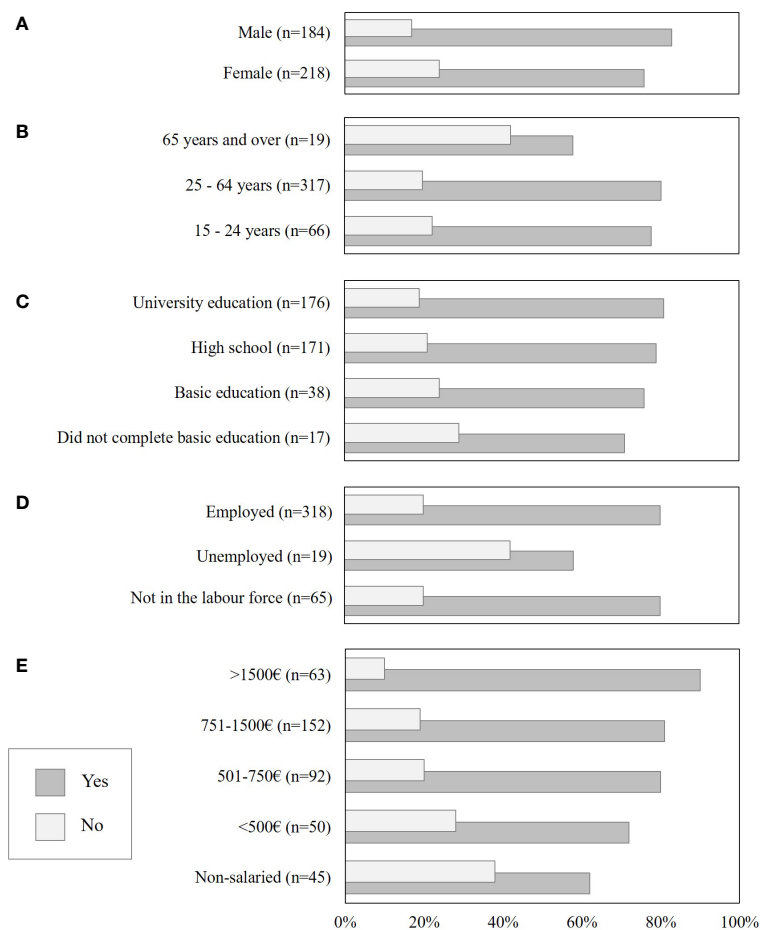

FIGURE 1
Seafood consumption in Madeira Island by gender (A), age group (B), level of education (C), work status (D) and salary (E).

TABLE 2 Preferences of consumers regarding frequency, amount, place, season and form of seafood consumption in Madeira archipelago.

	Consumption frequency					Consumption amount				Place		Season				Form of consumption			
	Do not consume	Less than 1/week	1 to 3/week	4 to 6/week	More than 6/week	1/4 of a dose	1/2 of a dose	1 dose	More than 1 dose	Domestic	Restaurant	Winter	Spring	Summer	Autumn	Raw	Cooked	Grilled	Other
Valids (n=402)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Gender																			
Female (n=218)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Male (n=184)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Age group																			
15 - 24 years (n=66)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
25 - 64 years (n=317)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
65 years and over (n=19)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Level of education																			
Did not complete basic education (n=17)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Basic education (n=38)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
High school (n=171)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
University education (n=176)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Work status																			
Employed (n=318)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Unemployed (n=19)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Not in the labour force (n= 65)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Total salary amount																			
Non-salaried (n=45)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
<500€ (n=50)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
501-750€ (n=92)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
751-1500€ (n=152)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
>1500€ (n=63)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

● 0; ● 1-20; ● 21-40; ● 41-60; ● 61-80; ● 81-100.

toxins, no statistically significant differences were shown (p>0.05) (Table 4).

Age group, level of education and total salary amount were the demographic variables responsible for the statistically significant differences observed regarding concerns about bacteria and viruses (p<0.05).

4 Discussion

The present study provides the first outlook on shellfish consumption preferences and the associated health concerns in the archipelago of Madeira. The questionnaire survey yielded a total of 402 valid questionnaires corresponding to a representative sample of the inhabitants of the archipelago (Israel, 1992). Participant related socio-demographic features such as place of residence, gender, age group, level of education, work status and salary were analysed. Questionnaires from non-residents and locals under 15 years old were discarded from the analysis as they were residual.

Seafood consumers in the archipelago of Madeira appear to be predominantly between 35 and 64 years old, with high educational qualifications, employed and more affluent. However, gender does not seem to directly influence the population's shellfish consumption. This is in line with results reported by Govzman et al. (2021), in a review from several works related to the determinants of consuming seafood.

The current analysis also demonstrated that the majority of local people (80%) usually consume limpets. From these, approximately half has already harvested limpets for their own consumption. In fact, traditional harvesting in the archipelago is allowed up to 3 kg/day/person. This high percentage may be linked to the cultural heritage of oceanic regions, generally characterized by a lack of animal protein. Once known as "the poor people's food' or 'famine food', limpets are nowadays a highly prized product, appreciated by both locals and tourists (Firth, 2021).

Additionally, results suggested that there is a local awareness about the degree of freshness of seafood and the potential risks associated with its consumption. According to the survey, approximately 80% of participants recognize the importance of seafood's freshness, 62% of which are mindful of the existence of risks associated with the consumption of limpets. Regarding the latter, food poisoning was elected as the greater potential threat by 48% of the inquired.

Despite being aware of the risks, participants did not express the expected concern in relation to the problem of heavy metals in limpets, regardless of their education level. This is particularly important since these molluscs tend to bioaccumulate metals from both geogenic and anthropogenic origins (*e.g.* cadmium) (Pedro et al., 2021).

The tolerable weekly intake (TWI) currently accepted as appropriate for cadmium in view of a safe seafood consumption is 2.5 μg/kg (ww) (EFSA, 2011). The maximum cadmium content in limpets, legislated by the Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs, is 1 mg of cadmium per 1 kg of seafood wet weight. Thus, an adult weighing approximately 60 kg (FAO/WHO, 2004) can consume up to 150 g of limpets edible parts, with the maximum legislated cadmium content. Nonetheless, the cadmium content in limpets depends on different factors, including geographic location (Collado et al., 2006; Reinecke et al., 2012), season (Reinecke et al., 2012), type of substrate on which it feeds (Mbandzi et al., 2021) and size of the limpet (Cubadda et al., 2001). Therefore, the tolerable weekly quantity of limpet soft tissue should not be considered linearly, since the cadmium content in certain batches may overwrite the maximum legislated content reaching, in some cases, 3 times this maximum content (Pedro et al., 2021).

Since traditional harvesting is duly regulated and allows the harvesting of 3 kg/day/person without the need for a license, it becomes impractical to control the heavy metal content in these batches. However, since only a small portion of the inquired consume limpets more than once a week (*ca.* 17%) and considering that the amount consumed each time is always less than one dose (*ca.* 6%), consumption of limpets should not pose a threat to health of these consumers. Even so, there is an urgent need to raise awareness on this topic.

TABLE 3 Results of GLM models for seafood consumption preferences.

Consumption measure	Model fit	Demographic variables				
	Deviance explained	Gender	Age group	Level of education	Work status	Total salary amount
Consumption frequency	33%	**0.012**	0.253	0.085	0.354	**0.02**
Consumption amount	25%	0.395	0.643	**0.023**	0.461	**0.007**
Place	58%	0.083	0.067	**2.00E-06**	0.661	**1.42E-04**
Season	27%	**0.007**	0.097	0.857	0.526	**0.005**
Form	34%	**0.032**	0.951	0.995	**0.008**	**0.001**

Significance of each variable is given as the p-value of the Chi-square test for the GLM models and the p-value of the F test for the linear model, respectively.
Bold values means statistically significant (p<0.05).

TABLE 4 Consumers concerns regarding possible risks associated to seafood consumption in Madeira Island.

	Allergies	Food poisoning	Toxins	Heavy metals	Bacteria	Viruses	Other
Total (n=402)	●	●	●	●	●	●	●
Gender							
Female (n=218)	●	●	●	●	●	●	●
Male (n=184)	●	●	●	●	●	●	●
Age group							
15 - 24 years (n=66)	●	●	●	●	●	●	●
25 - 64 years (n=317)	●	●	●	●	●	●	●
65 years and over (n=19)	●	●	●	●	●	●	●
Level of education							
Did not complete basic education (n=17)	●	●	●	●	●	●	●
Basic education (n=38)	●	●	●	●	●	●	●
High school (n=171)	●	●	●	●	●	●	●
University education (n=176)	●	●	●	●	●	●	●
Work							
Employed (n=318)	●	●	●	●	●	●	●
Unemployed (n=19)	●	●	●	●	●	●	●
Not in the labour force (n= 65)	●	●	●	●	●	●	●
Total salary amount							
Non-salaried (n=45)	●	●	●	●	●	●	●
<500€ (n=50)	●	●	●	●	●	●	●
501-750€ (n=92)	●	●	●	●	●	●	●
751-1500€ (n=152)	●	●	●	●	●	●	●
>1500€ (n=63)	●	●	●	●	●	●	●

● 0; ● 1-20; ● 21-40; ● 41-60; ● 61-80; ● 81-100.

Based on this study findings, future intervention strategies may take place in order to grow awareness about the real risks associated with the consumption of gastropod molluscs.

5 Conclusions

Limpets have been a delicacy consumed in oceanic archipelagos for several decades. Once consumed to combat hunger and lack of nutrients, nowadays it is considered a gourmet dish in such regions, highly sought by both locals and visitors.

The present study had the goal to identify preferences of limpet's consumption in Madeira Island. For so, a survey was conducted to evaluate several consumption measures, namely frequency, amount, season and risks associated. A relationship between these data and the demographic characteristics of the respondents was performed.

Some of the results showed that seafood consumers resident in Madeira Island are predominantly between 35 and 64 years old, presenting educational qualifications and better financial background. It was also evident a local awareness regarding the degree of freshness of seafood and the potential risks associated with its consumption. However, it was possible to state that work has to be done in the field of information related to the potential risks due to the accumulation of heavy metals in gastropod molluscs, in special cadmium from anthropogenic and geogenic origins. Moreover, the total salary amount was the sociodemographic characteristic which had more influence in the seafood consumption preferences.

The present study also made it possible to identify the existence of misinformation regarding health risks associated with limpets' consumption. Thus, the creation of a health surveillance network for fishery products must include actions to raise awareness of these aspects among the population.

This work adds new data on seafood consumption preferences in Madeira Island.

Data availability statement

Author contributions

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Conflict of interest

Publisher's note

Supplementary Material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2023.1149888/full#supplementary-material

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