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Consumption of Nuts and Similar Dried Foods in Portugal and Level of Knowledge about their Chemical Composition and Health Effects

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A R T I C L E I N F O

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A B S T R A C T

Nuts are consumed worldwide and have valuable nutritional compositions. However, few studies exist about the consumers' knowledge regarding nuts and similar dried fruits. This study aimed to investigate the knowledge on nuts composition (KNC) and health effects (KNHE) associated with nuts consumption and evaluate eating habits and preferences. A questionnaire survey was applied by direct interview to 300 Portuguese citizens, recruited by convenience. Anthropometric properties, behavioural and health aspects, knowledge about nuts composition and health effects, and consumption habits and preferences were evaluated and statistically analysed. Globally, the participants were not well informed on the chemical composition of nuts and about their effects on human health. Regarding age, the middle-aged adults showed a little higher level of KNC. However, no statistical differences were observed for KNC and KNHE across groups of Body Mass Index, physical exercise practice or balanced diet. Concerning eating habits and preferences, most participants (84%) like nuts, and usually consume them (58%). Among different nuts, the most consumed ones were peanuts and walnuts, followed by almonds and hazelnuts. A vast majority of participants (86%) preferred to eat the nuts in their simple form and consume them between meals. In conclusion, improvement of communication on nuts benefits to human health might be a way to increase their consumption. Our data can also help the nut industries to formulate a better strategy.

Introduction

Nuts, in a broad sense, include fruits such as chestnuts, almonds, hazelnuts, walnuts, pine nuts or pistachios, but also comprise peanuts, which, although botanically being a legume, have a nutrient profile similar to those of tree nuts (Emilio Ros, 2017).

Different nuts including Walnut, Pistachio, hazelnut, etc, are nutrient-rich foods and contain various bioactive compounds (Vahdati *et al.*, 2018; Hong *et al*., 2020; Sarikhani et al., 2021). The lipids found in nuts are mostly unsaturated fatty acids (mono and polyunsaturated Omega-3 and Omega-6), which are beneficial to health, so there is convincing evidences that shows that eating nuts provides protection against cardiovascular diseases (CVD) (Vale, 2019), by improving the lipids profile (Roozban *et al.*, 2005; Jahanbabi *et al.*, 2018). The consumption of nuts can protect against CVD by reducing oxidative stress, inflammation and improving endothelial function. Nuts components, such as unsaturated fatty acids, L-arginine, beneficial minerals, phenolic compounds and phytosterols, seem

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to be of great importance for their health effects (Hazrati et al., 2020; Bitok and Sabaté, 2018).

Nuts and similar dried fruits are rich in fibres which are beneficial for intestinal transit and help to satiate the appetite. In addition, the content of vitamin E (antioxidant) present in these fruits combats the harmful effects caused by free radicals, preventing premature ageing, helping in the prevention of cardiovascular diseases and atherosclerosis. On the other hand, the balanced content of minerals (calcium, magnesium, potassium and sodium) enhances the development of a healthy skeleton, and helps the control of blood pressure. Due to their characteristics, these fruits can, for example, be useful for students as they provide the necessary energy for intellectual activity. Sportspeople can also benefit from the energetic properties of these fruits. For vegetarians, for example, these fruits (namely nuts) can be good sources of protein (Rabadán *et al*., 2019; Souza *et al*., 2017; Vale, 2019).

The dietary benefits of nuts can be attributed to hemostatic factors, omega-3 fatty acids, monounsaturated fatty acids, essential and non-essential amino acids, vitamins, flavonoids, folic acid, and plant sterols that may be present in those fruits. The consumption of nuts was associated with a reduced risk of cardiometabolic diseases; obesity, metabolic syndrome, diabetes and cardiovascular diseases; coronary artery disease, hypertension and stroke (Eslami *et al*., 2019; Vargova *et al*., 2019).

The consumption of nuts is inversely related to fatal and non-fatal coronary heart disease and may lead to mortality. Randomised clinical trials have shown that diets enriched with nuts have a cholesterol-lowering effect, while beneficially impacting other cardiovascular risk markers, such as visceral adiposity, blood pressure, oxidative stress, inflammation and vascular reactivity, without incurring undue weight gain. Preliminary evidences suggest that nuts can also affect cognitive impairment and cancer (Jahanbani *et al.*, 2016). Recently, the PREDIMED study of long-term nutritional intervention in individuals at high cardiovascular risk showed that regular consumption of nuts is associated with a 30% reduction in cardiovascular disease. Thus, there is scientific evidence to support the inclusion of nuts in the diet to improve health (Ros, 2016).

The beneficial effects of nut consumption on human health have been widely confirmed. However, these benefits are variable, as a wide range of factors has a major influence on the nutritional properties of nuts, like for example, different cultivars produce nuts with different composition (Chatrabnous *et al.*, 2018). Also, other factors besides the effect of cultivar determine nut composition, such as climatic conditions during the development of the dried fruits. The results of a study by Rabadán *et al*., (2019) show that by using different cultivars, some of the main nutritional parameters of nuts, such as oil content or linoleic acid concentration, can be controlled. However, for some of the determining factors in the nutritional quality of the dried fruits, like protein content, phytosterol concentration and the presence of minerals such as iron or sulfur, the climatic conditions of the growing year are decisive. In this scenario, the health-promoting properties of nuts can be compromised by the variability associated with climate change (Rabadán *et al*., 2019).

The moisture content, oil content, fatty acids composition, as well as the rancidity, are considered the main parameters determining the quality of nuts (Duduzile Buthelezi *et al*., 2019). Recently, the global demand for nuts has been increased because these fruits can be excellent snacks (Bai *et al*., 2018). Although they should be avoided in their salty form, they are still much healthier than other snacks. They can be incorporated into breakfast cereals, cereal bars (snacks), salads, sweets and other culinary dishes. Despite the benefits described, these fruits should always be consumed in moderate dosages due to their high-calorie content, which can be harmful (Vale, 2019).

Because there are very limited studies about nuts consumption and there is an important gap about the

consumers' knowledge regarding nuts and similar dried fruits, this work intended to investigate the knowledge about the chemical components and beneficial health effects associated with consumption of this type of food products. This investigation in within the projects VALNTUS and VALOR CAST, which focus on nut' investigation and they include also the producers' perspectives. In this way it is relevant for them to know how it would be possible to incentive further consumption of these types of food among the Portuguese. Hence this research is designedto respond to the following resercah questions: 1) What are the patterns of nut consumption among Portuguese? 2) How knowledge exists about their chemical composition/nutritional value? 3) How much knowledge exists about their health effects? and finally 4) How can we target specific sociodemographic groups to increase consumption, i.e., how much do the sociodemographic variables influence these questions.

Material and Methods

Questionnaire

The instrument used for this research was developed purposely for the study. It included different parts as follows: Part I – sociodemographic data, Part II – anthropometric data and behavioural and health aspects, Part III – consumption habits related with nuts and similar dried products, Part IV – knowledge about the chemical composition of specific nuts or related products, Part V – knowledge about the health effects of particular nuts or similar products. Specifically, the products investigated were: chestnut, almond, hazelnut, walnut, carob, pine nut, pistachio, and peanut. All statements used in parts IV and V of the questionnaire are reproduced in Appendix A, and they were evaluated on a Likert scale. The participants would express their level of agreement with each statement on the following: 0 – no opinion, 1—strongly disagree, 2—disagree, 3—agree and 4—strongly agree. Because some of the questions were in inverted mode, the corresponding scores were reversed. In this way, higher global or average scores are indicative of a higher level of knowledge.

Data Collection

The questionnaire was applied through a direct interview to 300 Portuguese citizens, who voluntarily participated in the survey, after informed consent. The sample was recruited by convenience by picking random citizens on the street. All ethical procedures were strictly followed when designing and applying the questionnaire. It was ensured that the data provided was kept strictly confidential so that neither of the individual responses provided could ever be associated with the respondent. Respondents were aged between 14 and 75 years old. The municipalities covered in the study were: Aguiar da Beira, Aveiro, Braga, Caldas da Rainha, Carregal do Sal, Castelo Branco, Coimbra, Guarda, Leiria, Lisbon, Oliveira do Hospital, Porto, Santarém, São Pedro do Sul, Seia, Tondela, Vila Real and Viseu.

Data analysis

Data analysis was performed using the software SPSS (IBM, Inc.) Version 26. For the treatment of the data, basic descriptive statistics were used. Additionally, to assess the relations between some of the categorical variables chi-square tests were used. The 'Cramer's V coefficient was considered when evaluating the strength of the significant relations found between some of the variables under study. This coefficient varies from 0 to 1, and for $V \approx 0.1$ the association is considered weak, for $V \approx 0.3$ the association is moderate and for $V \approx 0.5$ or over, the association is strong (Witten and Witte, 2009).

To minimise the interpretation divergences and to assign a clear and precise meaning to the variables, creating the possibility of making them measurable, the conceptual and empirical operationalisation of the variables related to knowledge was performed. Prior

to that, the items of the questionnaire which were in reverse order of the intended measure were reversed (these are indicated in Appendix A), to have all items in a comparable scale of knowledge: 0 – no knowledge, 1 – very low, 2 – low, 3 – good, 4 – very good knowledge.

Following these procedures, a reliability analysis, by means of 'Cronbach's alpha was undertaken for the set of items in each of the measuring variables:

- Knowledge about Nuts Composition (KNC) – items 1 to 36 in Appendix A
- Knowledge about Nuts Health Effects (KNHE) – items 37 to 82 in Appendix A

After that, the two above mentioned variables were computed as the average scores for each participant in both groups of items, eventually excluding those who would not meet the criteria for reliability.

For comparison of means for variables KNC and KNHE, were used the Student's t-test for independent samples between two groups and one-way ANOVA between three or more groups. In case of ANOVA, the differences between groups were identified through the post-hoc Tukey HSD test, also known as the Tukey's HSD (Honestly Significant Difference) test. This statistical test is used to determine which means are significantly different from each other, and consists of a single-step multiple comparison procedure, coupled to ANOVA. In this test, the difference between means is evaluated to see whether or not it is greater than the standard error.

Two other variables were defined for the level of knowledge: LKNC and LKNHE. These are categorical variables, and they classify the scores obtained for the variables KNC and KNHE into categories, according to the following classification: very little knowledge ($0 \leq$ value ≤ 1), little knowledge ($1 <$ value ≤ 2), high knowledge ($2 <$ value ≤ 3) and very high knowledge ($3 <$ value ≤ 4). The variables measuring the level of knowledge LKNC and LKNHE were submitted to a tree classification analysis for assessment of the relative importance of the possible influential sociodemographic variables (sex, age group, education, marital status), as well as anthropometric and behavioural variables (BMI class, physical exercise, balanced diet, chronic diseases). A Classification and Regression Trees (CRT) algorithm with cross-validation was used in the analysis of the data, and the minimum number of cases considered for parent or child nodes was 30 and 15, respectively. The level of significance considered in data analysis was 5% ($p < 0.05$).

Results

Sample characterization

The participants were aged between 14 and 75 years old, being on average 27±12 years, with equal average ages for female and male participants (27±12 and 27±11, respectively). To facilitate data processing, the age values were classified into groups as follows: teenagers ($13 \leq$ age ≤ 17 years), young adults ($18 \leq$ age ≤ 25 years), middle-aged adults ($26 \leq$ age ≤ 50 years), senior adults ($51 \leq$ age ≤ 65 years) and elderly (age ≥ 66 years). Most of the people who participated in this study were young adults (66%), followed by middle-aged adults (26%). Senior adults were less abundant (5%), followed by the elderly (2%) and teenagers (1%). The number of female participants was higher (N = 208, 69%) when compared to male participants (N = 92, 31%). Regarding the level of education, most participants had completed secondary education (12 school years) (N = 131, 44%), followed by those who had a university degree (N = 103, 34%), and participants who completed a level IV course (N = 17, 6%). The participants with completed basic school (3^{rd} cycle: 9 school years) were few (N = 34, 11%), followed by the 2^{nd} cycle: 6 school years (N = 11, 4%) and finally those who had only primary school – 1^{st} cycle: 4 school years (N = 4, 1 %). The distribution of participants according to marital status was the

following: the majority were single (77%), 19% were married or lived together, 2% were divorced or separated, and another 2% were widowed.

Anthropometric variables and behavioural and health aspects

Table 1 shows the anthropometric measures of the participants, including the body mass index (BMI) calculated as the ratio between weight and height squared. The mean height was 1.67 ± 0.09 m for the entire sample, being slightly lower (1.63 ± 0.06) for the group of women compared to men (1.76 ± 0.08), which was expected. The results also reveal that the average weight was 65.41 ± 12.34 kg, and the difference between women and men was considerable in this case: 61.36 ± 10.26 and 74.53 ± 11.78 kg, respectively. The BMI was 23.41 ± 3.63 kg/m^2 for the entire sample, being higher in men (23.96 ± 3.69 kg/m^2) when compared to women (23.17 ± 3.58 kg/m^2) (Table 1).

Table 1. Anthropometric measures of the participants.

Sex	Measure	Minimum	Maximum	Mean± SD[(1)]
Female	Height (m)	1.46	1.80	1.63 ± 0.06
	Weight (kg)	42.0	100.0	61.36 ± 10.26
	BMI[(2)] (kg/m^2)	16.4	36.7	23.17 ± 3.58
Male	Height (m)	1.60	1.96	1.76 ± 0.08
	Weight (kg)	48.0	105.0	74.53 ± 11.78
	BMI[(2)] (kg/m^2)	16.6	37.2	23.96 ± 3.69
Global	Height (m)	1.46	1.96	1.67 ± 0.09
	Weight (kg)	42.0	105.0	65.41 ± 12.34
	BMI[(2)] (kg/m^2)	16.4	37.2	23.41 ± 3.63

[(1)]SD = standard deviation;
[(2)]BMI = body mass index = (weight / height^2)

Table 2 presents the results for the practice of physical exercise, for the whole sample and also for the different groups according to the sociodemographic variables. The possible differences between groups were evaluated by the chi-square tests at the level of significance of 5%, and the strength of associations were assessed by the value of the 'Cramer's coefficient, also indicated in Table 2. It was observed that, for the whole sample, about 50% of participants practice physical exercise occasionally, i.e., only once per week. In comparison, only about 25% do it 2-3 times/week. It was further observed that 40% of the elderly never do physical work. Still, an equal percentage do it 2-3 times/week. The young adults, middle-aged adults and senior adults also practice exercise mostly only once/week (50.3%, 45.6% and 46.7% of participants, respectively). Table 2 also shows that the results were very similar also for both sexes and marital statuses.

Table 3 shows the results for the associations between balanced diet frequency and the sociodemographic variables. While between different marital status groups, no significant differences were encountered, the differences across groups of age, sex or education were significant. Regarding age groups, senior adults showed a higher percentage (53.3%) for practising a balanced diet sometimes, as compared with the other groups for that frequency. On the other hand, those who practice a balanced diet several times/week are mostly young adults (35.6%).

Table 2. Practice of physical exercise according to the sociodemographic variables.

Variables		Physical exercise			
		Never	Occasional (1x/week)	Moderate (2-3x/week)	Intense (+3x/week)
		% in line	% in line	% in line	% in line
Sex (p = 0.058, V = 0.158)[1]	Women	22.1	50.0	24.5	3.4
	Men	18.5	43.5	27.2	10.8
Age group[2] (p = 0.412, V = 0.183)[1]	Teenagers	25.0	25.0	25.0	25.0
	Young adults	21.8	50.3	24.9	3.0
	Middle aged adults	15.2	45.6	26.6	12.7
	Senior adults	33.3	46.7	20.0	0.0
	Elderly	40.0	20.0	40.0	0.0
Education[3] (p = 0.101, V = 0.157)[1]	1st cycle	25.0	25.0	50.0	0.0
	2nd cycle	18.2	63.6	18.2	0.0
	3rd cycle	14.7	52.9	26.5	5.9
	Secondary	13.8	54.2	28.2	3.8
	Level IV course	35.3	35.3	29.4	0.0
	University degree	30.1	39.8	20.4	9.7
Marital status (p = 0.892, V = 0.069)[1]	Single	19.4	48.3	26.7	5.6
	Married	26.8	46.4	19.6	7.2
	Divorced	14.3	57.1	28.6	0.0
	Widowed	40.0	40.0	20.0	0.0
Global		21.0	48.0	25.3	5.7

[1]p = chi-square test p-value, V = Cramer's coefficient.
[2]Teenagers: 13 ≤ age ≤ 17 years, young adults: 18 ≤ age ≤ 25 years, middle aged adults: 26 ≤ age ≤ 50 years, senior adults: 51 ≤ age ≤ 65 years, elderly: age ≥ 66 years.
[3]1st cycle: 4 school years, 2nd cycle: 6 school years, 3rd cycle: 9 school years, secondary: 12 school years.

Table 3. Relation between a balanced diet and the sociodemographic variables.

Variables		Practice of a balanced diet				
		Never	Seldom	Sometimes	Several times/week	Always
		% in line	% in line	% in line	% in line	% in line
Sex (p = 0.006, V = 0.220)[1]	Women	1.5	9.5	51.0	33.2	4.8
	Men	4.3	22.8	37.0	28.3	7.6
Age group[2] (p < 0.0005, V = 0.205)[1]	Teenagers	0.0	25.0	50.0	0.0	25.0
	Young adults	2.0	11.7	47.7	35.6	3.0
	Middle-aged adults	1.3	19.0	44.3	26.6	8.8
	Senior adults	6.7	13.3	53.3	26.7	0.0
	Elderly	20.0	0.0	20.0	0.0	60.0
Education[3] (p = 0.002 V = 0.188)[1]	1st cycle	25.0	0.0	25.0	0.0	50.0
	2nd cycle	0.0	18.2	45.5	36.4	0.0
	3rd cycle	2.9	17.6	55.9	17.6	5.9
	Secondary	1.5	11.5	51.9	31.3	3.8
	Level IV course	0.0	29.4	52.9	17.6	0.0
	University degree	2.9	12.6	36.9	39.8	7.8

Marital status (p = 0.138, V = 0.139)[1]	Single	1.7	12.5	47.8	33.2	4.8
	Married	3.6	16.1	42.9	28.6	8.8
	Divorced	0.0	14.3	57.1	28.6	0.0
	Widowed	20.0	40.0	20.0	0.0	20.0
Global		2.3	13.7	46.7	31.7	5.7

[1]p = chi-square test p-value, V = Cramer's coefficient.
[2]Teenagers: 13 ≤ age ≤ 17 years, young adults: 18 ≤ age ≤ 25 years, middle-aged adults: 26 ≤ age ≤ 50 years, senior adults: 51 ≤ age ≤ 65 years, elderly: age ≥ 66 years.
[3]1st cycle: 4 school years, 2nd cycle: 6 school years, 3rd cycle: 9 school years, secondary: 12 school years.

It can be noted that, for the entire sample as well as for both sexes, the average values of BMI are within the the "normal weight" class (Table 4). In the entire sample, about 67% of the participants were of normal weight, but there were 22% of overweight and 5% of obese. Regarding gender differences, it was found that the prevalence of overweight was higher among men than women (28% versus 20%, respectively) and the same occurred with obesity (7% versus 5% for men and women, respectively). Nevertheless, these differences were not significant, as indicated by the p-value (p = 0.220).

Table 4 also reveals that BMI was significantly different across groups of age, education, marital status or physical exercise. Regarding the influence of education in the BMI, it was observed that for lower levels of education the prevalence of overweight and obesity were higher, although the association between these variables was weak (V = 0.167). As for marital status, while the great majority of the single participants were normal weight (75.3%), the divorced and widowed tended more to be overweight (57.1% and 60.0%, respectively), with a moderate to a strong association (V = 0.215). The differences in BMI according to the practice of physical exercise were only marginally significant (p = 0.049), and regardless of the frequency of exercise, most participants were normal weight. Although some increase was observed in the number of people with a normal weight for an increased frequency of practice of a balanced diet, meaning that better dietary patterns would favour normal weight incidence, this association was not significant (p > 0.05), at least for this sample.

Table 4. Relation between a balanced diet and the sociodemographic variables.

Variables		BMI Class[5]			
		Underweight % in line	Normal weight % in line	Overweight % in line	Obesity % in line
Sex (p = 0.220, V = 0.121)[1]	Women	4.3	71.0	19.8	4.9
	Men	6.5	58.7	28.3	6.5
Age group[2] (p < 0.0005, V = 0.220)[1]	Teenagers	25.0	50.0	25.0	0.0
	Young adults	6.1	75.6	15.2	3.1
	Middle-aged adults	2.6	57.7	32.1	7.6
	Senior adults	0.0	20.0	60.0	20.0
	Elderly	0.0	40.0	40.0	20.0
Education[3] (p = 0.049, V = 0.167)[1]	1st cycle	0.0	25.0	50.0	25.0
	2nd cycle	9.1	27.3	45.5	18.1
	3rd cycle	2.9	52.9	32.4	11.8
	Secondary	5.3	73.3	16.8	4.6
	Level IV course	5.9	64.7	23.5	5.9
	University degree	4.9	70.6	22.5	2.0

Marital status	Single	5.6	75.3	15.2	3.9
(p < 0.0005,	Married	3.6	42.9	44.6	8.9
V = 0.215)[1]	Divorced	0.0	28.6	57.1	14.3
	Widowed	0.0	20.0	60.0	20.0
Physical exercise[4]	Never	12.7	58.7	22.2	6.4
(p = 0.049,	Occasional	2.8	65.3	24.3	7.6
V = 0.138)[1]	Moderate	3.9	75.0	19.7	1.4
	Intense	0.0	81.2	18.8	0.0
Balanced diet	Never	14.2	28.6	28.6	28.6
(p = 0.080,	Seldom	4.9	61.0	29.3	4.8
V = 0.147)[1]	Sometimes	6.4	62.9	24.3	6.4
	Several times/week	3.2	77.8	15.8	3.2
	Always	0.0	75.0	25.0	0.0
Global		5.0	67.2	22.4	5.4

[1]p = chi-square test p-value, V = Cramer's coefficient.
[2]Teenagers: 13 ≤ age ≤ 17 years, young adults: 18 ≤ age ≤ 25 years, middle-aged adults: 26 ≤ age ≤ 50 years, senior adults: 51 ≤ age ≤ 65 years, elderly: age ≥ 66 years.
[3]1st cycle: 4 school years, 2nd cycle: 6 school years, 3rd cycle: 9 school years, secondary: 12 school years.
[4]Occasional: 1x/week, moderate: 2-3x/week, intense: +3x/week.
[5]Underweight: BMI <18.5, Normal weight: 18.5 ≤ BMI <25, Overweight: 25 ≤ BMI <30, Obesity: BMI ≥ 30.

Table 5 presents the association between balanced diet and physical exercise, showing statistical significant differences (p < 0.0005) and a strong association between variables (V = 0.259). Almost 30% of participants who always practice a balanced di*et al*so have a more intense physical activity.

Table 5. Relation between the practice of physical exercise and a balanced diet.

Variables		Physical exercise			
		Never	Occasional (1x/week)	Moderate (2-3x/week)	Intense (+3x/week)
		% in line	% in line	% in line	% in line
Balanced diet	Never	100.0	0.0	0.0	0.0
(p < 0.0005,	Seldom	31.7	48.8	14.6	4.9
V = 0.259)[1]	Sometimes	20.7	52.1	25.7	1.5
	Several times/week	14.7	46.3	30.5	8.5
	Always	0.0	41.2	29.4	29.4

[1]p = chi-square test p-value, V = Cramer's coefficient.

The great majority of the participants in this study did not suffer from any chronic disease (CD) (N = 218, 72.7%) and justsmall group suffered from CD (Fig. 1).The most relevant of the pathologies were undoubtedly food allergies and intolerances (31 participants), corresponding to about 40% of all CD. After that came high cholesterol (8 participants), hypertension, diabetes and obesity (7 participants each).

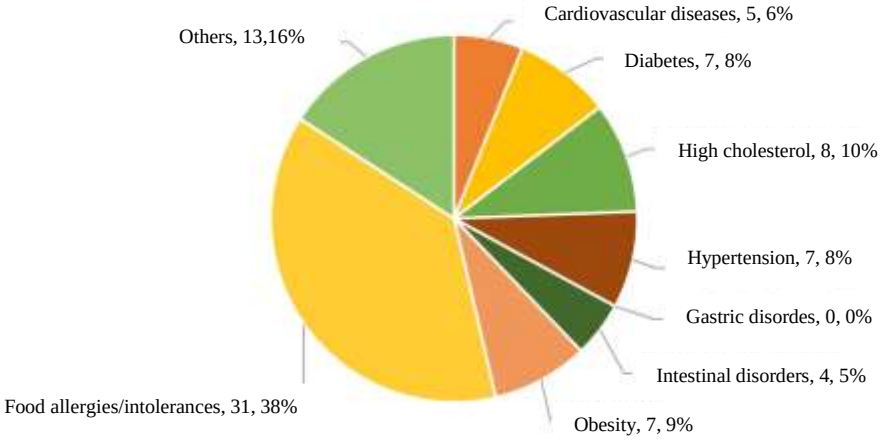

Fig. 1. Chronic diseases of the participants (N, %).

Table 6 shows the relations between the presence or absence of CD and the sociodemographic and behavioural variables. Significant differences were found across groups for all variables, except for sex (p = 0.324) and balanced diet (p = 0.159). In general, the incidence of CD increased with age and decreased with higher education. The widowed also presented a much higher incidence of CD. A high prevalence of CD was observed for participants who never practice physical exercise (41.3%) and also for those who never practice a balanced diet (57.1%).

Table 6. Relation between chronic diseases and the sociodemographic variables, BMI, physical exercise and balanced diet.

Variables		Chronic Diseases	
		No % in line	Yes % in line
Sex (p = 0.324, V = 0.035)(1)	Women	71.6	28.4
	Men	75.0	25.0
Age group(2) (p = 0.001, V = 0.250)(1)	Teenagers	50.0	50.0
	Young adults	77.7	22.3
	Middle-aged adults	70.9	29.1
	Senior adults	40.0	60.0
	Elderly	20.0	80.0
Education(3) (p = 0.013 V = 0.220)(1)	1st cycle	0.0	100.0
	2nd cycle	63.6	36.4
	3rd cycle	67.6	32.4
	Secondary	76.3	23.7
	Level IV course	58.8	41.2
	University degree	75.7	24.3
Marital status (p < 0.0005, V = 0.290)(1)	Single	78.0	22.0
	Married	51.8	48.2
	Divorced	100.0	0.0
	Widowed	20.0	80.0
BMI(4) (p = 0.002,	Underweight	73.3	26.7
	Normal weight	78.6	21.4

V = 0.222)[1]	Overweight	61.2	38.8
	Obesity	43.8	56.2
Physical exercise[5] (p = 0.004, V = 0.210)[1]	Never	58.7	41.3
	Occasional	78.5	21.5
	Moderate	68.4	31.6
	Intense	94.1	5.9
Balanced diet (p = 0.159 V = 0.148)[1]	Never	42.9	57.1
	Seldom	70.7	29.3
	Sometimes	70.7	29.3
	Several times/week	80.0	20.0
	Always	64.7	35.3
Global		72.7	27.3

[1]p = chi-square test p-value, V = Cramer's coefficient.
[2]Teenagers: 13 ≤ age ≤ 17 years, young adults: 18 ≤ age ≤ 25 years, middle-aged adults: 26 ≤ age ≤ 50 years, senior adults: 51 ≤ age ≤ 65 years, elderly: age ≥ 66 years.
[3]1st cycle: 4 school years, 2nd cycle: 6 school years, 3rd cycle: 9 school years, secondary: 12 school years.
[4]Underweight: BMI <18.5, Normal weight: 18.5 ≤ BMI <25, Overweight: 25 ≤ BMI <30, Obesity: BMI ≥ 30.
[5]Occasional: 1x/week, moderate: 2-3x/week, intense: +3x/week.

Knowledge about nuts composition and health effects

A reliability analysis by means of 'Cronbach's alpha was undertaken for the sets of items in each of the measuring variables: KNC – items 1 to 36 in Appendix A and KNHE – items 37 to 82 in Appendix A. The results obtained showed that for variable KNC with all 36 items the value of 'Cronbach's alpha was 0.945, which is very high (Davis 1964; Hair *et al*., 2009; Maroco and Garcia-Marques, 2006) and indicative of very good internal consistency of the items selected to measure the concept of knowledge about nuts composition and nutritional elements. Additionally, the results also indicated that the alpha did not increase by removing any of the items, so all 36 were considered for the definition of variable KNC. For variable KNHE with all 46 items, the value of 'Cronbach's alpha was 0.968, which is also indicative of very good internal consistency of the items chosen to measure the concept of knowledge about nuts health effects. Also, in this case, the alpha did not increase by removing any of the items, so all 46 were considered included for the definition of variable KNHE. Since none of the items was excluded, the two variables aimed at measuring the knowledge (KNC and KNHE) were calculated for each participant as the average scores of all items considered for each variable, in the following scale: 0 – no knowledge, 1 – very low, 2 – low, 3 – good, 4 – very good knowledge.

Table 7 shows the mean values and the corresponding standard deviations for variables KNC and KNHE, considering the global samples or according to groups of the sociodemographic variables considered, for testing whether differences were encountered. The global results indicated that the means values for each variable were very low (1.49 and 1.26, respectively for KNC and KNHE), demonstrating that the participants were very badly informed about the chemical composition of nuts and related products, as well as about their effects on the human health. No statistical differences were found between female and male participants for both types of knowledge, and also for the different marital statuses. Regarding age groups, significant differences were found only in the case of variable KNC, which relates to the composition of these products, with middle-aged adults showing a little higher level of knowledge. Significant differences were found between groups with different levels of education, for both variables.

Table 7. Measure of knowledge according to sociodemographic variables.

Variables		KNC[1]			KNHE[2]		
		Min	Max	M±SD	Min	Max	M±SD
Sex	Women	0.00	4.00	1.55±0.84	0.00	4.00	1.28±0.92
	Men	0.00	3.58	1.35±0.91	0.00	3.61	1.23±0.96
	p[3]		0.074			0.630	
Age group[5]	Teenagers	0.00	1.19	0.47±0.54^{a}	0.00	1.72	0.76±0.89^{a}
	Young adults	0.00	4.00	1.50±0.84^{ab}	0.00	4.00	1.26±0.92^{a}
	Middle-aged adults	0.00	3.75	1.57±0.91^{b}	0.00	4.00	1.36±0.97^{a}
	Senior adults	0.00	3.08	1.27±0.98^{ab}	0.00	3.07	1.00±0.97^{a}
	Elderly	0.00	2.44	1.22±1.14^{ab}	0.00	2.39	1.24±1.11^{a}
	p[4]		0.040			0.512	
Education[6]	1st cycle	0.00	2.19	1.33±0.96^{ab}	0.00	2.11	1.36±0.93^{ab}
	2nd cycle	0.00	2.31	1.15±0.82^{a}	0.00	2.35	1.18±0.70^{ab}
	3rd cycle	0.00	2.75	1.23±0.91^{ab}	0.00	2.28	1.03±0.84^{a}
	Secondary	0.00	3.58	1.40±0.83^{ab}	0.00	3.61	1.16±0.89^{ab}
	Level IV course	0.00	3.22	2.03±0.85^{b}	0.00	3.11	1.80±1.09^{b}
	University degree	0.06	4.00	1.63±0.87^{ab}	0.00	4.00	1.40±0.98^{ab}
	p[4]		0.008			0.035	
Marital status	Single	0.00	4.00	1.45±0.86^{a}	0.00	4.00	1.23±0.93^{a}
	Married	0.00	3.75	1.68±0.88^{a}	0.00	4.00	1.50±0.92^{a}
	Divorced	0.00	2.14	1.37±0.93^{a}	0.00	2.09	0.91±0.87^{a}
	Widowed	0.00	1.97	1.01±0.95^{a}	0.00	2.35	0.89±1.04^{a}
	p[4]		0.194			0.121	
	Global	0.00	4.00	1.49±0.87	0.00	4.00	1.26±0.94

[1]KNC = knowledge about nuts composition, Min = minimum, Max = maximum, M = mean value, SD = standard deviation (Scale: 0 – no knowledge, 1 – very low, 2 – low, 3 – good, 4 – very good knowledge).
[2]KNHE = knowledge about nuts health effects, Min = minimum, Max = maximum, M = mean value, SD = standard deviation (Scale: 0 – no knowledge, 1 – very low, 2 – low, 3 – good, 4 – very good knowledge).
[3]p: p-value of T-test for independent samples ($p < 0.05$).
[4]p: p-value of ANOVA. Mean values with the same superscript are not significantly different according to Tukey post-hoc test ($p < 0.05$)
[5]Teenagers: $13 \leq$ age ≤ 17 years, young adults: $18 \leq$ age ≤ 25 years, middle-aged adults: $26 \leq$ age ≤ 50 years, senior adults: $51 \leq$ age ≤ 65 years, elderly: age ≥ 66 years.
[6]1st cycle: 4 school years, 2nd cycle: 6 school years, 3rd cycle: 9 school years, secondary: 12 school years.

Table 8 presents the mean values obtained for the two variables of knowledge (KNC and KNHE) according to BMI, physical exercise, balanced diet and chronic diseases. The results showed that no statistical differences were observed for any of the variables across groups of BMI, exercise or balanced diet. In the case of CD, significant differences were found between people with CD and those without CD, only for the knowledge about nuts composition, with a slightly higher mean score for those who do not suffer from CD.

Table 8. Measure of knowledge according to BMI, physical exercise, balanced diet and chronic diseases.

Variables		KNC[1]			KNHE[2]		
		Min	Max	M±SD	Min	Max	M±SD
BMI class[3]	Underweight	0.00	2.86	1.28±0.88[a]	0.00	2.87	1.00±0.90[a]
	Normal weight	0.00	4.00	1.50±0.87[a]	0.00	4.00	1.27±0.93[a]
	Overweight	0.00	3.58	1.53±0.83[a]	0.00	3.61	1.37±0.93[a]
	Obesity	0.00	3.14	1.19±1.04[a]	0.00	2.87	0.85±0.93[a]
	p[4]		0.401			0.158	
Physical exercise[5]	Never	0.00	4.00	1.31±0.94[a]	0.00	4.00	1.08±1.00[a]
	Occasional	0.00	3.75	1.51±0.83[a]	0.00	4.00	1.25±0.90[a]
	Moderate	0.00	3.08	1.59±0.86[a]	0.00	3.24	1.46±0.91[a]
	Intense	0.00	2.97	1.42±1.00[a]	0.00	2.78	1.21±0.99[a]
	p[4]		0.287			0.107	
Balanced diet	Never	0.00	3.58	1.32±1.26[a]	0.00	3.61	1.21±1.26[a]
	Seldom	0.00	2.86	1.26±0.78[a]	0.00	2.80	1.05±0.83[a]
	Sometimes	0.00	4.00	1.52±0.91[a]	0.00	4.00	1.33±0.96[a]
	Several times/week	0.00	3.08	1.48±0.80[a]	0.00	3.07	1.22±0.88[a]
	Always	0.00	3.75	1.80±0.96[a]	0.00	4.00	1.52±1.12[a]
	p[4]		0.230			0.350	
Chronic diseases	No	0.00	4.00	1.50±0.86	0.00	4.00	1.29±0.95
	Yes	0.00	3.08	1.45±0.89	0.00	3.07	1.19±0.91
	p[6]		0.049			0.418	

[1]KNC = knowledge about nuts composition, Min = minimum, Max = maximum, M = mean value, SD = standard deviation (Scale: 0 – no knowledge, 1 – very low, 2 – low, 3 – good, 4 – very good knowledge).
[2]KNHE = knowledge about nuts health effects, Min = minimum, Max = maximum, M = mean value, SD = standard deviation (Scale: 0 – no knowledge, 1 – very low, 2 – low, 3 – good, 4 – very good knowledge).
[3]Underweight: BMI <18.5, Normal weight: 18.5 ≤ BMI <25, Overweight: 25 ≤ BMI <30, Obesity: BMI ≥ 30.
[4]p: p-value of ANOVA. Mean values with the same superscript are not significantly different according to Tukey post-hoc test ($p < 0.05$)
[5]Occasional: 1x/week, moderate: 2-3x/week, intense: +3x/week.
[6]p: p-value of T-test for independent samples ($p < 0.05$).

Although the results of the performed tests did not reveal significant differences between groups for many variables, yet, it was important to test in what way these variables could be influential for the two types of knowledge about the nuts studied. Hence, two other variables were defined for the level of knowledge: LKNC and LKNHE. These are categorical variables, and they classify the scores obtained for the measuring variables KNC and KNHE into categories, according to the following classification: very little knowledge ($0 \leq$ value ≤ 1), little knowledge ($1 <$ value ≤ 2), high knowledge ($2 <$ value ≤ 3) and very high knowledge ($3 <$ value ≤ 4). The variables measuring the level of knowledge LKNC and LKNHE were submitted to a tree classification analysis for assessment of the relative importance of the possible influential sociodemographic variables (sex, age group, education, marital status), as well as anthropometric and behavioural variables (BMI class, physical exercise, balanced diet, chronic diseases). A Classification and Regression Trees (CRT) algorithm with cross-validation was used in the analysis of the data, and the minimum number of cases considered for parent or child nodes was 30 and 15, respectively.

Fig. 2 presents the tree obtained for variable LKNC, highlighting the relative importance of the influential variables to define the level of knowledge about nuts composition. The estimated risk for this tree was 0.497 (with standard error 0.029) for resubstitution and 0.603 (with standard error 0.028) for cross-validation.

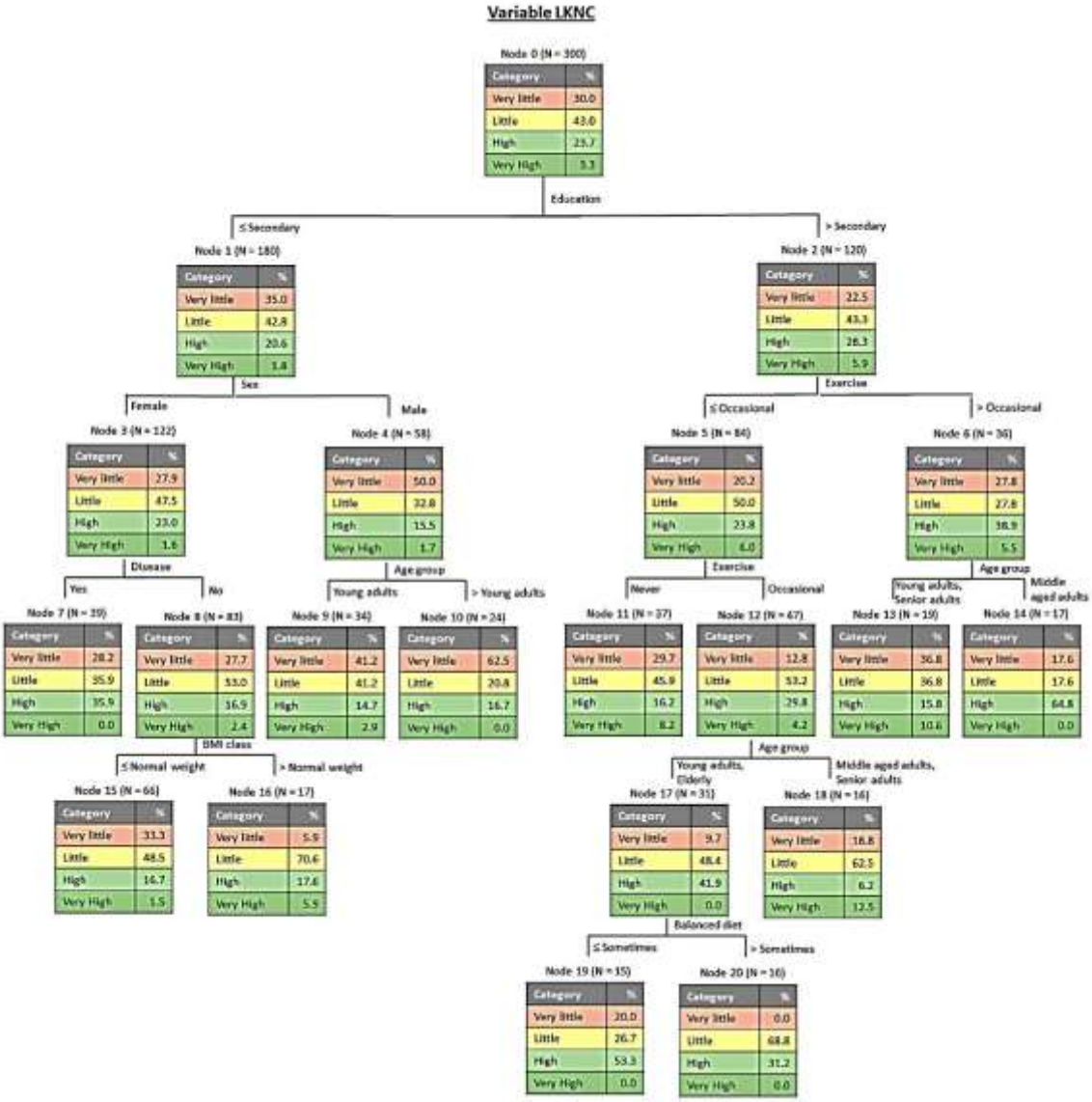

Fig. 2. Tree classification for variable LKNC: level of knowledge about nuts composition.

The obtained tree for LKNC had 5 levels and 21 nodes, of which 11 were terminal (Fig. 2). In the sample at study, most participants had little knowledge about nuts composition, 43.0%, and with very high knowledge, there were only 3.3%.

Fig. 3 shows the second tree, which was obtained for the variable LKNHE. In this case, the estimated risk was 0.530 (with standard error 0.029) for resubstituting and 0.620 (with standard error 0.028) for cross-validation. This tree had 3 levels and 9 nodes, of which 5 were terminal.

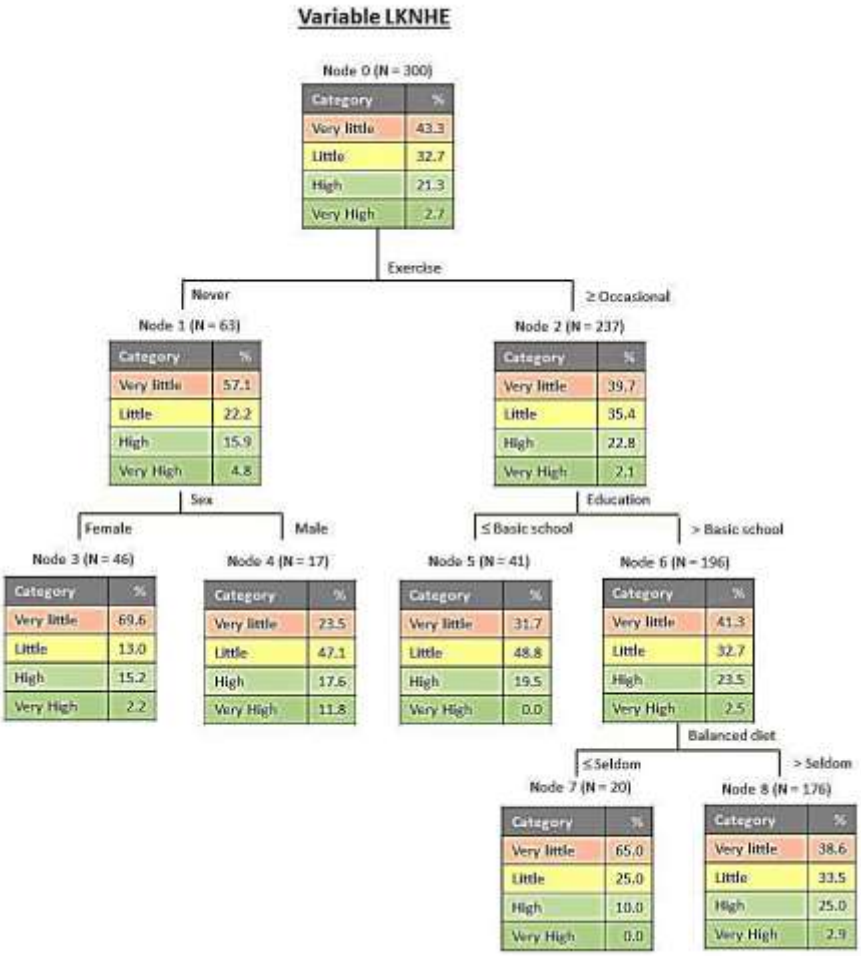

Fig. 3. Tree classification for variable LKNHE: level of knowledge about nuts health effects.

In the case of knowledge about the health effects of nuts, 43.3% of participants had a very little knowledge, 32.7% little, 21.3% high and only 2.7% very high (Fig. 3).

Consumption habits and preferences

Apart from analysing the knowledge of the participants about the characteristics and effects of consuming nuts, this research also addressed some aspects related to consumption habits and preferences of the participants regarding nuts and some related dried products, to better know the Portuguese market for this type of product. Most participants like nuts (N = 252, 84%), and usually consume them (N = 174, 58%). Fig. 4 presents the the frequency of consumption and amounts consumed. As for the frequency of consumption, 37.9% eat nuts 2 or 3 times per week, with some participants eating them daily (12.1%). While 25.3% eat them once per week, a similar percentage (24.7%) eat them just sporadically. Regarding the amount consumed each time, most participants couldn't mention it (44.8%), because they just eat them without paying attention to the quantity. Nearly 20% eat less than 20 g per dose, about 30% eat 20 to 30 g per dose, and a minority (6.9%) eat more than 30 g.

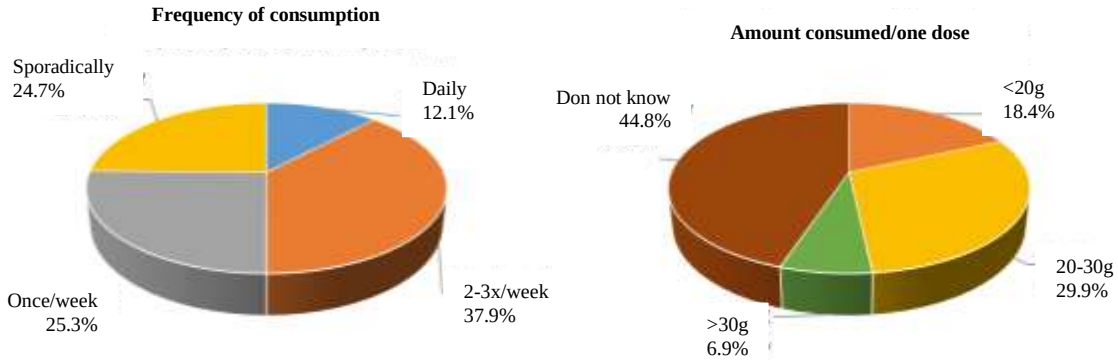

Fig. 4. Frequency of consumption and amount consumed per dose of nuts and related products.

Also, the consumption habits and preferences were investigated in relation to the possible differences according to the groups in each of the sample variables (sociodemographic and behavioural). To test these associations between the categorical variables were used chi-square tests and the strength of the associations was measured according to the Cramer's V coefficients, and these results are presented in Table 9. The results showed significant and moderate associations between a balanced diet and the liking for nuts (V = 0.357) and the usual consumption of nuts (V = 0.347). Another significant association was identified between sex and the usual consumption of nuts, but the strength of the association was lower (V = 0.166). The frequency of consumption was significantly associated with physical exercise (weak association: V = 0.200), but the amount consumed per dose was not related to any of the tested sample variables.

Table 9. Results of Chi-square tests between the consumption variables and the sample variables.

Variables		Chi-square test p-value and (Cramer's V coefficient)							
		Sex	Age group	Education	Marital status	BMI class	Physical exercise	Balanced diet	Chronic diseases
Likes nuts		0.390* (0.025)	0.545 (0.101)	0.974 (0.053)	0.516 (0.087)	0.283 (0.113)	0.104 (0.143)	< 0.0005 (0.357)	0.560* (0.002)
Usually consumes nuts		0.003* (0.166)	0.244 (0.135)	0.264 (0.147)	0.071 (0.153)	0.646 (0.075)	0.310 (0.109)	< 0.0005 (0.347)	0.143* (0.069)
Frequency of consumption		0.489 (0.118)	0.804 (0.122)	0.238 (0.188)	0.820 (0.099)	0.525 (0.125)	0.013 (0.200)	0.393 (0.156)	0.081 (0.197)
Amount consumed/dose		0.295 (0.146)	0.054 (0.199)	0.236 (0.188)	0.072 (0.174)	0.066 (0.176)	0.127 (0.163)	0.103 (0.188)	0.841 (0.069)
Consumed nuts	Chestnuts	0.420* (0.029)	0.387 (0.155)	0.009 (0.297)	0.415 (0.129)	0.298 (0.147)	0.545 (0.111)	0.143 (0.200)	0.299* (0.054)
	Almonds	0.027* (0.162)	0.764 (0.103)	0.311 (0.185)	0.306 (0.144)	0.161 (0.173)	0.069 (0.202)	0.275 (0.172)	0.507* (0.012)
	Hazelnuts	0.481* (0.017)	0.918 (0.074)	0.618 (0.143)	0.011 (0.253)	0.865 (0.065)	0.176 (0.169)	0.582 (0.128)	0.119 (0.103)
	Carobs	0.088* (0.133)	0.084 (0.218)	0.143 (0.218)	0.594 (0.105)	0.085 (0.196)	0.209 (0.162)	0.001 (0.325)	0.105* (0.124)
	Walnuts	0.251	0.618	0.443	0.902	0.062	0.760	0.843	0.433*

		(0.066)	(0.123)	(0.166)	(0.057)	(0.206)	(0.082)	(0.090)	(0.027)
	Pine nuts	0.397*	0.731	0.001	0.909	0.984	0.023	0.029	0.580*
		(0.040)	(0.108)	(0.349)	(0.056)	(0.031)	(0.235)	(0.250)	(0.010)
	Pistachios	0.206*	0.227	0.136	0.455	0.825	0.253	0.620	0.207*
		(0.077)	(0.181)	(0.220)	(0.123)	(0.072)	(0.154)	(0.123)	(0.077)
	Peanuts	0.001*	0.454	0.522	0.162	0.842	0.327	0.351	0.252*
		(0.235)	(0.145)	(0.155)	(0.172)	(0.069)	(0.141)	(0.160)	(0.065)
Forms of consumption	Simply the nuts	0.223	0.934	0.013	0.974	0.384	0.470	0.778	0.124*
		(0.078)	(0.069)	(0.288)	(0.036)	(0.133)	(0.121)	(0.101)	(0.107)
	Breakfast cereals	0.027*	0.021	0.693	0.059	0.077	0.120	0.043	0.434*
		(0.158)	(0.257)	(0.132)	(0.207)	(0.199)	(0.183)	(0.238)	(0.026)
	Cereal bars	0.446*	0.396	0.035	0.296	0.644	0.065	0.653	0.332*
		(0.025)	(0.153)	(0.262)	(0.146)	(0.098)	(0.204)	(0.119)	(0.046)
	Salads	0.063	0.222	0.255	0.933	0.401	0.016	0.054	0.428*
		(0.131)	(0.182)	(0.195)	(0.050)	(0.131)	(0.245)	(0.232)	(0.033)
	Desserts & Sweets	0.127	0.059	0.057	0.229	0.755	0.605	0.253	0.029*
		(0.104)	(0.229)	(0.248)	(0.157)	(0.083)	(0.103)	(0.175)	(0.165)
	Culinary dishes	0.137	0.452	0.689	0.418	0.732	0.639	0.247	0.221*
		(0.101)	(0.145)	(0.133)	(0.128)	(0.086)	(0.099)	(0.176)	(0.075)
Moments of consumption	Breakfast	0.001*	0.809	0.456	0.835	0.092	0.166	0.041	0.394*
		(0.235)	(0.096)	(0.164)	(0.070)	(0.193)	(0.171)	(0.239)	(0.035)
	Between meals	0.351*	0.165	0.109	0.088	0.132	0.801	0.220	0.221*
		(0.045)	(0.193)	(0.227)	(0.194)	(0.180)	(0.076)	(0.182)	(0.075)
	Bedtime snack	0.063*	0.853	0.819	0.802	0.727	0.357	0.006	0.328*
		(0.145)	(0.088)	(0.113)	(0.076)	(0.087)	(0.137)	(0.290)	(0.062)
	Meals	0.170*	0.316	0.062	0.061	0.953	0.094	0.275	0.389*
		(0.089)	(0.165)	(0.246)	(0.206)	(0.044)	(0.192)	(0.172)	(0.036)
Preference for origin		0.550*	0.489	0.319	0.600	0.575	0.423	0.901	0.365*
		(0.005)	(0.140)	(0.184)	(0.104)	(0.107)	(0.127)	(0.078)	(0.039)
Buying preferences	Individual	0.535*	0.749	0.274	0.402	0.999	0.904	0.005	0.210*
		(0.009)	(0.105)	(0.191)	(0.130)	(0.013)	(0.057)	(0.293)	(0.076)
	Mix of nuts	0.579*	0.919	0.938	0.191	0.944	0.996	0.022	0.382*
		(0.000)	(0.073)	(0.085)	(0.165)	(0.047)	(0.019)	(0.257)	(0.038)
	Mix of nuts with dried fruits	0.384*	0.212	0.213	0.288	0.818	0.398	0.833	0.098*
		(0.060)	(0.183)	(0.202)	(0.147)	(0.073)	(0.130)	(0.092)	(0.126)

*Fisher's exact test

Fig. 5(a) shows the percentage of participants who consumed specific types of nuts and dried fruits. These fruits were selected for being those with higher economic relevance in Portugal and easily commercialised in supermarkets and other food stores.

The most consumed are peanuts and walnuts (by 75% and 74% of the participants, respectively), followed by almonds (64%) and hazelnuts (59%), while carobs and pine nuts are not much consumed.

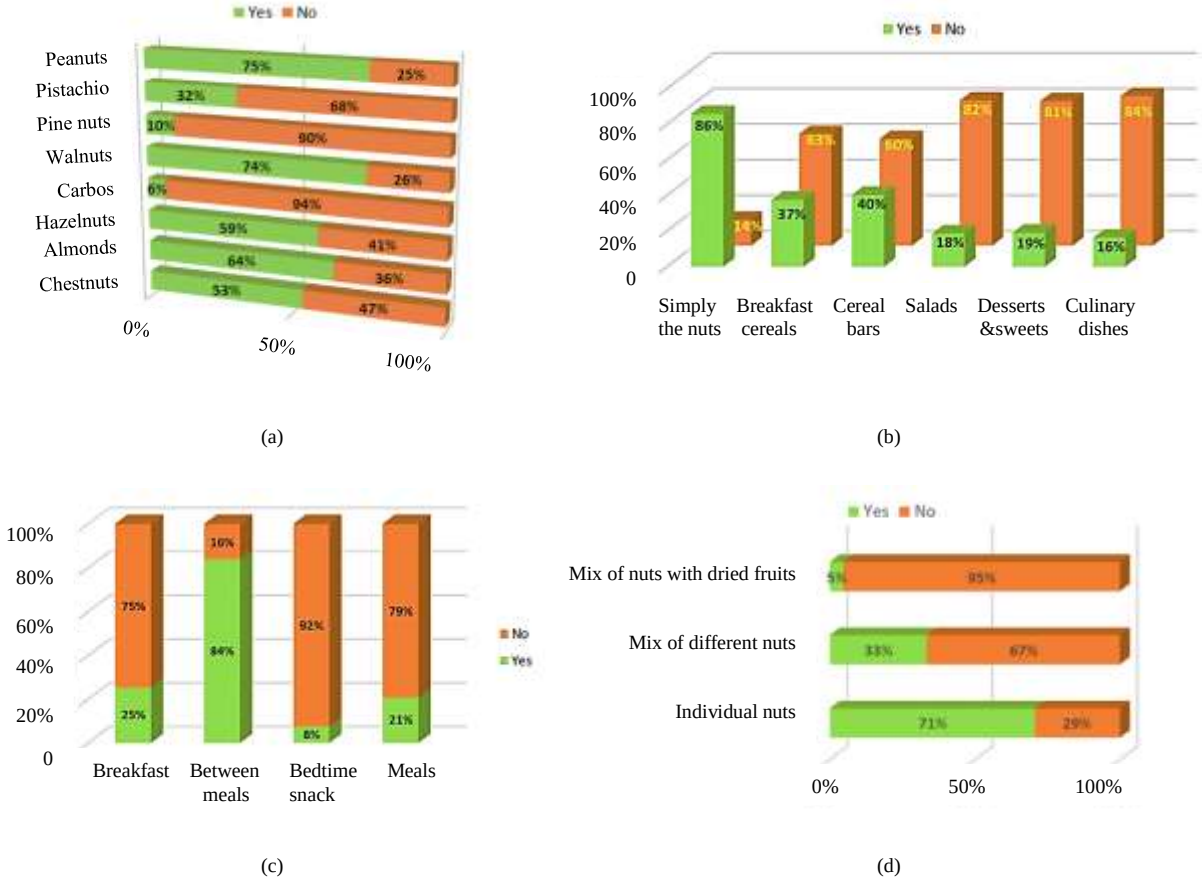

Fig. 5. a) Nuts usually consumed by the participants, b) Forms of consumption of nuts and related products, c) Moments of the day for consumption of nuts and related products, d) Buying preferences regarding nuts and related products

Some associations were found between the consumption of certain nuts and the sample variables, as highlighted in Table 9. The consumption of almonds was significantly associated with sex (weak: V = 0.162), but for peanuts, the association was moderate (V = 0.235). Chestnuts and pine nuts were significantly associated with education (moderate in both cases: V = 0.297 and V = 0.349, respectively). Hazelnuts were moderately associated with marital status (V = 0.253), and pine nuts with physical exercise (V = 0.235). Finally, the practice of a balanced diet was found moderately associated with the consumption of carobs and pine nuts (V = 0.325 and V = 0.250, respectively).

The results obtained for the different forms of consumption of nuts and related products are shown in Figure 5(b). A great majority of participants (86%) referred that they eat the nuts in their simple form, i.e., not incorporated into other food products, and following comes the consumption of cereal bars (by 40%) or breakfast cereals (by 37%), which incorporate nuts. The other forms of consumption showed a very low expression (salads – 18%, desserts & sweets – 19% and culinary dishes – 16%).

The results in Table 9 reveals significant associations between the consumption of nuts in simple form and education (moderate: V = 0.288), between the consumption in breakfast cereals and sex (weak: V = 0.158), age (moderate: V = 0.257) and balanced diet (moderate: V = 0.238), between cereal bars and education (moderate: V = 0.262), between the use of nuts in salads and physical exercise (moderate: V = 0.245) and between the use in desserts & sweets and CD (weak: V = 0.165).

In Fig. 5(c) the preferences regarding the moment of the day selected to consume nuts is presented. Undoubtedly, consumption of nuts between meals, as snack food stands out to the other moments, with 84% of participants choosing to eat them between meals. Table 9 reveals significant associations between nuts consumption at breakfast and sex (moderate: V = 0.235) and balanced diet (moderate: V = 0.239). The consumption as bedtime snacks was found significantly associated with a balanced diet as well.

The source of the consumed nuts was also investigated, and the results indicated that 38.5% prefer to consume self-produced nuts and dried fruits. This fact is possible only for some people who have nut production, and all other consumers have to buy them in local markets, food stores or supermarkets (61.5%).

Fig. 5(d) shows some buying preferences for nuts and related products and indicates a vast preference to buy nuts individually (71% of participants). In comparison, only 33% prefer mixtures of different nuts, and a minority prefer to buy mixtures of nuts with other dried fruits. The choice for individual nuts was found associated with a balanced diet (moderate; V = 0.293), as shown in Table 9.

Discussion

The results showed that there was a considerable difference between the average weight of women and men. It should be noted that these measures were self-reported and, therefore, some inaccuracy may be present. Population-based studies commonly use self-reported values for weight and height for being more convenient and less expensive and time-consuming. However, when refferring to self-reported values, possible validity of the sources of measurement and their associated errors along with inaccuracy in the report itself should be considered. To overcome these limitations, self-reported values could be validated by using standardised measurement protocols (Tuomela *et al*. 2019). Even though suffering from the constraints of being self-reported, the anthropometric measures are of interest and allow calculation the BMI values and to classify the participants based on those values.

It was further noticed that about half of the participants practice physical exercise only once per week, while about one quarter do it two to three times/week, which would be recommended. According to the World Health Organization (WHO 2010), healthy adults aged from 18 to 64 years old should do at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic physical activity in one week. Although physical inactivity is a prominent risk factor for non-communicable diseases, it remains very prevalent in the population, despite the recommendations and information (Liu *et al*. 2017; Rosselli *et al*. 2020; Stringhini *et al*. 2017). When age groups were considered in analysis, it was observed that nearly half of the elderly never do physical work, although a similar fraction do it more regularly, i.e., two or three times/week, which is according to the recommendations of the WHO for this age group, i.e. for those aged 65 or over (WHO 2010). The participants in these age groups: young adults, middle-aged adults and senior adults also practice exercise mostly only one time per week, which is manifestly low. The differences for age groups were not statistically significant, and the same was verified for all other sociodemographic variables tested. Nevertheless, the widowed tend to show a higher percentage of participants with no activity at all, which may be due to high age that widowed people usually also have. More men practice high-intensity physical exercise (more than 3 times/week) as compared with women. Many studies have reported gender differences for physical activity, including for specific age groups. For example, Rosselli *et al.* (2020) evaluated gender differences for the practice of physical activity among adolescents, and also Looze *et al*. (2019) addressed the physical activity in adolescents in various countries. Lee *et al*. (2020) studied how physical activity can influence mental

health, specifically depression symptom, in persons with diabetes, and as a function of age, gender or race.

There is not a unanimous definition for a balanced diet, still generating some debate around it. However, there is some general acceptance that it encompasses a triple burden of malnutrition accounting for under-nutrition, micronutrient deficiencies and over-nutrition. Most attempts to define "balanced diet" rely on the quantities and quality of some food components, such as carbohydrates, protein, fibre, fat, and also dietary micronutrients (for example, minerals, vitamins, and bioactive compounds) (Burlingame and Dernini 2010; May 2018; Pinstrup-Andersen 2007; Schoenaker *et al*. 2016). Under-nutrition and micronutrient deficiencies result from inadequate food intakes, both in terms of quantity and/or quality, from poor utilisation of nutrients, like for example due to some pathologies, or from a combination of both types of factors. On a broader sense, the malnutrition includes both under-nutrition and over-nutrition, which are to unbalanced diets, frequently consisting of excessive calories as to body requirements combined with insufficient intake of micronutrient-rich foods (Bvenura and Sivakumar 2017). The consequences of malnutrition are vast and impact public health on a large scale, gaining the dimension of epidemics, like for example the incidence of obesity, type 2 diabetes or cardiovascular diseases all around the world. For this reason, the self-assessment about the practice of a balanced diet was investigated. Different marital status groups revealed no significant differences relatively to the practice of a balanced diet, but the differences across groups of age, sex or education were significant. A higher percentage of women said they practice a balanced diet sometimes or several times/week, when compared with men. In the work by Guiné *et al*. (2019) statistically significant differences were found between male and female participants regarding the frequency of practicing a balanced diet. However, there are many factors that contribute for these differences, including more care about body image and/or seeking health benefits and a better global health status (Beccia *et al*. 2019; Borooah 2004; Travassos *et al*. 2020).

The WHO classification for BMI (WHO 2019) indicates the following: underweight: BMI <18.5; normal weight: 18.5 ≤ BMI <25; overweight: 25 ≤ BMI <30; obesity: BMI ≥ 30. Although there are still some classes differentiating the degrees of obesity, for the purpose of this study, the four classes are sufficient. Regarding gender differences, it was found that the prevalence of overweight was higher among men than women and the same occurred with obesity. According to the First Portuguese Health Examination Survey (INSEF 2015) (Gaio *et al*. 2018), the prevalence of overweight and obesity was 39.1% and 28.6%, respectively. Additionally, the authors also found that the prevalence of overweight was higher for male participants (46% *versus* 33%) while being the contrary for obesity, which was more frequent in female participants (32% versus 25%). These results are not in agreement with our findings since they indicate a considerably higher prevalence of overweight and particularly obesity than the results obtained for our sample.

It was found that BMI was significantly different across groups of age, education, marital status or physical exercise. Overweight and obesity were more frequent in senior adults and elderly while underweight was more frequent in teenagers, as compared with the other age groups. It has been suggested that the need to "fit in" or "belong to a group" is important in teenages, and this, allied to self-esteem issues, and idolisation of fashion stereotypes makes teenagers particularly susceptible to extreme bodyweight conditions, such as underweight or overweight (Apostu and Predescu 2015; Halloran *et al*. 2012; Paola *et al*. 2009; Wills *et al*. 2006).

The association between balanced diet and physical exercise showed significant differences and a strong association between variables. Nearly one third of participants who always practice a balanced diet

also have a more intense physical activity. These participants tend to nurture their body with healthy diets and regular exercise, demonstrating that they are aware of the well-documented benefits of these two factors for health improvement and maintenance (Campbell *et al*. 2011; Dongen *et al*. 2020; Gomez-Pinilla 2008; Powell and Greenberg 2019).

Significant differences were found between CD and the sociodemographic/behavioural variables across groups, except for sex and balanced diet. Globally, the incidence of CD increased with age and decreased with higher education. The widowed also presented a much higher incidence of CD, which is expected because usually, they are older people. Participants who were overweight and obese also showed a higher incidence of CD, which is in line with documented evidence. Obesity is a global public health challenge and is recognised as a major risk factor for the development of several non-communicable diseases, being a cause of high mortality and morbidity (Fitzpatrick *et al*. 2018; Li *et al*. 2018; Pharr *et al*. 2018). A high prevalence of CD was reported among the participants who tend to neglect the practice of exercise or do not care for their diets.

The results revealed that the participants were very badly informed about the chemical composition of nuts and related products, as well as about their effects on the human health. However, it was not possible to establish a pattern for the effect of increased education in knowledge. The beneficial effects of nuts for the human health are widely announced, although they are highly variable according to a great number of factors, which have a decisive influence on the chemical composition and nutritional value of these food products. The type of nut and also the cultivar are the first factors to consider because they produce nuts with highly differentiated composition. Additionally, the weather conditions during nut development also impact decisively on the nuts health-promoting properties, such as bioactive antioxidant compounds, for example (Rabadán *et al*. 2019). In general, nuts have a high lipid content, 40–67% (dry basis) for almonds, 50–62% for pistachio, 60–72% for walnut (Catalán *et al*., 2017; Kodad *et al*., 2016; Yada *et al*., 2011). The lipid fraction contains high amounts of unsaturated fatty acids, such as oleic acid (particularly high in almond and pistachio) or linoleic acid (especially in walnuts) (Rabadán *et al*., 2019). However, not only the lipids are include in nuts composition, but also nuts containhigh quality proteins that are rich in essential amino acids and having a good digestibility (Sze-Tao and Sathe, 2000). Additionally, nuts contain phytosterols, vitamins and dietary minerals, like for example magnesium, calcium and potassium. For this favourable composition, nuts represent a good ally in the promotion of health. Their consumption has been reported to improve the lipoprotein profile, to contribute for the regulation of immunological activity and inflammatory response, to reduce oxidative stress underlying many CD, to mediate insulin resistance, to prevent bone demineralisation, to reduce blood pressure, to decrease the risk of coronary heart disease and to benefit pathologies like endothelial dysfunction, metabolic syndrome, visceral adiposity or cancer. Finally, nuts show high antioxidant capacity and anti-atherogenic properties, and contrarily to preconceived ideas, their consumption, even when in high amounts, is not associated to weight gain (Ibarrola-Jurado *et al*., 2013; Rabadán *et al*., 2019; Robbins *et al*., 2011; Roncero *et al*., 2016; Segura *et al*., 2006; Souza *et al*., 2017). In a review by Alasalvar *et al*., (2020), the bioactive compounds and health benefits of nuts and dried fruits are discussed and summarised. Despite all these benefits, the results of this study clearly reveal a lack of knowledge in the general population about the richness of nuts in terms of macro and micronutrients and their beneficial effects for the human body. Hence, it is important to communicate the scientific evidence to the general public more efficiently and effectively to help consumers making better food choices, such as deciding for a healthy snack of nuts

and/or dried fruits instead of high fat and high sugar snacks. However, nuts are not always beneficial, because some of them can have negative effects on the human body, such as for people who suffer from allergies, for which some nuts are problematic and can bear important health risks. The prevalence of food allergies is increasing worldwide, and the symptoms can range from mild (like hives and itching) to severe (such as vomiting, diarrhoea, wheezing) or even cause life-threatening anaphylactic reactions (Robert, 2019; Soon, 2018).

The results showed no statistical differences in the level of knowledge across groups of BMI, exercise or balanced diet. In the case of CD, significant differences were found between people with CD and those without CD, only for the knowledge about nuts composition, with a slightly higher mean score for those who do not suffer from CD. Food and nutrition literacies are assuming prominent roles in society as a way to help to establish healthier relations with food. Food literacy consists of the daily practicalities connected to navigation in the food system to use it in a way that leads to healthier eating practices (Gibbs *et al*. 2018; Malan *et al*. 2020; Palumbo *et al*. 2019). It is expected that people with some chronic diseases, which have eventually special nutritional needs, might be more informed about the foods they eat. However, the group of nuts and related foods does not appear as so relevant for people to be more informed, as they are about other foods groups. Hence, the results from the present study highlight the need to improve the literacy of the common citizens regarding the composition and the health effects of nuts, as a way to incentive their consumption.

Tree classification for knowledge about nuts composition revealed that the first discriminant variable was education, being so the best predictor for LKNC, separating the participants up to the secondary school from those with higher levels of education. For the participants with lower education, the second predictor variable was sex while for the more educated participants it was exercise. The female participants with up to secondary school and not suffering from CD were finally separated according to BMI, so that a high percentage of those with underweight and normal weight demonstrated a very little knowledge (33.3%) while for the overweight and obese participants, only 5.9% had very little knowledge, although with a very high percentage in the category of little knowledge (70.6%). A higher percentage of participants with a very high knowledge was observed for those with higher education, who practice physical exercise occasionally (second and third predictors), and with ages above 50 years (fourth predictor), representing 12.5%.

In the case of knowledge about the health effects of nuts, the first predictor variable was exercise, separating the participants who never practice exercise from the remaining ones. While for the participants who never practice exercise, the next predictor was sex, for the ones who practice exercising the second predictor was education. While for the female participants who never practised exercise the great majority had very little knowledge (69.6%), for the male participants that percentage was substantially lower (23.5%), increasing all other categories (47.1% for little, 17.6% for high and 11.8% for very high), being these two nodes terminal. The participants who practiced exercise and had education up to basic school (9 school years) were 41, from which most had little knowledge (48.8%) and none had very high knowledge (0.0%). For the other participants, i.e., with education corresponding to secondary school or higher, the following predictor variable was a balanced diet, separating the participants who do it never or seldom from those who practice a balanced diet sometimes or more often. These last (N = 176), corresponding to participants who practice some exercise, are more educated and have a balanced diet at least sometimes, have just slightly higher levels of knowledge about the health effects of nuts (38.6% for very little, 33.5% for little, 25.0% for high and 2.9% for very high knowledge).

Although it is recognised that nutrition knowledge and food literacy play important roles in the shaping of eating patterns, it is still a domain in which much is left to be accomplished. Some consensus has been reached as to some categories of food literacy: food and nutrition knowledge, food skills, self-efficacy and confidence, ecologic (external) factors, and food decisions. However, their measurements pose challenges for being highly variable according to the context, the targeted population and the particular characteristics of the individuals (Malan *et al*., 2020; Thomas *et al*., 2019).

Regarding the consumption habits, the results showed significant and moderate associations between a balanced diet and the appreciation for nuts and their usual consumption. Another significant association was identified between sex and the usual consumption of nuts. The frequency of consumption was significantly associated with physical exercise, but the amount consumed per dose was not related to any of the tested sample variables. A work by Ghazzawi and Akash (2019) studied the consumption of nuts for university students in Jordan, and found that it was not dependent on the field of study or level of physical activity, but, on the other hand, gender and BMI showed to significantly impact both the nuts consumption and preferences.

The most consumed nuts are peanuts, walnuts, almonds and hazelnuts. Carobs, although being quite traditional in the southern regions of Portugal, Algarve and Alentejo (DGDR 2001), are not so much consumed in the other areas of the country. Pine nuts are also consumed by a low percentage of participants, which might be linked to their extremely high price, about 50 € per kilo. The consumption of different nuts is beneficial because they can complement each other due to differences in the macro- and micro-nutrient contents. The most common nuts consumed as reported by Ghazzawi and Akash (2019) were peanuts, explained by their low price and also because peanuts are those most used in other foods as hidden nuts.

The consumption of almonds was significantly associated with sex, while for peanuts, there was a moderate association with sex. Chestnuts and pine nuts were significantly associated with education. On the other hand, hazelnuts were associated with marital status, and pine nuts with physical exercise. Additionally, the practice of a balanced diet was found associated with the consumption of carobs and pine nuts. In the work by Ghazzawi and Akash (2019), significant differences were found between sex for cashew nuts and between BMI groups for peanuts, while the practice or not of physical activity did not influence the consumption of nuts.

Most participants eat the nuts in their simple form or, alternatively, as part of formulation in cereal bars or breakfast cereals. With low expression appeared other forms of consumption (salads, desserts, sweets or culinary dishes). Different ways are available on the food market to consume nuts, which can appeal to different age and socio-economic groups, as well as lifestyles. Their consumption in the form of snacks was most-valued by consumers in the study by Ghazzawi and Akash (2019), higher than the preference of consuming nuts within meals. It has been reported that nuts provide high satiety and strong compensatory dietary responses while being relatively inefficient in terms of energy absorption. Therefore, despite their high calori, they are not so problematic like other foods with similar energetic value. On the other hand, they increase resting energy expenditure and augment fat oxidation. These beneficial properties seem to be particularly important when nuts are consumed as snacks (Ghazzawi and Akash 2019; Tan *et al*. 2014).

Most participants choose to consume nuts between meals, as snack. Significant associations between nuts consumption at breakfast and sex and balanced diet were found in this study. Also, the consumption as bedtime snacks was found significantly associated with a balanced diet. Ghazzawi and Akash (2019) reported significant differences between the moments

of consumption for different sexes and according to the practice or not of physical activity.

Most participants prefer to buy nuts individually instead of mixtures of different nuts or even mixtures of nuts with other dried fruits. This can be explained by individual preferences of each person, who might not equally like all types included in commercially available mixtures. Finally, the choice for individual nuts was found associated with the practice of a balanced diet, being these participants more careful about their food choices and therefore might want to choose specific types of nuts for their properties or even to control the ingestion.

Conclusions

This study describes the eating habits and consumer knowledge about nuts and similar dried foods. Even though most participants of the present study like nuts and usually consume them, they were unaware of the chemical composition of nuts and related products, as well as about their effects on human health. Thus, the communication of scientific evidence to the general public needs to be more easily understandable and transmitted more efficiently and effectively. Communication improvement will help consumers to make healthier food choices. Future studies should examine if previously explaining the composition and health benefits of nuts and related products to consumers in a controlled way will increase their level of knowledge. The data obtained will be fundamental to implement effective health policy strategies and to help the nut industry.

Abbreviations

SPSS: Statistical Package for the Social Sciences; IBM: International Business Machines; V: Cramer's Coefficient; KNC: Knowledge about Nuts Composition; KNHE: Knowledge about Nuts Health Effects; BMI: Body Mass Index; CRT: Classification and Regression Trees; WHO: World Health Organization; p: p-value; CD: Chronic Diseases; LKNC: Level of Knowledge about Nuts Composition; LKNHE: Level of Knowledge about Nuts Health Effects

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Appendix A

The questions included in the questionnaire for evaluation of the level of knowledge about nuts composition (KNC) were divided by eight groups according to the fruit, as follows:

Chestnut:

1. Is a good source of essential nutrients.
2. Is a good source of essential minerals, such as potassium, magnesium, iron, manganese and copper.
3. Consists mostly of carbohydrates, of which there are considerable amounts of amylose and amylopectin.
4. Has a higher caloric content compared to other nuts. (Inverse)
5. One serving (10 nuts / 179 kcal) provides half the recommended daily dose of vitamin C.
6. Contains significant amounts of fibre.

Almond:

7. Contains many vitamins, such as vitamin E (it is the best source of this vitamin).
8. Contains minerals, such as iron, copper, magnesium, potassium and calcium.
9. Is a source of fibre.
10. Has a high sodium content. (Inverse)

11. Is low in saturated fat.
12. Contains phytochemicals.

Hazelnut:

13. Poor in saturated fats, but rich in monounsaturated fats.
14. Contains significant amounts of group B vitamins, including folate and vitamin B_6.
15. Among nuts has the highest fibre content.

Walnut:

16. Is low in protein. (Inverse)
17. Good source of fibre.
18. Good source of minerals like magnesium.
19. Excellent source of alpha-linolenic acid (ALA) and plant-based omega-3 fatty acids.

Carob:

20. Rich in fibres (pectin and lignin).
21. Rich in vitamins like vitamin E.
22. Rich in minerals like calcium, phosphorus, potassium and sodium.
23. Does not contain phenolic compounds. (Inverse)

Pine nut:

24. Has a balanced content of monounsaturated and polyunsaturated fatty acids.
25. Abundant in linoleic acid (omega-6) and oleic acid (omega-9).
26. Rich in calories.
27. Contains several minerals, such as copper, zinc, manganese, iron, magnesium, calcium, phosphorus, sodium and potassium.

Pistachio:

28. Is very rich in minerals such as potassium, calcium, copper, phosphorus, iron and magnesium.
29. Excellent source of vitamins like vitamin B_6 and thiamine.
30. Has a high content of monounsaturated fats.
31. Has the highest phytosterol content compared to other nuts.
32. Is low in fibre. (Inverse)

Peanut:

33. Rich in protein.
34. Rich in minerals such as potassium, calcium, magnesium, iron, phosphorus and sodium.
35. Rich in vitamins like vitamin E and complex B vitamins.
36. Rich in folic acid.

The questions for evaluation of the level of knowledge about health effects of nuts (KNHE) followed a similar grouping as above:

Chestnut:

37. Can cause flatulence.
38. Contributes to the regulation of cholesterol levels and the insulin response (blood sugar control).
39. One serving (10 nuts) effectively satisfies your appetite.
40. Can be used by those suffering from dyslipidaemia (high cholesterol and triglycerides in the blood)
41. Is considered useful for the prevention of obesity due to the good induced intestinal digestion.
42. Generates free radicals in the human body. (Inverse)

Almond:

43. Can be included in the diet for those suffering from ferropenic anaemia.
44. Good food in hypertensive diets and in cases of high cholesterol and triglycerides due to its high content of monounsaturated fatty acids.
45. In the case of diabetes, almond appears to improve insulin sensitivity.
46. Can help protect against cardiovascular disease.
47. Has the potential to reduce the risk of cancer.

Hazelnut:

48. Is indicated in diets to regulate cholesterol or even in cases of heart problems due to the richness of polyunsaturated fatty acids and omega-3.
49. Provides benefits to the circulatory system.
50. Does not contain nutrients beneficial in weight loss. (Inverse)
51. Contains many nutrients that can be beneficial in managing the onset of type 2 diabetes.

Walnut:

52. Is indicated in diets to regulate cholesterol or even in cases of heart problems due to the richness of polyunsaturated fatty acids and omega-3.
53. Helps in reducing the risk of cancer.
54. Helps to prevent and control diabetes.
55. Has an impact on health with regard to proper bowel function.
56. Contributes to accelerated ageing. (Inverse)
57. Has "good" fats, which play an important role in diet and weight control.

Carob:

58. Has antidiarrheal properties.
59. Can adsorb toxins from the digestive tract.
60. In excessive amounts and ingested for long periods, it can lead to reduced absorption of nutrients like iron and protein.
61. Is effective against ulcers and intestinal infections.
62. Has a slight laxative effect.
63. Increases blood pressure. (Inverse)
64. Has beneficial diuretic effects against fluid retention.

Pine nut:

65. Helps in reducing the level of cholesterol in the blood.
66. Contributes to the proper functioning of the nervous system.
67. Prevents intestinal diseases.
68. Prevents cardiovascular diseases.
69. Contains components that help in caloric intake.
70. Helps control blood pressure.

Pistachio:

71. Helps to keep our hearts healthy and are seriously nutritious.
72. Increases the absorption of cholesterol from the diet. (Inverse)
73. Beneficial effect on the body mass index.
74. Beneficial effect on blood pressure.
75. Helps prevent heart diseases.

Peanut:

76. Prevents cardiovascular diseases.
77. Prevents atherosclerosis.
78. Helps prevent cancer.
79. Can help in the reduction of low density lipoproteins (LDL-C) also known as "bad cholesterol".
80. Can cause anaemia. (Inverse)
81. Has antioxidant properties.
82. Has anti-inflammatory properties.

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