



Consumption of fibre rich foods: comparative study in different countries

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ABSTRACT

Foods such as fruit, vegetables, and cereals, and particularly whole grain, are rich in dietary fibre and have been proved to have multiple beneficial effects for the human health. The present research was designed to assess some eating practices related to fibre-rich foods in different countries, namely Argentina, Croatia, Hungary, Latvia, Portugal, and Romania. A cross-sectional descriptive study was undertaken on a sample of 4905 adult participants, obeying all ethical guidelines for this type of research. Regarding the data treatment, basic statistics was complemented with the tree classification analysis. Generally, the results show a low consumption of salads and vegetables, i.e., up to 11 servings/week (for 78.2% of participants), with Croatia in the lead (86.6%). Regarding fruit, a great majority of data also indicated low consumption (92.3%), most especially for Latvia (98.3%). The level of consumption of whole cereals was also low (72.6%), particularly for Latvia (90.0%). The tree classification analysis showed that while the first discriminant variable for the consumption of salads and vegetables was country, followed by education, for the consumption of fruit, it was country and then sex, and finally, for the consumption of whole cereals, it was sex and followed by country. The results allowed the conclusion that the consumption of foods rich in dietary fibre was very low for these countries, highlighting the necessity to implement strategies that incentivise the consumption of such foods, which are very important for a healthy diet.

Introduction

Although there is not a one universal definition for dietary fibre (DF), it is assumed it refers to the constituents of non-digestible carbohydrates of three or more monomeric units found inherently in foods, but it can also include isolated or synthetic fibres with demonstrated physiologic benefits (such as resistant starches) or other minor components (like lignin), which are associated with non-digestible

carbohydrates in plant cell walls. The polysaccharides that constitute DF are very diverse regarding their composition, structure, or size (Jakobek and Matic, 2019; Qi and Tester, 2019; Stephen et al., 2017; Zhang et al., 2018). The sources of different molecular species of DF are varied and depend on the plant origin as well as on the tissue from where they were obtained (Qi and Tester, 2019).

In recent decades, DFs are receiving considerable attention, because many studies connect them to

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beneficial effects for the human body. There is accumulated evidence that DF can modulate intestinal microflora and improve the gut microbiome (Cuervo et al., 2014; Yang et al., 2013). Diets that include a good amount of high DF foods, like vegetables, fruit, and whole grains, have been associated with a decreased risk of many chronic diseases. Research has demonstrated that the intake of DF can reduce the risk of obesity, type II diabetes, and cardiovascular disease, improving serum lipid levels and lowering blood pressure (Aleixandre and Miguel, 2016; Lin et al., 2019; Silva et al., 2013; Zhang et al., 2018). Also, the adequate consumption of DF can have a preventive effect against the development of gastrointestinal disorders or associated types of cancer (Lin et al., 2019; Yang et al., 2018).

Modern Western diets tend to be deficient in DF, providing insufficient amounts of this important food component. The recommendations of the Scientific Advisory Committee on Nutrition (UK) for adults propose a consumption of 30 g/day of DF (SACN, 2015), but the amounts ingested are under this recommendation for many countries, like for example the United States or the United Kingdom (Qi and Tester, 2019).

The aim of the present research was to investigate the eating habits related to fibre-rich foods in different countries, namely Argentina, Croatia, Hungary, Latvia, Portugal, and Romania.

Materials and methods

Data collection

The questionnaire used for the survey was structured into two different parts with questions as follows:

Part I. DEMOGRAPHICS:

1. Age, 2. Gender, 3. Level of education, 4. Country, 5. Living environment

Part II. CONSUMPTION HABITS:

6. How many meals do you have in a week that include vegetables and/or salads?
7. How many pieces of fruit do you eat per week?
8. How often do you eat outside from home per week?
9. How many times a week do you eat fast food?
10. How many times a week do you eat whole grains (in bread, in pasta or other cereal based products)?

These were open-answer questions, and to answer them the respondents should indicate their consumption habits, considering a typical week.

The methodological study consisted of a questionnaire survey applied to a sample of 4905 participants, from five countries, namely: Argentina, Croatia, Hungary, Latvia, Portugal, and Romania, which had been part of a multinational framework related to dietary fibre.

In each country, the participants were selected from both genders, with different levels of education and different living environments, so as to gather a sample as diverse as possible and as representative of each reality and social involvement. The participation in the survey was voluntary, and the questionnaire was applied by direct interview only to adult citizens, after verbal informed consent was obtained. All the answers were anonymous because no personal data was collected that could lead to any kind of identification of the participants, for their protection. All ethical issues were strictly obeyed when preparing and applying the questionnaire, which was approved by the Ethical Committee of the Health School of Viseu (REF. 03/2015).

Data analysis

The consumption habits related to fibre-rich foods were studied, using the guidance provided by the recommendations of the Portuguese Food Wheel (Fig. 1), which advises a daily consumption of three to five servings of fruit and vegetables, as well as four to eleven servings of carbohydrate-rich foods, including cereal-based foods (Rodrigues et al., 2006). Although this guide might not be adopted by other countries, it still serves as a reference, since the study was initiated in Portugal and then extended to other countries.

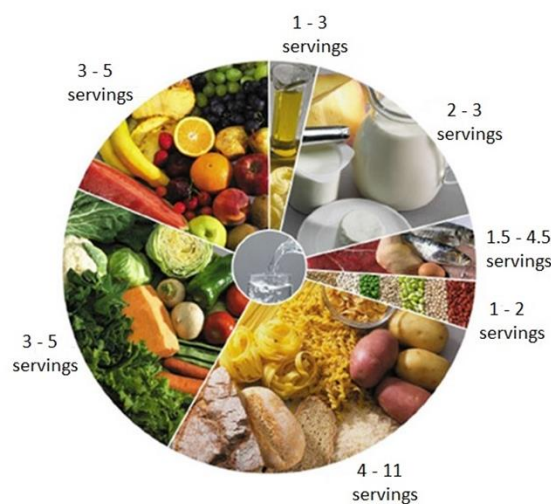


Fig. 1. Recommended daily doses according to the Portuguese Food Wheel

Based on this guide, the number of servings was extrapolated for a week, to be taken as reference. Considering the wide range of possible answers obtained by the questionnaires, the variables were categorized according to the criteria defined in Table 1 and four categories were defined accordingly: low, adequate, more than adequate, and another separate category for those who do not eat these types of food at all.

Table 1. Categorization of the variables of the study

<i>Questions about the consumption of fibre-rich foods</i>				
Frequency per WEEK	Inexistent	Low	Adequate	More than adequate
Meals including vegetables/salads	0	1 - 11	12 - 16	≥17
Servings of fruit	0	1 - 20	21 - 35	≥36
Servings of whole cereals	0	1 - 11	12 - 16	≥17

Basic descriptive statistical tools were used to process the data. Furthermore, in order to evaluate the relative importance of each of the possible influential variables (age group, sex, country, living environment, level of education) on the participants' consumption habits of fruit, vegetables and salads, or whole cereals, the tree classification analysis was used, following the CRT (Classification and Regression Trees) algorithm with cross validation, and the minimum number of cases considered for parent-child nodes was 100 and 50 for child nodes. The SPSS software from IBM Inc. (version 25) was used for all data analyses and the level of significance considered was 5% ($\alpha < 0.05$).

Results and discussion

Sample characterization

This research involved 4905 participants aged between 18 and 84. The average age was 35 ± 14 , being lower for the female participants when compared to men (34 ± 13 and 37 ± 14 , respectively), although this difference was not statistically significant. Table 2 shows the data for the demographic characteristics of the study sample. The majority of the participants were aged between 18 and 30

(48.9%), of female sex (67.1%), and living in urban environments (82.9%). The distribution by country indicated that the participants were primarily from Croatia (about half), with Latvia as the least represented country (only 3.7%).

Concerning the level of education, 53.0% of the participants had a university degree, 43.8% had completed secondary school, and a minority had primary school as the highest level of completed education.

Eating habits related to some fibre-rich foods

According to the results obtained and presented in Table 3, a great majority of participants showed a *low* intake of salads/vegetables (78.2%, consuming up to 11 servings/week, corresponding to less than two servings per day), with only 15.6% showing an *adequate* consumption of these important foods. The results for fruit were even more worrying, with more than 90% eating less than two servings per day, i.e., they do not eat fruit even with the main meals. Furthermore, 2.1% admitted that they never eat fruit at all, corresponding to zero portions of fruit in a whole week. It is well known and established that there is a direct relation between fruit and vegetable intake and health promotion effects. Numerous efforts reinforce an increased consumption of these types of food because of the many resulting health benefits associated with the presence of nutrients, including minerals and vitamins, as well as bioactive compounds with several beneficial properties, including antioxidant activity and protection against cardiovascular disease and cancer (Ashton et al., 2019; Kim et al., 2014; Ramsay et al., 2017).

Table 2. Sociodemographic characterization (N = 4905)

Sociodemographic Data	%	
Age	Young adults: $18y \leq \text{age} \leq 30y$	48.9
	Average adults: $31y \leq \text{age} \leq 50y$	35.4
	Senior adults: $51y \leq \text{age} \leq 64y$	13.6
	Elderly: $\text{Age} \geq 65y$	2.1
Gender	Women	67.1
	Men	32.9
Highest Level of Education	Primary School	3.2
	Secondary School	43.8
	University Degree	53.0
Living environment	Rural	17.1
	Urban	82.9
Country	Argentina	17.3
	Croatia	51.6
	Hungary	6.0
	Latvia	3.7
	Portugal	7.8
	Romania	13.7

The results in Table 3 further show that the consumption of whole cereals was also deficient, with 23.1% never eating whole cereals and 72.6% eating them less frequently than recommended. Presently, there is a well-established association between higher whole grain intake and a number of beneficial health effects. Hence, recommendations about the consumption of whole grain foods and health claims have been established in several countries, thus highlighting their importance for a healthy diet and encouraging consumers to incorporate whole-grain foods into their daily diet (Niven et al., 2019).

According to the results in Table 3, people from different age groups showed similar habits regarding the consumption of fruit, vegetables, or whole cereals. However, small differences were observed, particularly for the elderly, with a higher percentage of people with *adequate* consumption of salads/vegetables (22.9%) as compared to the other age groups. Also, the consumption of fruit was slightly more appropriate for the elderly (10.5% with *adequate*) than for the other age groups, in which the percentage was half or less. On the contrary, the consumption of whole cereals was *inexistent* for more than a quarter of the elderly participants (26.7%), a higher percentage when compared to the other age groups. According to a study by Mingioni et al. (Mingioni et al., 2016) undertaken in Europe, fruit and vegetables were generally appreciated by the elderly, with some exceptions for exotic fruit, which might be because these types of fruit were not so familiar to older people as they presently are to the younger generations already accustomed to the globalization of the food markets (Franz et al., 2018).

In the study by Heng and House (2018), the authors studied the habits of the consumption of fruit in different countries and across various different segments. They found that most of the participants belonging to the category of low-fruit-consumption individuals were young people, living alone, who admitted not having a healthy diet and assuming that they were not active. In our research, the results indicated that 93.3% of the younger adults (aged between 18 and 30) also consumed fruit below the recommended quantities.

Regarding gender, no meaningful differences were found for the weekly consumption of salads/vegetables or fruit (Table 3). However, regarding whole cereals, some differences were identifiable, namely, that there were less women who never ate whole cereals when compared to men (50.5% against 28.2%), and also, there was less women who ate *adequate* dosages of whole cereals when compared to men (1.6% for women, while the percentage was 4.7% for men). Mingioni et al.

(Mingioni et al., 2016) also reported that the selectivity of fruit and vegetables was not different between men and women.

The study by Grieger et al. (2012) evaluated the daily consumption of certain food groups in a sample of girls from Australia and found that about half of them (56%) consumed fruit, and that most of them (70%) consumed at least one vegetable. In our research, the great majority of the young adults consumed up to 2 servings/day of vegetables and up to 3 servings/day of fruit.

Finally, Table 3 also shows how the habits of eating fruit, vegetables, and whole cereals varied according to the level of education. If we target the *adequate* consumption of these foods, the participants with a university education showed a higher weekly consumption of salads/vegetables (18.4%) when compared to other education levels. On the contrary, the consumption of whole cereals was *adequate* for more people who completed only primary school (7.0%) when compared to the higher levels of education (2.8% and 2.2%, respectively for secondary and university levels), which is a very interesting and unexpected result, having in mind that this group also showed a very high percentage of people who never ate whole cereals. The results in Table 4 refer to the weekly consumption of fibre-rich foods according to the country of residence and the living environment. Regarding the effect of the living environment, it was observed that people living in cities, or at least urban areas, tend to eat just slightly higher amounts of salads/vegetables, so a higher percentage of consumers ate *adequate* amounts (16.2%) when compared to rural areas, for which the *adequate* consumption was only 13.1%. For the other types of foods analysed (fruit or whole cereals), no differences were observed for those who resided in rural or urban environments.

According to Blas et al. (2019), presently, the consumption of fruit and vegetables is low in Spanish households, accounting for only about 1/4th of the total dietary intake, which makes this finding similar to what we have found in our research for the studied countries (Argentina, Croatia, Hungary, Latvia, Romania, and Portugal). Both Portugal and Spain are countries in which the Mediterranean Diet (MD) should be the basis for food patterns, and according to this standard, food patterns of fruit and vegetables should be at the base of the food pyramid (Blas et al., 2019). In the study by Blas et al. (2019), it was also found that the consumption of cereals in Spain is also under the recommended amounts according to the MD. In our research, the consumption of cereals was investigated only in terms of whole-grain cereals, i.e., non-refined grains, but it was still possible to observe the low consumption of these types of cereals.

Table 3. Consumption of fibre-rich foods in the whole sample and separated by age, gender, and education

Servings/week		Percent (%)									
		Whole sample	Age ¹				Gender ²		Education ³		
			YoA.	AvA.	SeA.	Eld.	Fem.	Mal.	Prim.	Sec.	Univ.
Salads/ Vegetables ⁴	Inexistent	0.9	0.7	1.2	1.2	0.0	0.6	1.6	0.6	1.6	0.4
	Low	78.2	79.4	77.3	77.9	69.5	77.6	79.7	77.8	81.6	75.5
	Adequate	15.6	14.8	16.3	15.8	22.9	16.2	14.3	15.8	12.3	18.4
	More than adequate	5.2	5.1	5.2	5.1	7.6	5.6	4.3	5.7	4.6	5.7
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Fruits ⁵	Inexistent	2.1	1.9	2.7	1.8	0.0	1.4	3.5	4.4	3.1	1.2
	Low	92.3	93.3	91.3	91.7	89.5	93.1	90.8	91.8	92.3	92.3
	Adequate	4.4	3.8	4.7	5.1	10.5	4.5	4.2	2.5	3.6	5.2
	More than adequate	1.2	1.0	1.3	1.4	0.0	1.0	1.4	1.3	0.9	1.3
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Whole cereals ⁴	Inexistent	23.1	22.7	23.1	23.5	26.7	20.5	28.2	25.9	26.4	20.2
	Low	72.6	75.1	71.6	67.3	66.7	76.7	64.5	66.5	68.8	76.1
	Adequate	2.6	1.4	2.9	5.7	5.7	1.6	4.7	7.0	2.8	2.2
	More than adequate	1.7	0.8	2.4	3.5	1.0	1.2	2.7	0.6	1.9	1.5
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 4. Consumption of fibre rich foods separated by country and living environment

Servings/week		Percent (%)							
		Country						Living environment	
		Argentina	Croatia	Hungary	Latvia	Portugal	Romania	Rural	Urban
Salads/ Vegetables ¹	Inexistent	1.3	0.5	0.7	0.0	0.5	2.5	0.6	1.0
	Low	61.5	86.6	80.1	66.7	70.7	74.3	81.0	77.7
	Adequate	25.1	9.8	12.8	22.8	26.2	18.7	13.1	16.2
	More than adequate	12.0	3.0	6.4	10.6	2.6	4.5	5.3	5.2
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Fruit ²	Inexistent	4.0	1.7	2.0	0.0	0.8	2.8	2.0	2.2
	Low	90.4	92.4	94.6	98.3	87.4	94.5	92.2	92.4
	Adequate	5.5	4.3	1.7	1.1	9.2	2.7	3.6	4.5
	More than adequate	0.0	1.6	1.7	0.6	2.6	0.0	2.2	0.9
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Whole cereals ¹	Inexistent	24.2	24.2	18.2	3.3	34.0	18.5	26.1	22.4
	Low	75.7	74.3	77.7	90.0	62.8	61.3	69.7	73.2
	Adequate	0.0	0.8	2.7	3.9	1.8	12.7	2.9	2.6
	More than adequate	0.1	0.7	1.4	2.8	1.3	7.5	1.3	1.8
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

¹Scale: Inexistent: 0, Low: 1 – 11 servings, Adequate: 12 – 16 servings, More than adequate: ≥17.

²Scale: Inexistent: 0, Low: 1 – 20 servings, Adequate: 21 – 35 servings, More than adequate: ≥36.

The variations between countries were high, confirming that cultural and traditional influences are important determinants of dietary patterns. While a high percentage of participants in Portugal had an adequate consumption of salads/vegetables (26.2%),

and also fruit (9.2%), Romanian citizens were those with the highest consumption of whole cereals (12.7% adequate and 7.5% more than adequate) (Table 4). On the other hand, 34.0% of the Portuguese participants referred to never eating whole cereals at all, which is

a very preoccupying reality, given the importance of whole cereals. The consumption of whole cereals has been associated with a decreased risk of metabolic syndrome as well as various chronic diseases, due to the presence of components which may have synergistic activities to potentiate those protective effects, unlike refined cereals, in which those beneficial components are lost in the course of the processing operations of chemical or physical nature applied to cereals (Anuniação et al., 2017; Gong et al., 2018; Zhu, 2018).

In the study by Khalid et al. (2017), which investigated food consumption patterns in Sudan, they found that the daily consumption of cereals and vegetables was very low, with 62.8% consuming vegetables only once per week and the rest (36.2%) consuming vegetables rarely or not at all. The consumption of fruit was even rarer, with 27.2% eating it only once/week and 72.8 eating them rarely or not at all. These findings indicate an extremely low consumption of vegetables and fruit, much lower than what we found in our research, but this could be explained due to the differences in the geographic location and the level of development of the countries involved in our study (all developed countries) and Sudan.

Influence of sociodemographic variables on the consumption of fibre-rich foods

A tree classification procedure was followed to assess the most influential determinants on the eating habits regarding vegetables, fruit, and whole cereals. The results obtained are presented in Figs. 2 to 4. It can be seen from Fig. 2 that the most important discriminating variable for the consumption of vegetables was country, separating the group with Croatia and Hungary, for which the group with *adequate* consumption of vegetables represented only 10%, as opposed to the other countries, for which the group with *adequate* represented more than double that percentage (23.0%). In the next level, education appeared as the second discriminating variable for the group (Croatia and Hungary), while country was again the discriminant factor for the other group, separating Argentina and Latvia from Portugal and Romania. For the participants from Croatia and Hungary, those with a university degree presented higher percentages for *adequate* and *more than adequate* consumptions of vegetables (12.0% and 3.9%, respectively) when compared to the participants with lower levels of education (8.3% and 2.8%, respectively for *adequate* and *more than adequate* consumption of vegetables). Regarding the

participants from Argentina and Latvia, 36.5% showed an *adequate* or *more than adequate* consumption of vegetables, while for those from Portugal and Romania, the value was 21.4% for *adequate* and much lower for *more than adequate* (3.8%). From this last group, the next level of differentiation came with the variable level of education, so that the participants with a secondary level of education showed a lower percentage for the *adequate* consumption of vegetables (14.1%) when compared to the other levels of education (25.5%). The reviews by Qaim (2019) and Kearney (M Kearney, 2019) highlight the factors associated with food consumption patterns and their alterations. Factors like the sociodemographic characteristics, cultural influences, marketing, and economic considerations are among the drivers of consumer patterns. Nevertheless, only sociodemographic and geographic factors were studied in our research. The results in Fig. 3 also show that the most important differencing factor for the consumption of fruit was country, separating the group with Argentina and Portugal from the other 4 countries, with a higher incidence of *adequate* and *more than adequate* consumption of fruit (7.5% against 5.0%). For the first group, the next level again shows country as the discriminant variable, with Argentina showing a lower percentage of *adequate* fruit consumption (5.6%) when compared to Portugal (9.2%), with this as the last terminal node, while age appeared as the next discriminant variable for Argentina, separating the elderly, for which fruit consumption was visibly higher (16.7% for *adequate*). Regarding the group of participants from Croatia and Hungary and Latvia and Portugal, sex was the following discriminant variable, with a lower percentage of women with the *adequate* consumption of fruit (2.8%), with this as a terminal node. On the other hand, for the male participants, the next influential variable was again country, separating Croatia from the other three countries, considering that the percentage of men from Croatia that ate *adequate* amounts of fruit is considerably higher than for the other countries (4.6% and 0.9%, respectively).

The study by Pan et al. (2018) highlighted the differences in consumption of fruit and vegetables between men and women, and according to age categories. In our research, these two sociodemographic variables were identified as discriminating for the consumption of fruit (after country) (Fig. 3), but not for the consumption of vegetables (Fig. 2).

Variable:
Consumption of salads/vegetables

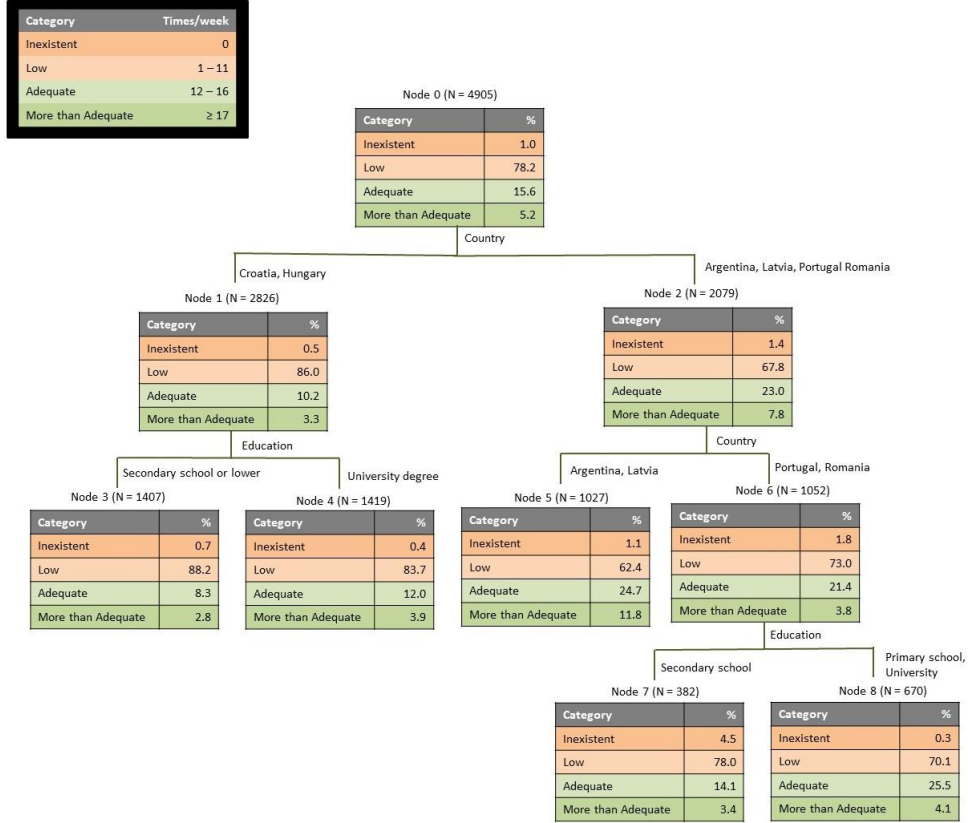


Fig. 2. Tree classification for the variable weekly consumption of salads/vegetables

Variable:
Consumption of fruit

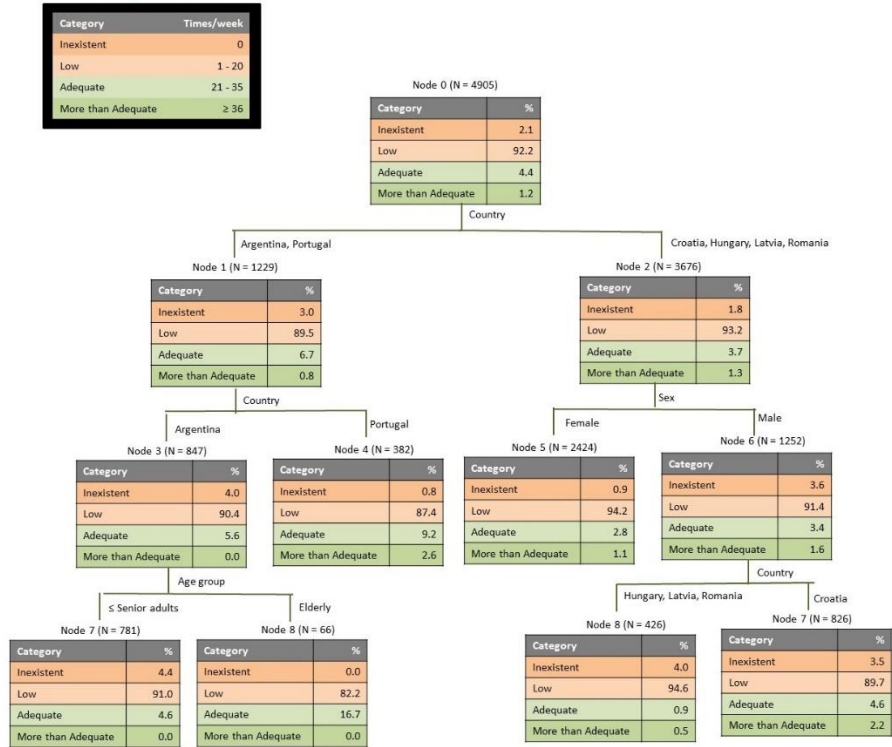


Fig. 3. Tree Classification for the variable weekly consumption of fruit

According to Fig. 4, and contrary to what happened for the two previous variables, country was not the most important discriminant variable, it was sex. Hence, men appeared as consuming whole grains differently than women, with higher percentages in the *adequate* and *more than adequate* categories, but, interestingly, also higher in the *inexistent* category (28.2%, when compared to women, 20.5%). In the case of women, the next level discriminated according to country, with Latvian participants showing a higher level of consumption of whole cereals when compared to all the other countries (very low incidence in the *inexistent* category, 3.3%, and a little higher in the *adequate* and *more than adequate* categories, 6.7% total). Regarding men, the next level also discriminated according to country, but in this case, Romanian participants stood out as consuming more whole cereal foods (19.3% and 10.9% in the *adequate* and *more than adequate* categories, respectively). Finally, the next level of discrimination for the Romanian men was the age group, separating the young adults from all others, in which the younger men consumed significantly lower amounts of whole cereals (6.6% joining the *adequate* and *more than adequate* categories) when compared to older Romanian men (42.2%, for both categories joined).

These results were entirely new and no studies were found in the scientific literature that applied this kind of a statistical technique to similar problems. Therefore, although not comparable with other results reported in scientific literature, these findings assume an innovative character.

According to the study by Heien et al. (1989), the demographic factors and economic aspects influence food consumption patterns in Mexican consumers. The region of living particularly influenced the consumption of cereals, fruit, and vegetables, among other food groups. In the urbanized area of Mexico City, for example, the consumption of fruit was higher when compared with other less urbanized regions. They also found that age, the level of education, or type of employment also influenced the food consumption patterns, similarly to some of the findings in our study.

In the study by Wannu et al. (2019), food consumption patterns were investigated according to rural nature areas and differences were found. However, in our research, the influence of rural or urban residence did not show such a significant impact in the consumption of the three food groups investigated, not being identified as a discriminating factor in any of the tree classifications performed for fruit, vegetables, and cereals.

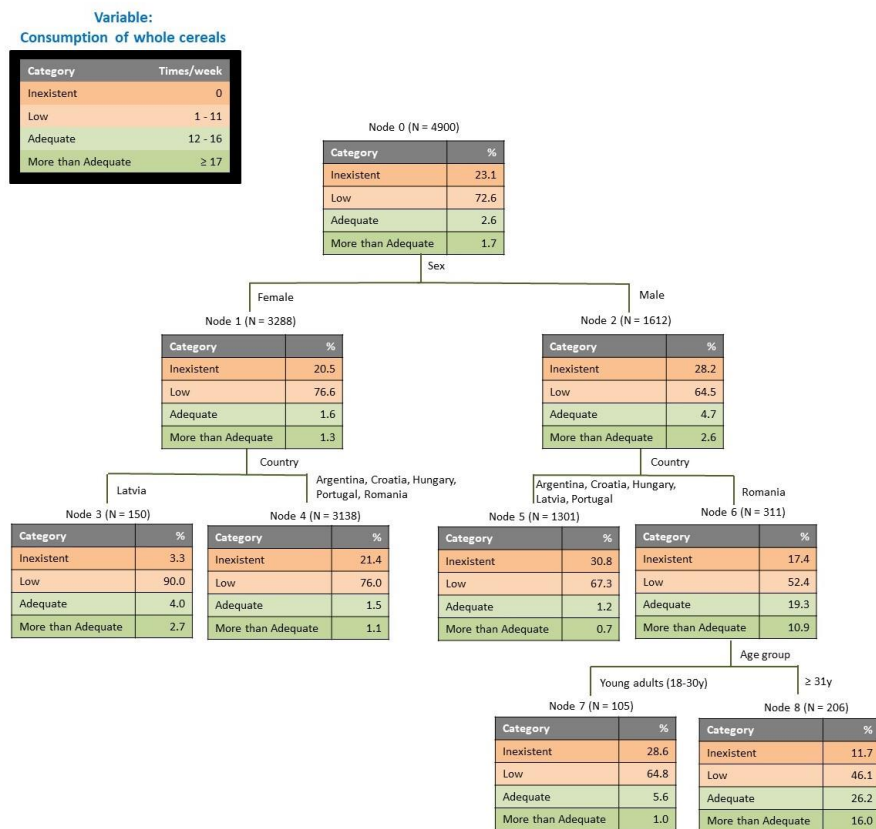


Fig. 4. Tree Classification for the variable weekly consumption of whole cereals

Conclusion

This study allowed the characterisation of the consumption habits related to fibre-rich foods for the sample studied, and these results allowed the conclusion that less than a quarter of participants ate adequate amounts of vegetables, an even lower percentage ate proper amounts of fruit per week, and the situation was even worse for the consumption of whole cereals. These results highlight that there is still an imminent need to improve food policies in the six countries participating in the study, so as to incentivise the consumption of fibre-rich foods with proven benefits for the human health. Finally, the tree classification analysis highlighted the relative importance of the considered factors for the consumption of fibre rich foods, with country appearing in the first place for vegetables and fruit, while sex appeared first for whole cereals.

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Ethical Approval

All ethical issues were strictly obeyed when designing and applying the questionnaire. Approval was received from the Ethical Committee with the reference n° 03/2015. The data collection was only from adults and after informed consent has been received.

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