Research Article

Raquel P. F. Guiné*, Sofia G. Florença, Ana Cristina Ferrão, Maša Černelič Bizjak, Blanka Vombergar, Natália Simoni, Viviane Vieira

Factors affecting eating habits and knowledge of edible flowers in different countries

https://doi.org/10.1515/opag-2020-0208
received August 15, 2020; accepted October 29, 2020

Abstract: The use of edible flowers (EF) in gastronomy is gaining popularity; however, there is still a lack of information about the factors that most contribute to the acceptance of this product. Therefore, the objective of this study was to investigate the habits associated with the usage of EF in gastronomy in three different countries (Portugal, Slovenia, and Brazil) and also to evaluate the major determinants for those habits. In addition, the level of knowledge was also investigated, particularly with regard to the aspects such as perceived risks of toxicity and pesticides. For that, a questionnaire survey of self-response was carried out on a sample of 559 participants, from the above-mentioned countries. To analyse the data, basic descriptive statistical tools were used combined with crosstabs and chi-square tests. Finally, a tree classification was performed using the classification and regression trees algorithm. The results revealed that, regardless of the country, the participants were familiar with the use of EF in gastronomy. The participants had, in general, already consumed EF, and their use was more popular between the Portuguese participants, being the Brazilian those who used them less. Significant differences were found between the countries in the form of consumption of EF and also in the types of EF consumed. There were also significant differences regarding the reasons for eating EF. The classification analysis showed that the country and the level of education were the major determinants for the consuming habits and knowledge about EF. This study highlighted that eating habits are very dependent on the customs and traditions of each country and helped understanding the factors that most affect the participants' attitudes towards the consumption and knowledge of EF.

Keywords: edible flowers, food security, gourmet kitchen, knowledge, questionnaire survey, tree classification

*** Corresponding author: Raquel P. F. Guiné,** Department of Food Industry, CI & DETS and CERNAS Research Centres, Polytechnic Institute of Viseu, Viseu, Portugal, e-mail: raquelguine@esav.ipv.pt
Sofia G. Florença: Faculty of Food and Nutrition Sciences, University of Porto, Porto, Portugal
Ana Cristina Ferrão: Department of Food Industry, CI & DETS and CERNAS Research Centres, Polytechnic Institute of Viseu, Viseu, Portugal
Maša Černelič Bizjak: Faculty of Health Sciences, Department of Nutritional Counselling-Dietetics, University of Primorska, Koper, Slovenia
Blanka Vombergar: The Educational Centre Piramida Maribor, Maribor, Slovenia
Natália Simoni, Viviane Vieira: Department of Nutrition, Faculty of Public Health, University of São Paulo, São Paulo, Brazil

1 Introduction

There are many vegetable species used in gastronomy, among which are edible flowers (EF). For a flower to be considered edible, it must be nontoxic, innocuous, and have nutritional properties (Navarro-González et al. 2014; Lu et al. 2016). Historically, EF have been used for culinary purposes for centuries in many different places, such as Asia, ancient Greece, Rome, and also medieval France (Chen et al. 2020). There are many different EF (Chen and Wei 2017; Mulík and Ozuna 2020), and they can be consumed in different ways (Huang et al. 2017). Nowadays, the interest in the use of EF is increasing, especially among culinary chefs, because of their health and aesthetic properties (Pires et al. 2017). These kinds of flowers can be used fresh or cooked, serving as ingredients in different recipes, for example salads, desserts, garnishes, beverages, jellies, or drinks (Koike et al. 2015).

From a nutritional point of view, EF are mostly composed of water (approximately 80%), being the amounts of the different nutrients variable according to the kind of flower (Navarro-González et al. 2014; Fernandes et al. 2017). They constitute a source of nutrients such as vitamins A, C, B_2 (riboflavin), and B3 (niacin) and different dietary minerals, as well as different phytochemical compounds (Arya et al. 2014; Petrova et al. 2016; Chen and Wei 2017). In addition, they are a good source of bioactive

Open Access. © 2021 Raquel P. F. Guiné *et al.*, published by De Gruyter. This work is licensed under the Creative Commons Attribution 4.0 International License.

compounds, particularly phytochemicals, associated with several pharmacological properties, namely protecting against cardiovascular diseases and having antianxiety, anticancer, antidiabetic, anti-inflammatory, anti-oxidant, diuretic, anthelmintic, immunomodulatory, and antimicrobial effects (Petrova et al. 2016). In recent years, EF have gained a renewed attention because of their potential for culinary purposes and also their beneficial health effects in different pathologies (He et al. 2015; Zheng et al. 2021). However, there are also some risks associated with the consumption of these flowers, and for that reason it is important that the consumers properly identify EF and only consume them from a reliable source, preferably from organic production, avoiding obtaining them from florists' shops because they could contain pesticides residues. Furthermore, to prevent problems in the digestive system, it is also important to consume EF only in small quantities and preferably one species at a time (Ebert 2013). There were reported some allergic reactions associated with the consumption of EF, especially among those who are more sensitive (Mlcek and Rop 2011). EF are used in the gastronomy of many countries to add special colours and flavours to different recipes. In some European countries, such as England, Spain, or Italy, the use of EF is popular (Yamamoto and Kono 2018), whereas in some countries of South America, such as Brazil, its use is not so familiar (Rodrigues et al. 2017).

There are numerous EF all over the world, such as chrysanthemum, daylily, lilac, mint, nasturtium, pansy, rose, marigold, tulip, and violet (University of Kentucky 2012). However, not all the EF are safe for human consumption, being this the consumers' major concern (Cunningham 2015). Therefore, it is essential that the consumers properly identify the flowers and guarantee that they are not poisonous before eating them. For that, the following flowers should be avoided: flowers that have been grown in soil fertilized with untreated animal manure within 4 months before harvest; grown on the roadside; purchased at a florist, garden centre, or nursery, unless they are labelled as edible; and also that may have been sprayed with pesticides (Lauderdale and Bradley 2014). Furthermore, it is also important to take into consideration that some flowers are safe at an appropriate dosage and for that reason can only be consumed in small quantities. This is the case, for example, of linden flowers (*Tilia* spp.), which, if consumed in high quantities, may lead to heart damages (Guiné et al. 2017). Moreover, there are some flowers that can trigger allergic reactions, especially to those who suffer from hay fever, asthma, or allergies (Cunningham 2015). For example, allergic reactions, such as rash and eczema, have often been caused by chrysanthemum flowers (Osimitz et al. 2006).

Food preferences and eating habits are influenced by different factors, such as biological, physiological, cultural, economic, and also political concerns (Steptoe et al. 1995; Pearcey and Zhan 2018). Every country has a different cultural heritage and therefore the consumers' curiosity and acceptance for unfamiliar products also differ between nations (Güneş and Özkan 2018). Despite the increasing popularity of EF, the knowledge about peoples' habits and familiarity towards the consumption of this product is still limited (Chen and Wei 2017). Therefore, the aim of this study was to assess the level of familiarity of the population as well as understand some of the habits and knowledge about EF in three different countries, namely Portugal, Slovenia, and Brazil, representing different parts of the globe, for comparison of the realities among different geographic regions. Furthermore, the best predictors for those variables relating to EF were also evaluated.

2 Materials and methods

2.1 Research questions and instrument

This study intended to answer the following research questions:

- Do consumers in the countries at study consume EF regularly?
- How do consumers eat the EF, with what frequency, and for what reasons?
- Are consumers aware of the potential risks associated with EF, namely toxicity and pesticides?
- To what extent the sociodemographic variables influence the habits and perceptions towards EF?

To answer these questions, a questionnaire survey was carried out, with an instrument that was designed purposely for the study and previously validated. The questionnaire contained different parts aimed at assessing information about several issues related to the level of knowledge and consumption habits about EF. The instrument used in the present investigation included questions dedicated to the characterization of the sample as well as other questions aimed at evaluating what people know about EF as well as if and how they eat them. The questionnaires were applied online, after informed consent, only to adults and all ethical issues were followed when designing and applying the questionnaire, which was approved for the investigation.

2.2 Sample and data collection

The data collection occurred in different parts of the globe: Portugal (Iberian Peninsula), Slovenia (South Central Europe), and Brazil (South America), and guaranteeing that all data obtained would be treated with absolute confidentiality and meeting all ethical issues. The participants were selected in the three countries based on the following assumptions: regular citizes, possible consumers of EF, with different levels of education, living environments or other sociodemographic characteristics.

2.3 Data analysis

For the exploratory analysis of the data, different basic descriptive statistical tools were used, such as the mean and the standard deviation. The crosstabs and the chi-square test were used to access the relations between some of the categorical variables under study. Moreover, the Cramer's V coefficient was used to analyse the strength of the significant relations found between some of the variables at study. This coefficient ranged from 0 to 1 and can be interpreted as follows: $V \approx 0.1$, the association is considered weak; $V \approx 0.3$, the association is moderate; and $V \approx 0.5$ or over, the association is strong (Witten and Witte 2009).

To evaluate the relative importance of each of the possible influential variables (age group, sex, country, living environment, level of education, and area of work/studies) on the participants' consumption and knowledge about EF, a tree classification analysis was used. For that purpose, the classification and regression trees algorithm with cross-validation was followed, and the minimum number of cases considered for parent–child nodes was 20 and 10 for child nodes.

The data were processed using the SPSS program, version 25 from IBM, Inc., and the level of significance used was 5%.

Ethical approval: The conducted research is not related to either human or animal use.

3 Results and discussion

3.1 Sample characterization

Table 1 presents the sample characterization and shows that the majority of the participants were women, 79.8%, against 20.2% of men. Regarding the country distribution, the percentage of female participants showed differences, being lowest in Portugal (74.1%), then 82.8% for Slovenia, and 89.0% for Brazil, corresponding to the highest value.

The age of the participants ranged from 17 to 84 years, being on average 37 ± 14 years. The average age of women, 37 ± 14 years, was slightly lower when compared to that of men, 40 ± 14 years. The participants were classified into age groups according to: young adults (18 years ≤ age ≤ 30 years), accounting for 42.4%; average adults (31 years ≤ age ≤ 50 years), corresponding to 36.9%; senior adults (51 years ≤ age ≤ 64 years), representing 17.0%; and finally elderly (≥65 years), which accounted for 3.8% of the sample. The results in Table 1 further show that the average age of the Portuguese participants was higher, 42 ± 14 years, when compared to the average age of the Slovenian and Brazilian participants (34 ± 15 and 33 ± 11 years, respectively) (Table 1).

As for the level of education, 57.1% of the respondents had a university degree, 41.8% had the secondary school as their terminal education, and only 1.1% had the basic school as the highest level of education achieved.

Table 1: Sample characterization by country

Country	N[a]	Age[b] (years)	Gender[c]		Level of education[d]			Living environment[e]		
			F (%)	M (%)	B (%)	S (%)	U (%)	R (%)	U (%)	SU (%)
Portugal	247	42 ± 14	74.1	25.9	0.6	18.4	81.0	24.7	68.5	6.8
Slovenia	239	34 ± 15	82.8	17.2	1.6	65.3	33.1	46.4	25.1	28.5
Brazil	73	33 ± 11	89.0	11.0	0.0	12.3	87.7	1.4	98.6	0.0
Total	559	37 ± 14	79.8	20.2	1.1	41.8	57.1	32.2	50.8	17.0

[a] N = number of participants. [b] Age expressed as mean ± standard deviation. [c] Gender: F = female, M = male. [d] Education: B = basic school, S = secondary school, U = university degree. [e] Living environment: R = rural, U = urban, SU = suburban.

When seen by country, the results showed that the majority of the Portuguese and Brazilian participants had a university degree (81.0 and 87.7%, respectively), whereas most of the Slovenian participants, 65.3%, had the secondary school as their highest level of education (Table 1).

Regarding the living environment, 50.8% of the participants lived in an urban area, 32.2% in a rural area, and 17.0% in suburban surroundings, being this tendency quite different when analysed by country. For Portugal and Brazil, most of the participants were from urban areas, whereas in Slovenia the participants were mainly from rural areas (Table 1).

Figure 1 shows the frequencies of participant's professional area, in the global sample and in each of the surveyed countries. Most of the participants, 62.7%, indicated that they had a profession or studies related to nutrition/food, being this percentage higher for the participants from Brazil, 74.0%, when compared to those from Portugal and Slovenia, 56.8 and 62.8%, respectively (Figure 1). Other professional areas of the participants included agriculture (19.9%) and hotels/restaurants (16.8%).

3.2 Knowledge and habits about EF

For the sample at study, 90.0% of the participants indicated that they already heard about EF, being this trend similar for Portugal and Brazil (94.3 and 93.2% respectively), but in Slovenia this percentage was lower (84.5%). The results of the chi-square test showed that these differences between countries were significant ($\chi^2 = 13.911$, $p = 0.001$), with a weak association between the variables ($V = 0.158$). The majority of the participants, 64.7%, answered that they had already consumed EF. However, it was observed that a higher percentage of the Slovenian participants answered yes (73.2%), when compared to the Portuguese and Brazilian participants (58.9 and 56.2% respectively). Again significant differences were found ($\chi^2 = 13.497$, $p = 0.001$), meaning that the country influenced the fact that the participants had already consumed EF. The Cramer's V coefficient showed that the association between the variables was weak ($V = 0.156$). In fact, in Slovenia there is a tradition about the use of edible plants, including EF, which is usually transmitted from generation to generation (Lumpert and Kreft 2017).

Figure 2 shows the percentage of participants who ate EF according to the possible ways to consume them. The results in Figure 2 show that the most frequent answers were in salads (77.0%) followed by decoration/confection of dishes (76.5%).

As it can be observed in Table 2, the Slovenian participants preferred to use EF for decoration or for confection of dishes, whereas for the Portuguese and Brazilian participants the trend was to consume EF mostly in salads. The results of the chi-square test showed that there were significant differences between countries regarding the use of EF in jelly ($\chi^2 = 7.118$, $p = 0.028$) and for decoration/confection of dishes ($\chi^2 = 7.738$, $p = 0.021$). However, in both cases the association between the variables was weak.

The results showed that the most consumed EF by the participants, globally, was camomile with 66.7% of positive answers (Table 2). When the results were analysed by country, it was observed that this trend was similar for all

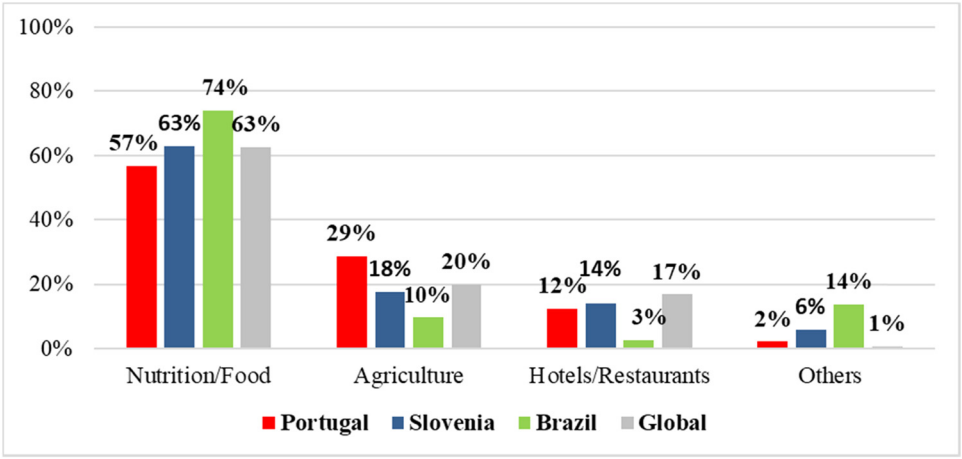

Figure 1: Participants' profession by country.

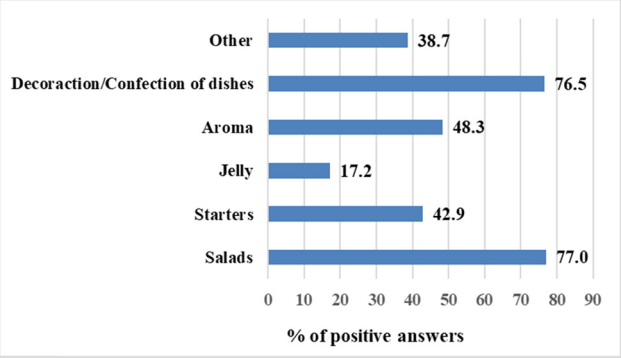

Figure 2: Possible ways to consume edible flowers.

countries. The results further showed that the Slovenian participants consumed more frequently camomile, rose, and pumpkin flower, those from Portugal consumed more camomile, sunflower and pansy, and finally for those from Brazil the choice relies more on camomile, rose, and pansy. These differences among countries were statically significant for all flowers tested except for orchid, meaning that the country influenced the type of EF consumed.

Table 3 presents the frequency of consumption of EF in the different countries. The results show that for most participants, 85.5%, the consumption of EF is sporadic, being this a common trend in the three countries. However, it was also observed that more Portuguese participants consumed EF on a usual basis (29.7%) when compared to the other countries. As for the association between the Country and the Frequency of consumption of EF, the results showed that there were significant differences (χ^2 = 45.066, p = 0.000), with a moderate association between the variables (V = 0.355).

For the sample at study, 50.7% of the participants indicated that they did not use EF in gastronomy, against 49.3% that answered yes, as it can be observed in Table 3. When the results were analysed by country, 57.9% of the Portuguese and 50.9% of the Slovenian participants used EF for gastronomic purposes, whereas only 12.2% of the Brazilian participants indicated that they used EF in gastronomy. In view of these results, it was found that the differences between countries were statistically significant (χ^2 = 27.075, p = 0.000), with a moderate association (V = 0.274). These results are not surprising, because the use of EF in gastronomy in some South American countries, such as Brazil, is relatively recent (Chen and Wei 2017; Rodrigues et al. 2017).

When the participants were asked about the reasons that prompt them to eat EF (Tables 4), 64.8% answered decoration, followed by taste (61.1%). In Slovenia, the major reason appointed by the participants was also decoration, 76.6%, in Brazil it was decoration together with novelty, 73.2% of positive answers for both, and in Portugal the most valued attribute was taste (61.4%). The results of the chi-square showed that there were significant differences between countries regarding the reasons that led the participants to eat EF, with the exception of the antioxidant activity. Some recent studies support the strong antioxidant activity of several EF owing to the presence of some phytochemicals and bioactive molecules such as phenolic compounds, such as anthocyanins,

Table 2: Possible ways to consume edible flowers and type of edible flowers consumed, according to country

	Global		Portugal		Slovenia		Brazil		Chi-square test		Cramer's coefficient
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	χ^2	p	V
Possible ways to consume edible flowers											
In salads	77.0	23.0	75.2	27.8	79.4	20.6	73.2	26.8	1.196	0.550	0.058
In starters	42.9	57.1	48.3	51.7	41.1	58.9	31.7	68.3	4.027	0.134	0.106
In jelly	17.2	82.8	20.7	79.3	12.1	87.9	26.8	73.2	7.118	0.028	0.141
As aroma intensifiers	48.3	51.7	46.2	53.8	52.9	47.1	36.6	63.4	3.969	0.137	0.105
Decoration/confection of dishes	76.5	23.5	70.3	29.7	82.9	17.1	70.7	29.3	7.738	0.021	0.146
Types of edible flowers consumed											
Orchid	4.4	95.6	4.1	95.9	4.6	95.4	4.9	95.1	0.057	0.972	0.013
Pansy	30.6	69.4	37.2	62.8	24.7	75.3	31.7	68.3	5.880	0.053	0.128
Sunflower	37.5	62.5	40.0	60.0	41.4	58.6	12.2	87.8	12.706	0.002	0.188
Camomile	66.7	33.3	62.1	37.9	74.1	25.9	51.2	48.8	10.152	0.006	0.168
Marigold	28.8	71.2	19.3	80.7	41.1	58.9	9.8	90.2	26.616	0.000	0.272
Pumpkin flower	43.2	56.8	33.1	66.9	56.0	44.0	24.4	75.6	23.619	0.000	0.256
Rose	47.9	52.1	35.9	64.1	58.3	41.7	46.3	53.7	16.023	0.000	0.211

Table 3: Frequency of consumption of edible flowers and their use in gastronomy, by country

	Global (%)	Portugal (%)	Slovenia (%)	Brazil (%)	Chi-square test		Cramer's coefficient
					χ^2	p	V
Frequency of consumption of edible flowers							
Sporadic	85.5	70.3	95.3	97.6	45.066	0.000	0.355
Usual	14.5	29.7	4.7	2.4			
Use of edible flowers in gastronomy							
Yes	49.3	57.9	50.9	12.2	27.075	0.000	0.274
No	50.7	42.1	49.1	87.8			

which are present in flowers, for example, as colourings (Barros et al. 2020; Mikołajczak et al. 2020; Skrajda-Brdak et al. 2020; Takahashi et al. 2020). According to other studies, for example, in Brazil, EF are usually used for decorative purposes (Aki and Perosa 2002; Rodrigues et al. 2017).

Most of the participants, 64.6%, prefer to consume EF fresh (Table 4). These results were quite different when seen by country because in Portugal most of the participants (82.1%) eat EF cooked, and in Slovenia and Brazil the trend is more towards eating them fresh (78.8 and 60.0%, respectively). Again, there were found significant differences, meaning that the country influenced the form of consumption of EF, with a weak association in the case of fresh (V = 0.262) and a strong association for cooked (V = 0.525).

Regarding the place where the participants obtained EF (Table 4), for the Slovenian participants the most common way to obtain them was the collection from wild (92.1%), whereas the participants from Portugal preferred to get this product from the supermarket (79.8%). As for the Brazilian participants, they equally indicated to obtain EF from the supermarket and through home cultivation (60.0% for both cases). In Slovenia, there seems to be an important tradition of collecting EF from wild (Lumpert and Kreft 2017). Furthermore, significant differences were found between countries for the different ways of obtaining EF, except for florist, with strong association between variables for the cases of supermarket (V = 0.645) and wild (V = 0.597) and with a moderate association in the case of home cultivation (V = 0.328).

Considering that some EF can be toxic (Fernandes et al. 2016), it was also investigated if the participants were aware about the risks associated with their consumption. As it can be observed in Table 5, Slovenian participants seem to be the ones who were more aware about those

Table 4: Participants' reasons for eating edible flowers, form of consumption, and how to obtain them, by country

	Global		Portugal		Slovenia		Brazil		Chi-square test		Cramer's coefficient
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	χ^2	p	V
Reasons for eating edible flowers											
Decoration	64.8	35.2	48.3	51.7	76.6	23.4	73.2	26.8	29.256	0.000	0.285
Taste	61.1	38.9	61.4	38.6	66.7	33.3	36.6	63.4	12.641	0.002	0.187
Aroma	55.1	44.9	42.1	57.9	66.9	33.1	51.2	48.8	19.982	0.000	0.235
Nutritional value	32.4	67.6	48.3	51.7	23.4	76.6	14.6	85.4	29.020	0.000	0.284
Antioxidant activity	28.3	71.7	28.3	71.7	29.7	70.3	22.0	78.0	0.988	0.610	0.052
Novelty	26.9	73.1	35.2	64.8	9.1	90.9	73.2	26.8	77.803	0.000	0.464
Other	27.0	73.0	15.9	84.1	32.0	68.0	24.4	75.6	6.639	0.036	0.153
Form of consumption of edible flowers											
Fresh	64.6	35.4	50.0	50.0	78.7	21.3	60.0	40.0	15.562	0.000	0.262
Cooked	55.1	44.9	82.1	17.9	29.2	70.8	60.0	40.0	48.977	0.000	0.525
How to obtain edible flowers											
Supermarket	46.6	53.4	79.8	20.2	14.6	85.4	60.0	40.0	74.085	0.000	0.645
Home cultivation	61.8	38.2	45.2	54.8	77.5	22.5	60.0	40.0	19.092	0.000	0.328
Florist	9.0	91.0	6.0	94.0	11.2	88.8	20.0	80.0	2.237	0.327	0.112
Collect from wild	63.5	36.5	35.7	64.3	92.1	7.9	20.0	80.0	63.536	0.000	0.597

Table 5: Participants' awareness about the risks associated with the consumption of flowers and opinion regarding the facility to access them, by country

Country	Do you consider that are risks associated with the consumption of edible flowers?			Do you think it is easy to find edible flowers?		
	Yes (%)	No (%)	Maybe/No opinion (%)	Yes (%)	No (%)	Maybe/No opinion (%)
Portugal	34.4	33.2	32.4	23.9	28.3	47.8
Slovenia	51.0	15.5	33.5	39.8	25.9	34.3
Brazil	28.8	35.6	35.6	8.2	28.8	63.0
Chi-square test statistics, χ^2	29.125			35.101		
Significance, p	0.000			0.000		
Cramer's coefficient, V	0.161			0.177		

risks (51.0%), followed by the Portuguese (34.4%), and finally the Brazilian participants (28.8%). Moreover, it was found that these differences were statistically significant, meaning that the country influenced the participants' conscientiousness about the possible health problems that can derive from the consumption of EF. However, the association between the variables was weak (V = 0.161). Regardless of the country, the majority of the participants identified the presence of pesticides as the major risk that could be associated with the ingestion of EF (Portugal – 90.4% of positive answers, Slovenia – 82.7%, Brazil – 76.2%). In addition, the participants indicated that there is no enough information about this subject (Portugal: 91.9%; Slovenia: 88.7%; and Brazil: 95.9%).

As for the facility to access EF, 44.0% of the participants did not know, 27.4% considered that it is difficult to obtain EF, and 28.6% answered that they find it easy to get these flowers. When analysed by country (Table 5), it was observed that only 8.2% of the participants from Brazil thought that it is easy to obtain EF. On the

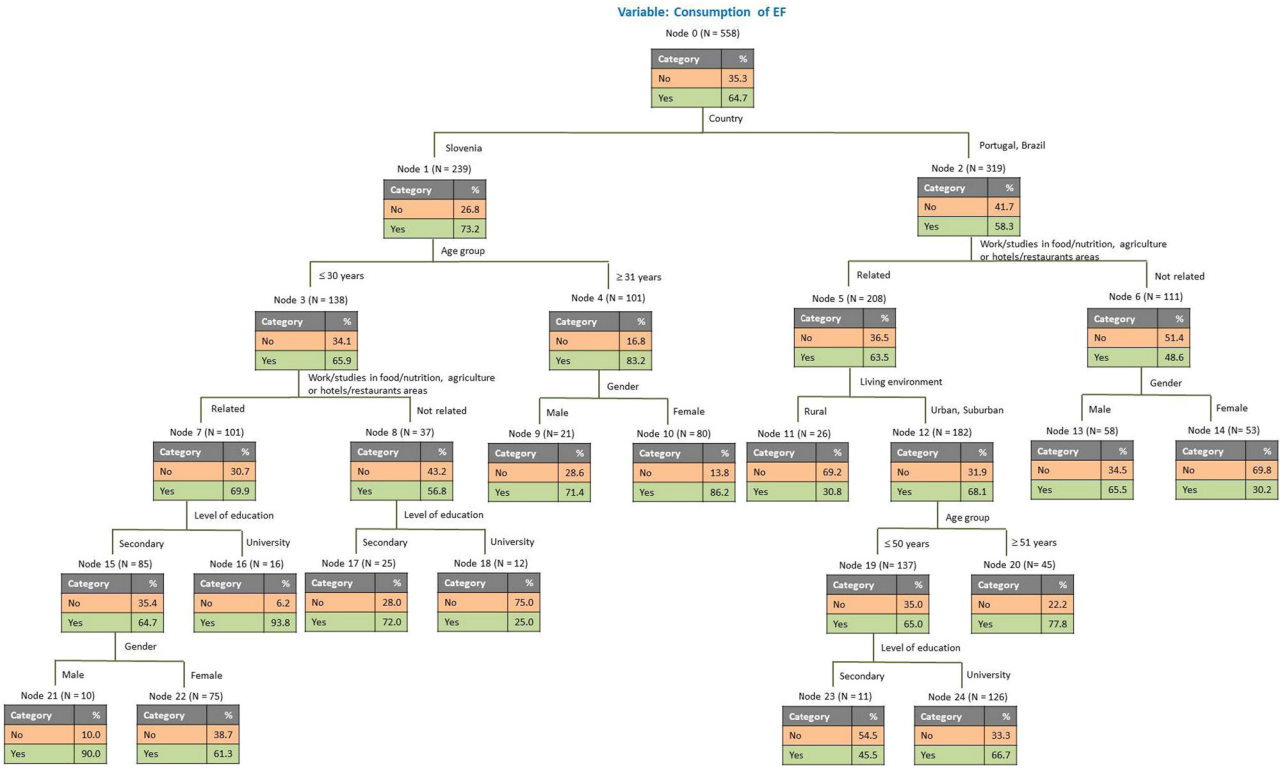

Figure 3: Classification tree for variable "Consumption of EF."

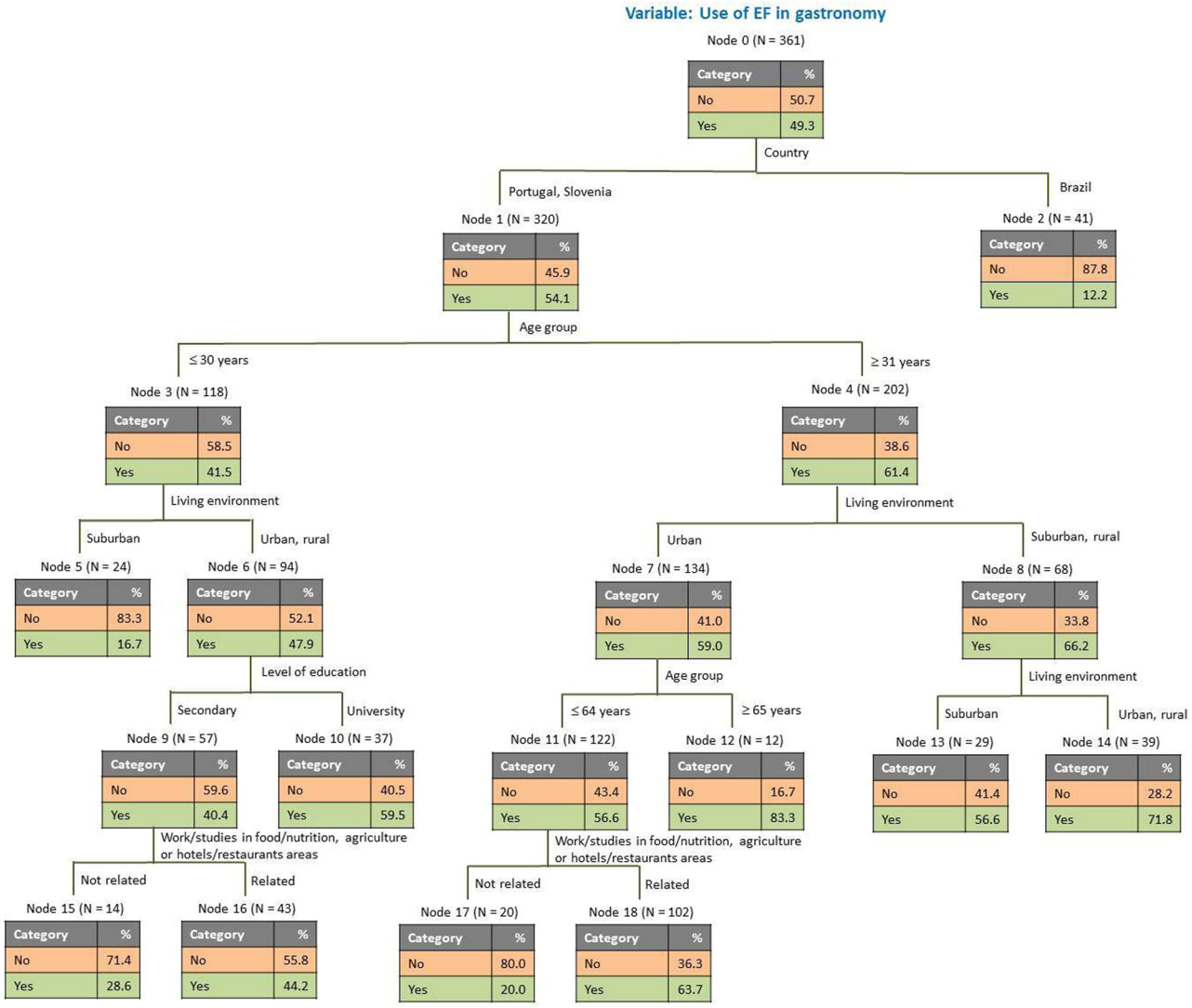

Figure 4: Classification tree for variable "Use of EF in gastronomy."

contrary, a higher percentage of the Slovenian participants, 39.7%, considered that it is easy to get this kind of product, being this percentage 23.9% for the Portuguese participants. The results of the chi-square test showed that the differences among countries were statistically significant, but with a weak association ($V = 0.177$).

When the participants were asked if EF should be a part of a regular diet, 60.3% answered maybe/do not know, 30.9% of them indicated yes and only a few percentage of the respondents, 8.8%, answered no, being this trend similar for the three countries (Portugal – maybe/do not know: 58.3%, yes: 32.4%, no: 9.3%; Slovenia – maybe/do not know: 62.4%, yes: 30.1%, no: 7.5%; Brazil – maybe/do not know: 60.2%, yes: 28.8%, no: 11.0%).

3.3 Classification of predicting factors affecting knowledge and habits about EF

Figure 3 shows the classification tree for variable "Consumption of EF", which related the influence of the sociodemographic variables on the consumption of EF, measured as YES – has consumed and NO – has not consumed. The results show that the best predictor for this variable was the country that was differentiating Slovenia from Portugal and Brazil. In the case of Slovenia, the next predictor was age group, followed by the area of work or studies for the young adults and gender for the other age groups. For the young adults having a work or studies in the fields of nutrition/food, agriculture, or hotels/restaurants, the next predictor was school, being this predictor also observed for the young adults who did not have a

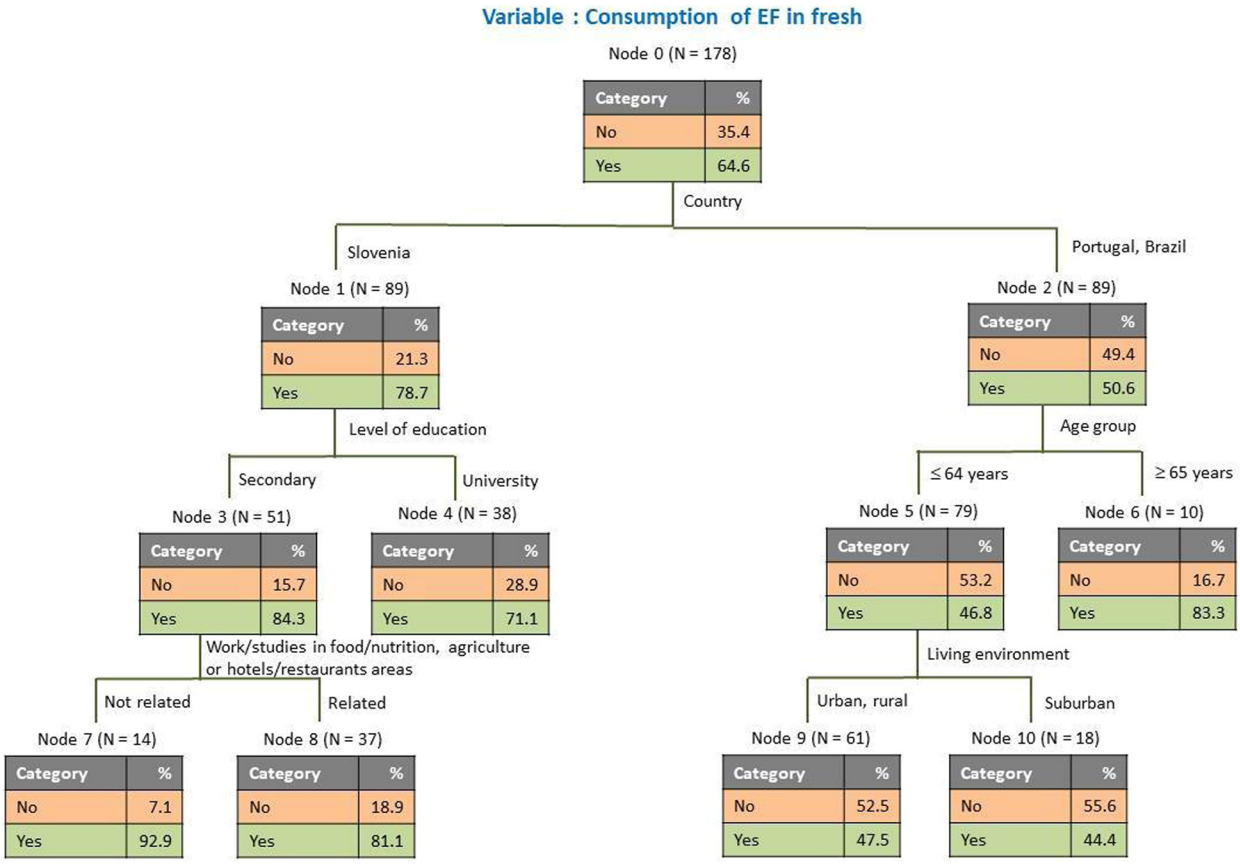

Figure 5: Classification tree for variable "Consumption of EF in fresh".

work or studies in those areas. As for the young adults with a secondary degree, the next predictor was gender. Figure 2 further shows that 90.0% of the Slovenian male young adults having a secondary degree and a work or studies in the areas of food/nutrition, agriculture or hotels/restaurants already ate EF, when compared with the young females (61.3%). Regarding the Slovenian male adults aged 31 or over, it was observed that 71.4% already consumed EF, being this percentage higher for the Slovenian females aged 31 or over (86.2%).

In the case of Portugal and Brazil, for the participants having a work or studies in the areas of food/nutrition, agriculture, or hotels/restaurants, the next predictor was the living environment, followed by age group for the participants who lived in urban/suburban areas and age groups in the next level for the average adults who lived in urban/suburban areas. As for the participants who did not have studies/work in those areas, the next predictor was gender. According to Figure 2, it was possible to see that 66.7% of the participants from Portugal or Brazil with a university degree, under 50 years, living in an urban/suburban environment and with a profession or studies in the areas of nutrition/food, agriculture, or hotels/restaurants, already consumed EF.

The results for variable "Use of EF in gastronomy" are shown in Figure 4, which presents the relative influence of the sociodemographic variables on the variable accounting for the use of EF in gastronomy. Again the best predictor for the use of EF in gastronomy was country, but in this case the separation was between Portugal/Slovenia and Brazil. For Portugal and Slovenia, the next best predictor was age group that was differentiating the young adults from the other age groups. For the young adults, the next predictor was living environment, followed by education level for those who lived in urban or rural areas and the area of work or studies was a predictor only for the participants with a secondary level of education. As for the other age groups, the next predictor was the living environment, followed by age group for the participants living in urban areas and in the next level the best predictor was the area of work or studies. For those who lived in suburban or rural areas, living environment differentiation continued in the subsequent level. Figure 3 further shows that the use of EF for

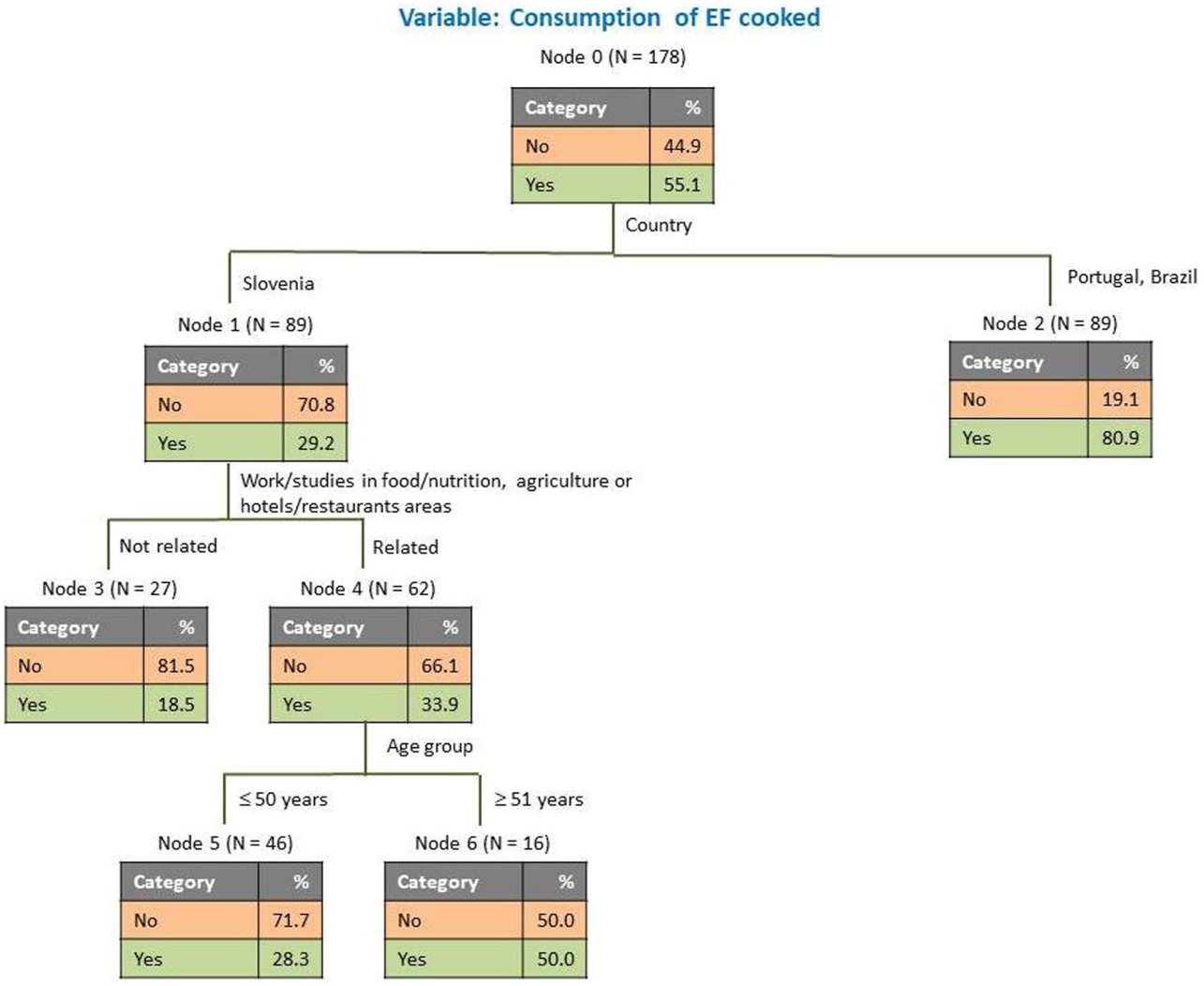

Figure 6: Classification tree for variable "Consumption of EF cooked."

gastronomic purposes was more common among the Portuguese and Slovenian participants aged 31 years or over (61.4%), especially among those who lived in suburban and rural areas (66.2%).

Figure 5 shows the classification tree for variable "Consumption of EF in fresh", according to the sociodemographic variables used. As it can be observed in Figure 5, the best predictor for the "Consumption of EF in fresh" was the country that was differentiating Slovenia from Portugal and Brazil. For Slovenia, the next predictor was the level of education, followed by the area of work or studies for the participants with a secondary level of education. In the case of Portugal and Brazil, the next predictor was age group, followed by living environment for the participants aged less than 51 years old. Figure 4 also shows that 92.9% of the Slovenian participants with the secondary education who did not have a profession or studies in the mentioned areas preferred to consume EF in fresh, when compared to those with a secondary education but with a work or studies in the areas of food/nutrition, agriculture, or hotels/restaurants, 81.1%. When the age of the participants from Brazil or Portugal was 65 years or over, 80.0% of them consumed EF in fresh.

The classification tree for variable "Consumption of EF cooked" is shown in Figure 6, revealing the relative importance of the sociodemographic variables considered in the analysis. The results of the classification tree for the "Consumption of EF cooked" show that, again, the best predictor was the country that was differentiating Slovenia from Portugal and Brazil. For the Slovenian participants, the next predictor was the area of work or studies, followed by age group for the participants who had a work or studies in the areas of nutrition/food, agriculture, or hotels/restaurants. According to Figure 5, 50.0% of the

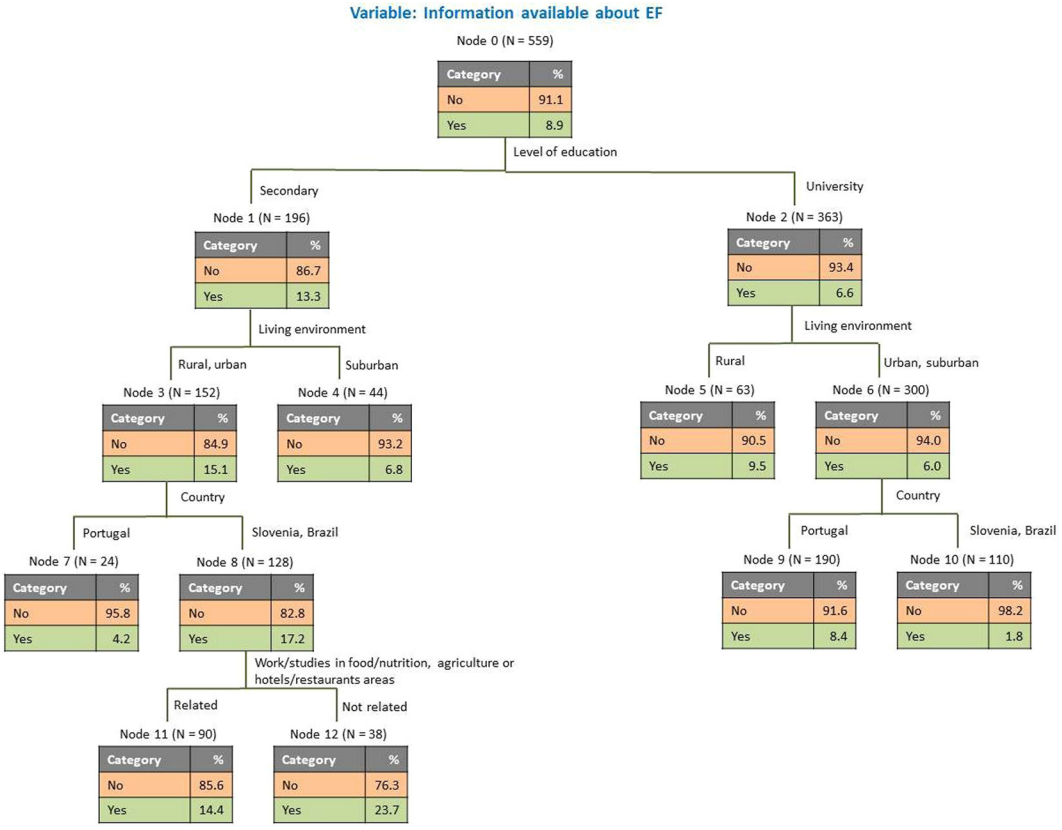

Figure 7: Classification tree for variable "Information available about EF."

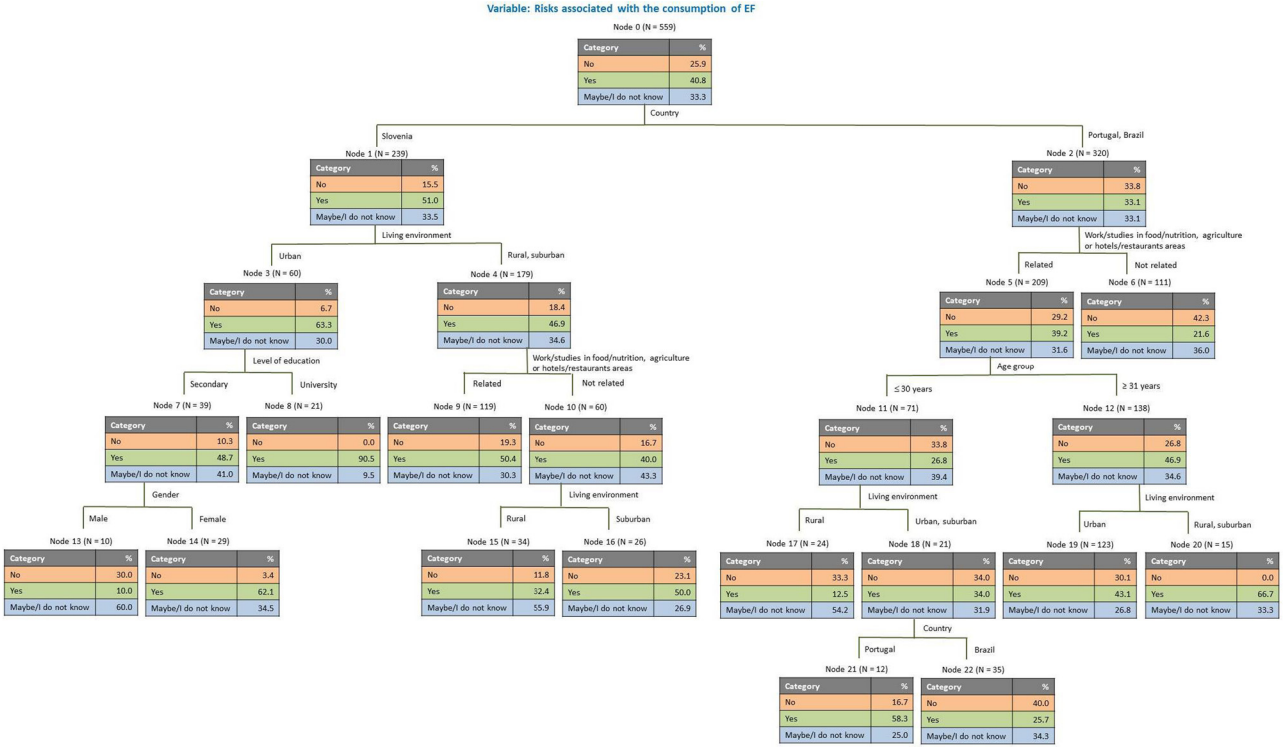

Figure 8: Classification tree for variable "Risks associated with the consumption of EF."

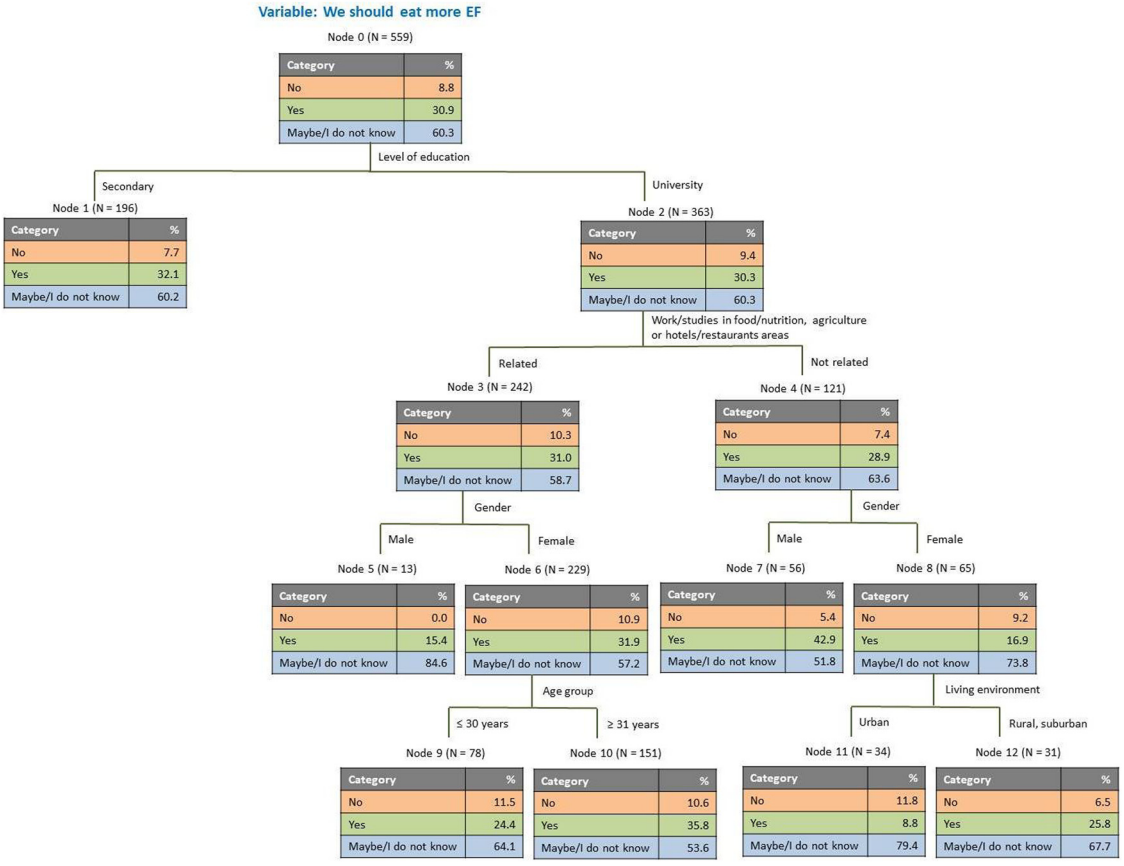

Figure 9: Classification tree for variable "We should eat more EF."

Slovenian participants aged 51 years or over with a work/studies in the mentioned areas consumed EF cooked.

Figure 7 shows the classification tree for variable "Information available about EF", again relating the influential sociodemographic variables to the output variable, in this case related to the information found available about EF. Figure 7 shows the classification tree for variable "information available about EF", and the best predictor for this variable was the level of education that was differentiating secondary from the university degree. For the participants with a secondary education, the next predictor was the living environment, followed by country for those who lived in rural or urban areas. The area of work or studies was a predictor only for the participants from Slovenia and Brazil. For those who had a university degree, the next predictor was also the living environment, followed by the country in the case of the participants who lived in urban and suburban areas. In all cases, the participants believed that there is a lack of information about this subject.

The classification tree for variable "Risks associated with the consumption of EF" is shown in Figure 8 and also identifies which of the sociodemographic variables are best predictors for the output variable related to the risks. As it can be observed in Figure 8, the best predictor for the participants' consciousness about the risks associated with the consumption of EF was the country that was distinguishing Slovenia from Portugal and Brazil. In the case of Slovenia, the next predictor was the living environment. For the participants who lived in an urban area, the next predictor was the level of education, followed by gender for those who had a secondary education. For the participants who lived in suburban or rural areas, the next predictor was the area or work or studies and living environment differentiation continued in the subsequent level for those who did not have a work or studies in food/nutrition, agriculture, or hotels areas. Figure 7 also shows that 90.5% of the Slovenian participants with a university degree and who lived in an urban area were aware about the risks involved in the consumption of EF, when compared to those who had a secondary education (48.7%). For Portugal and Brazil, the next predictor was the area of work or studies, followed by age group for the participants who had a profession or studies

in the areas of food/nutrition, agriculture or hotels/restaurants. In this case, age group was differentiating the young adults from the other age groups, and in both cases the next predictor was the living environment. Country differentiation continued in the subsequent level for the young adults living in urban or suburban areas, being the Portuguese young adults with a profession or studies related to the mentioned areas who lived in urban or suburban areas, 58.3%, more aware about the risks associated with the consumption of EF, when compared to those from Brazil (25.7%).

Figure 9 shows the classification tree for variable "We should eat more EF" and reveals the most important sociodemographic variables influencing the opinion about eating more EF. Figure 9 shows the tree classification for variable "We should eat more EF", and the best predictor for this variable was the level of education, followed by the area of work or studies for the participants with a university degree. Regardless of the area of work or studies, the next predictor was gender. For the females having a profession or studies in the areas of food/nutrition, agriculture, or hotels/restaurants, the next predictor was age group, whereas for those who did not have a work or studies in that areas, the next predictor was the living environment. According to Figure 8, most of the participants were not sure if EF should be a part of a regular diet.

4 Conclusions

This work allowed concluding that, independently of the country, this is not a new theme for the majority of the participants, who indicated to consume EF sporadically. There were significant differences between countries regarding the possible ways to consume EF and also regarding the types of EF consumed. Although most of the participants from Portugal consumed EF because of their taste, in Slovenia the most valued attribute was decoration and for the Brazilian participants was equally valued decoration and novelty. There were also significant differences between countries in the form of consumption of EF; in Portugal, they are preferred cooked unlike in the other two countries where they are consumed mostly fresh. As for the risks associated with the ingestion of EF, the Slovenian participants were those who showed a higher level of awareness about those risks, followed by the Portuguese and finally the Brazilian participants.

The classification analysis revealed that country was the major discriminant for the consumption of EF, their usage in gastronomy, the preferred way to eat EF, and also for the level of awareness associated with the consumption of this kind of product. On the contrary, the level of education was the most important discriminant for the amount of information that the participants believed to exist about EF and also for the participants' opinions regarding the increase in the intake of EF.

These results highlighted the importance of the country and other sociodemographic characteristics on eating patterns. Thus, the findings of this study are essential to promote and implement interventions that effectively contribute to a better knowledge about EF and to incentive their consumption if recognized as beneficial for the health.

Because the consumption of EF is still so little known, some suggestions for future work include the possible expansion of this survey into more countries, so as to have a better idea of the panorama in other parts of the world. This is most important because the consumption of EF is very much related to cultural variables, and these are different from country to country and from continent to continent, as our preliminary results indicated.

Acknowledgements: This work was funded by National Funds through the FCT – Foundation for Science and Technology, I.P., within the scope of the project Ref[a] UIDB/00681/2020. Furthermore, the authors would like to thank the CERNAS Research Centre and the Polytechnic Institute of Viseu for their support.

Funding source: The Open Access Article Processing Charges was funded by FCT – Foundation for Science and Technology, I.P., through CERNAS Research Centre, within the scope of the project Ref[a] UIDB/00681/2020.

Author contributions: R. P. F. G. – conceptualization, data curation, formal analysis, funding acquisition, and methodology; R. P. F. G., M. Č. B., B. V., N. S., and V. V. – resources; R. P. F. G., A. C. F., and S. G. F. – writing: original draft; R. P. F. G., S. G. F., M. Č. B., B. V., N. S., and V. V. – writing: review and editing.

Conflict of interest: The authors declare no conflict of interest.

Data availability statement: The datasets generated during and/or analysed during the current study are

available from the corresponding author on reasonable request.

References

[1] Aki A, Perosa JMY. Aspectos da produção e consumo de flores e plantas ornamentais no Brasil. Rev Bras Hortic Ornam. 2002;8:13–23. doi: 10.14295/rbho.v8i1.304.

[2] Arya V, Kumar D, Gautam M. Phytopharmacological review on flowers: Source of inspiration for drug discovery. Biomed Prev Nutr. 2014;4:45–51. doi: 10.1016/j.bionut.2013.08.009.

[3] Barros RGC, Andrade JKS, Pereira UC, de Oliveira CS, Rafaella Ribeiro Santos Rezende Y, Oliveira Matos Silva T, et al. Phytochemicals screening, antioxidant capacity and chemometric characterization of four edible flowers from Brazil. Food Res Int. 2020;130:108899. doi: 10.1016/j.foodres.2019.108899.

[4] Chen N-H, Wei S. Factors influencing consumers' attitudes towards the consumption of edible flowers. Food Qual Prefer. 2017;56:93–100. doi: 10.1016/j.foodqual.2016.10.001.

[5] Chen Q, Xu B, Huang W, Amrouche AT, Maurizio B, Simal-Gandara J, et al. Edible flowers as functional raw materials: A review on anti-aging properties. Trends Food Sci Technol. 2020;106:30–47. doi: 10.1016/j.tifs.2020.09.023.

[6] Cunningham E. What nutritional contribution do edible flowers make? J Acad Nutr Diet. 2015;115:856. doi: 10.1016/j.jand.2015.03.002.

[7] Ebert AW. Sprouts, microgreens and edible flowers: the potential for high value specially produce in Asia. In: Holmer R, Linwattana G, Nath P, Keatinge JDH, (Eds.). SEAVEG 2012: High Value Vegetables in Southeast Asia: Production, Supply and Demand. Chiand Mai, Thailand: AVRDC-WorldVegetableCenter; 2013. p. 216–27.

[8] Fernandes L, Casal S, Pereira JA, Saraiva JA, Ramalhosa E. Edible flowers: A review of the nutritional, antioxidant, antimicrobial properties and effects on human health. J Food Compos Anal. 2017;60:38–50. doi: 10.1016/j.jfca.2017.03.017.

[9] Fernandes L, Casal S, Pereira JA, Saraiva JA, Ramalhosa E. Uma perspetiva nutricional sobre flores comestíveis. Acta Port Nutr. 2016;6:32–7. doi: 10.21011/apn.2016.0606.

[10] Guiné R, Santos E, Correia P. Edible flowers: Knowledge and consumption habits. Acta Sci Nutr Health. 2017;1:18–22.

[11] Güneş E, Özkan M. Insects as food and feed in the Turkey: Current behaviours. Int J Environ Pollut Environ Model. 2018;1:10–15.

[12] He J, Yin T, Chen Y, Cai L, Tai Z, Li Z, et al. Phenolic compounds and antioxidant activities of edible flowers of Pyrus pashia. J Funct Foods. 2015;17:371–9. doi: 10.1016/j.jff.2015.05.045.

[13] Huang W, Mao S, Zhang L, Lu B, Zheng L, Zhou F, et al. Phenolic compounds, antioxidant potential and antiproliferative potential of 10 common edible flowers from China assessed using a simulated in vitro digestion–dialysis process combined with cellular assays. J Sci Food Agric. 2017;97:4760–9. doi: 10.1002/jsfa.8345.

[14] Koike A, Barreira JCM, Barros L, Santos-Buelga C, Villavicencio ALCH, Ferreira ICFR. Edible flowers of Viola tricolor L. as a new functional food: Antioxidant activity, individual phenolics and effects of gamma and electron-beam irradiation. Food Chem. 2015;179:6–14. doi: 10.1016/j.foodchem.2015.01.123.

[15] Lauderdale C, Bradley L. Choosing and Using Edible Flowers. Raleigh, North Caroline, USA: Department of Horticultural Science North Carolina State University, NC State Extension; 2014.

[16] Lu B, Li M, Yin R. Phytochemical content, health benefits, and toxicology of common edible flowers: A review (2000–2015). Crit Rev Food Sci Nutr. 2016;56:S130–48. doi: 10.1080/10408398.2015.1078276.

[17] Lumpert M, Kreft S. Folk use of medicinal plants in Karst and Gorjanci, Slovenia. J Ethnobiol Ethnomed. 2017;13:16. doi: 10.1186/s13002-017-0144-0.

[18] Mikołajczak N, Sobiechowska DA, Tańska M. Edible flowers as a new source of natural antioxidants for oxidative protection of cold-pressed oils rich in omega-3 fatty acids. Food Res Int. 2020;134:109216. doi: 10.1016/j.foodres.2020.109216.

[19] Mlcek J, Rop O. Fresh edible flowers of ornamental plants – A new source of nutraceutical foods. Trends Food Sci Technol. 2011;22(10):561–9. doi: 10.1016/j.tifs.2011.04.006.

[20] Mulík S, Ozuna C. Mexican edible flowers: Cultural background, traditional culinary uses, and potential health benefits. Int J Gastron Food Sci. 2020;21:100235. doi: 10.1016/j.ijgfs.2020.100235.

[21] Navarro-González I, González-Barrio R, García-Valverde V, Bautista-Ortín AB, Periago MJ. Nutritional composition and antioxidant capacity in edible flowers: Characterisation of phenolic compounds by HPLC-DAD-ESI/MSn. Int J Mol Sci. 2014;16:805–22. doi: 10.3390/ijms16010805.

[22] Osimitz TG, Franzosa JA, Maciver DR, Maibach HI. Pyrethrum allergic contact dermatitis in humans – Real?, Common?, or not documented?: An evidence-based approach. Cutan Ocul Toxicol. 2006;25:287–308. doi: 10.1080/15569520601013392.

[23] Pearcey SM, Zhan GQ. A comparative study of American and Chinese college students' motives for food choice. Appetite. 2018;123:325–33. doi: 10.1016/j.appet.2018.01.011.

[24] Petrova I, Petkova N, Ivanov I. Five edible flowers – Valuable source of antioxidants in human nutrition. Int J Pharmacog Phytochem Res. 2016;8:604–10.

[25] Pires TCSP, Dias MI, Barros L, Ferreira ICFR. Nutritional and chemical characterization of edible petals and corresponding infusions: Valorization as new food ingredients. Food Chem. 2017;220:337–43. doi: 10.1016/j.foodchem.2016.10.026.

[26] Rodrigues H, Cielo DP, Goméz-Corona C, Silveira AAS, Marchesan TA, Galmarini MV, et al. Eating flowers? Exploring attitudes and consumers' representation of edible flowers. Food Res Int. 2017;100:227–34. doi: 10.1016/j.foodres.2017.08.018.

[27] Skrajda-Brdak M, Dąbrowski G, Konopka I. Edible flowers, a source of valuable phytonutrients and their pro-healthy effects – A review. Trends Food Sci Technol. 2020;103:179–99. doi: 10.1016/j.tifs.2020.06.016.

[28] Steptoe A, Pollard TM, Wardle J. Development of a measure of the motives underlying the selection of food: the food choice questionnaire. Appetite. 1995;25:267–84. doi: 10.1006/appe.1995.0061.

[29] Takahashi JA, Rezende FAGG, Moura MAF, Dominguete LCB, Sande D. Edible flowers: Bioactive profile and its potential to be used in food development. Food Res Int. 2020;129:108868. doi: 10.1016/j.foodres.2019.108868.

[30] University of Kentucky. Edible Flowers. College of Agriculture, Food and Environment; 2012.
[31] Witten R, Witte J. Statistics. 9th edn. NJ: Wiley; 2009.
[32] Yamamoto Y, Kono M. Physiological functions of 70% ethanol extracts of 6 edible flowers *in vitro*: A comparative study. Food Nutr Sci. 2018;9:314. doi: 10.4236/fns.2018.94024.
[33] Zheng J, Lu B, Xu B. An update on the health benefits promoted by edible flowers and involved mechanisms. Food Chem. 2021;340:127940. doi: 10.1016/j.foodchem.2020.127940.