The Knowledge of Fermentation and Health Benefits among General Population in North-Eastern Slovenia

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Abstract

Background

Fermented foods are staples of the human diet and fermentation process has been used by humans for thousands of years. The preparation of fermented foods was performed in the past without knowledge of the role of microorganisms involved. Nowadays, fermented foods, due to their proclaimed health benefits for consumers, are becoming increasingly popular. Our study was constructed to provide data on awareness and use of fermented foods among people in North-eastern Slovenia.

Methods

The cross-sectional study included 349 individuals (16-89 years of age). An online survey was designed to assess the participants' knowledge of fermentation, fermented foods, the consumption of fermented foods and awareness of the health benefits. Data were collected from March to June 2021 and analyzed using IBM SPSS 27.0.

Results

Compared with the youngest participants (<21 years) knowledge of fermentation was higher in older individuals ($p < 0.001$). More than a half of the participants recognized the role of lactic acid bacteria and yeasts in fermentation process, however, only 18.3% of participants were aware of the role of the molds. Only 25.9% of the participants have become acquainted with fermented foods at home and 62.2% of them were aware of health benefits of fermented foods, but mostly on gastrointestinal health and the immune system.

Conclusions

As people today live predominantly in urban areas and incline towards westernized foods, they often lack the knowledge of fermentation and awareness regarding the nutritional value of fermented foods and their preparation. Steps should be taken to educate younger generations regarding the health benefits of fermented foods especially considering that most of them expressed their interest in learning more about the process.

Introduction

Food preservation has been important since the early days of humanity and the process of fermentation (in addition to salting) represents one of the oldest methods for preserving and producing foods and beverages (Bourdichon et al., 2012). Consequently, fermented foods have been a part of the human diet since early history and today account for nearly a third of the world's food consumption (Xiang et al.,

2019). The term “fermentation” comes from the Latin word “fermentum” and defines a process that utilizes the growth and metabolic activities of microorganisms that are present in plant or animal material (Terefe, 2016). It involves the chemical transformation or breakdown of complex organic substances or other food components into simpler compounds by the action of naturally occurring enzymes and fermenting microorganisms, bacteria (e.g. anaerobic lactic acid bacteria (LAB) such as *Lactobacillus* spp., *Streptococcus* spp., *Enterococcus* spp., aerobic *Bacillus* spp. and *Acetobacter* spp. as well as *Brevibacterium* spp., *Propionibacterium* spp.), yeasts (e.g. *Saccharomyces*, *Pichia*, *Candida* genera), or molds (e.g. *Aspergillus oryzae*, *Aspergillus sojae*, *Penicillium roqueforti*, *Rhizopus* spp.) (Batt, 2016; Marco et al., 2021). The definition of fermentation has been updated by the International Scientific Association of Probiotics and Prebiotics as “foods made through desired microbial growth and enzymatic conversions of food components” (Marco et al., 2021). Many fermentations are spontaneous and occur when indigenous microorganisms are allowed to grow and metabolize raw ingredients under favorable conditions while other fermentations require starter cultures (representing individual or mixture of defined microorganisms), that are deliberately added to induce a desired change in the food substrate (Batt, 2016). During food fermentation, the fermenting microorganisms synthesize a vast variety of metabolites that prevent the growth of spoilage and pathogenic microorganisms, consequently extending the shelf life of fermented product (Terefe, 2016). For example, LAB synthesize metabolites including lactic acid, acetic acid, carbon dioxide, ethanol, hydrogen peroxide, bacteriocins, and antimicrobial peptides that suppress the growth of spoilage and pathogenic microorganisms (Di Cagno et al., 2013). In addition to the food preserving role of fermentation, the metabolic activity of microorganisms can change the nutritive characteristics of foods and provide beneficial effects on human health (Melini et al., 2019). For example, fermented foods convey health benefits for consumers due to the presence of vitamins and nutrients with prebiotic, antiproliferative, antimicrobial or antioxidant properties, that are created during the fermentation process (Marco et al., 2021; Şanlıer et al., 2019; Xu et al., 2021). Fermentation also helps in significant reduction of antinutritional factors such as phytic acid, trypsin inhibitors, etc. (Xiang et al., 2019). In addition, fermented foods have unique properties (i.e. enhanced digestibility, increase nutritional value, etc.) and help in prevention of cardiovascular disease, gastrointestinal disorders, allergic reactions, diabetes, prevention of cancer, etc. (Divya et al., 2012; Marco et al., 2017).

Besides, fermented foods also serve as a vehicle for beneficial microorganisms that might have an important role in human health. Certain strains of these bacteria and yeasts are referred to as “probiotic” when they adhere to the well-established World Health Organization (WHO) definition, updated by the International Scientific Association for Probiotics and Prebiotics (ISAPP): “live microorganisms which, when administered in adequate amounts, confer a health benefit on the host” (Hill et al., 2014). Many uses of probiotics from fermented foods have been proposed, including modulation of gut mucosal immunity, the prevention and treatment of intestinal infections (Divya et al., 2012), lowering serum cholesterol, suppression of the growth of pathogenic microorganisms, modulating the immune system, etc. (Mukisa et al., 2019). Due to their health benefits, it has been suggested that fermented foods should become a part of national dietary recommendations (Childton et al., 2015; Ebner et al., 2014). However, it should be noted that to consider a “fermented food” a “probiotic fermented food” there should be

scientific evidence from well-designed, randomized controlled clinical trials in addition to proven safety and adequate amount of the particular probiotic strain in the final product (Marco et al., 2021). Likewise, fermented foods with unidentified content of microorganisms cannot be considered as “probiotic fermented foods” (Bell et al., 2018).

Worldwide, different products are a result of fermentation process reflecting biocultural diversity of communities across the globe. Different microorganisms (bacterial and yeast species) are involved in the process contributing to the unique flavors, textures, and nutritional profile of fermented foods (Bell et al., 2018; Marco et al., 2021). Fermented foods are manufactured and consumed throughout the world and in Slovenia where traditionally fermented foods include sauerkraut, sour turnip, fermented beets, salami, vinegar, wine, cheese, yogurt, smetana, etc. As in other countries, throughout the past, traditional knowledge of fermentation used by the people in Slovenia was passed down from older to younger generation most frequently with no understanding of the role of the microorganism(s) involved in the process. The emergence of microbiology as a science in the middle of the 19th century resulted in an increased knowledge of the biological basis behind food fermentations, and since then the process was being understood for the first time (Kabak and Dobson, 2011). Consequently, nowadays, much is known about the process, however, due to lack of interest the traditional knowledge of fermentation is not being transferred to the younger generation as it was the case before (Sahoo et al., 2017). Poor knowledge about fermentation process, about the health benefits of fermented foods, lack of interest and time together with western diet/lifestyle has led to gradual decrease of the use of traditional foods (Sahoo et al., 2017).

The present study is aimed to assess the knowledge about the preparation of fermented foods and awareness about the health-promoting benefits of fermented foods among people of all ages in North-eastern Slovenia. To the best of our knowledge, this is the first study to address that question in our country.

Materials And Methods

This cross-sectional study applied a qualitative design. In the present study we analyzed the participants' knowledge of fermentation process and fermented foods, consumption of fermented foods and awareness of the health benefits. For the purposes of the study, an online questionnaire consisting of closed and opened type of questions was designed to assess three different areas of interest. The questions were modelled based on those used in previously published studies on the knowledge of and awareness about health benefits of fermented foods (Camire et al., 2019; Chaiyasut et al., 2018; Hekmat and Koba, 2006; Sahoo et al., 2017; Sobharani Devi et al., 2019). The questionnaire was designed very broadly to shed light on all major issues in relation to people's attitude and knowledge of fermentation.

The first part of the questionnaire contained demographic data of respondents (gender, age, education, marital status, socioeconomic status, etc.). The second part included questions regarding the knowledge of respondent about fermentation process and microorganisms involved as well as the awareness of the

health benefits of fermentation and ingestion of fermented foods. The third part of the questionnaire assessed the intake of fermented foods through their everyday diet and their attitude towards fermented foods. The last part of the questionnaire contained data regarding the overall health of the respondents.

The questionnaire was prepared with a web survey tool, 1.KA online application and it was distributed to the study participants through direct personal contact, e-mail, Facebook, Twitter and other applications of social media. Data were collected from January to March 2021 in an electronic database and were further analyzed. We obtained 367 questionnaires, however, 18 of them were excluded due to missing data hence the final sample size included 349 participants.

The focus of the questionnaire were the questions regarding knowledge of fermentation, health benefits and consumption of such foods in addition to overall health of the participants. Each question had multiple possible answers. The study was approved by the Ethic Committee of Faculty of Health Sciences University of Maribor (038/2020/1786-04/504). All methods were performed in accordance with the relevant guidelines and regulations.

Statistical analysis

Descriptive statistics were used to characterize participants demographic details. Data were presented by frequencies and percentages for categorical variables, or by means and standard deviations for continuous variables. Variability around mean values was measured by standard deviations.

Only fully completed questionnaires were included in the analyses. Ordinal logistic regression was used as our main analytical tool to identify associations between the variables. The dependent variable in the model preparation of fermented foods at home. The seven independent variables were as follows: participant's characteristics (such as sex and age), level of formal education, employment, socioeconomic status, place of residence, and presence of chronic health issues. Results are presented as an odds ratio with 95% confidence interval and p-value. The statistical analyses were conducted using IBM SPSS ver.27.0 (IBM Corp., Armonk, NY). Statistical significance was set at $p < 0.05$.

Results

Out of 367 who gave their consent, 349 participants were included in the study (95.1%). As shown in Table 1, 84% of the participants were female and 16% of them were men. The average age of participants included in the study was 31.6 ± 15.7 ; for men it was 33.5 ± 15.7 years and for women 30.9 ± 15.5 years, ranging from the youngest participant aged 16 to oldest aged 89 years. Most patients originated from northeast Slovenia, whereas about 20% of patients came from other Slovenian regions. Approximately 37.5% lived in an urban setting. More than a half of them (64.8%) were married or lived in a civil union while 35.2% of them were single. Slightly less than a third (29.8%) of participants tried preparing fermented foods at home while 70.2% never tried to ferment at home.

Table 1
Characteristics of the study population

	n = 349	%
Sex		
male	56	16.0
female	293	84.0
Age		
≤ 20	89	25.5
21 - 30	137	39.3
31 - 40	35	10.0
41 - 50	41	11.7
≥ 51	47	13.5
Education		
primary school	60	17.2
high school	101	28.9
vocational school	34	9.7
university	90	25.8
Master's degree or higher	64	18.3
Marital status		
married or civil union	122	35.2
single	226	64.8
Monthly income (EUR)		
≤ 840	173	49.6
841 – 1.260	45	12.9
1.261 – 1.680	49	14.0
1.681 – 2.380	48	13.8
≥ 2.380	34	9.7
Place of residence		

Legend: n – frequency; % - percentage

	n = 349	%
urban	131	37.5
rural	218	62.5
Employment status		
high school pupil	64	18.3
student	109	31.2
employed	132	37.8
unemployed	17	4.9
retired	27	7.7
Chronic disease		
no	300	86.0
yes	49	14.0
Preparing fermented foods at home		
no	245	70.2
yes	104	29.8
Legend: n – frequency; % - percentage		

27.3% of participants included in the study had limited of knowledge about microorganisms involved in the process of fermentation. More than a half of participants (60.9%) knew the fermentation process is led by lactic acid bacteria and yeasts, however, only 18.3% of participants were aware of the role of molds. Only 11.8% had excellent knowledge of microorganisms involved in fermentation and were able to identify all three groups of microorganisms involved (LAB, yeasts and molds) and at the same time knew parasites, viruses or pathogens were not involved in the process. Compared with the youngest participants (< 21 years) good or excellent knowledge about microorganisms involved in fermentation was better in older individuals ($p < 0.001$) (Fig. 1).

Surprisingly, only 25.8% of the participants became acquainted with fermented foods at home, 31.2% of participants became acquainted with fermented foods at school while 29.2% of them became acquainted with fermented foods on the internet. Next, 62.2% of participants were aware of health benefits of fermented foods, but mostly regarding its beneficial effect on gastrointestinal health (digestion and gut microbiota) and the immune system. In Table 2, the awareness of health benefits of fermented foods is presented. The participants were the least aware of the potential beneficial effect of fermented foods on allergy (10.6%) and depression (10.6%) symptoms. It is interesting that 296 (84.8%) of the participants would consume more fermented foods if they knew more about the health influence of such foods.

Table 2
The awareness of the health benefits of
fermented foods among study population

	n = 349	%
on immune system		
yes	152	43.6
no	197	56.4
on digestion		
yes	202	57.9
no	147	42.1
on gut microbiota		
yes	171	49.0
no	169	48.4
on skin		
yes	60	17.2
no	256	73.4
on cholesterol		
yes	63	19.1
no	266	80.9
on depression symptoms		
yes	37	10.6
no	312	89.4
on diabetes		
yes	41	11.7
no	308	88.3
on allergy symptoms		
yes	37	10.6
no	312	89.4
Legend: n – frequency; % - percentage		

Frequency and types of fermented foods consumed by the participants of our study can be seen in Table 3. The results depict that fresh and semi-soft cheeses were the most frequently consumed as 162 (46.4%) and 183 (52.4%) participants declared eating fresh or semi-soft cheeses several times per week. Most of the participants consumed yogurt once per week (N = 143; 41.1%) while kefir was consumed less frequently. Of all fermented foods, kombucha and water kefir were the least used as 290 (83.9%) and 292 (83.7%) participants declared never consuming them. As expected, most participants used sour turnip (N = 83; 23.8%) and sauerkraut (N = 177; 50.7%) only seasonally, even though they are readily available in Slovenia in the supermarkets throughout the whole year.

Table 3
Frequency and types of fermented food consumed by respondents

	Daily n (%)	Several times per week n (%)	Once a week n (%)	Several times per month n (%)	Once a month n (%)	Rarely n (%)	Seasonally n (%)	Never n (%)
Yoghurt	33 (9.5)	84 (24.1)	49 (14.1)	31 (8.9)	13 (3.7)	29 (8.3)	1 (0.3)	12 (3.4)
Milk Kefir	11 (3.2)	20 (5.7)	18 (5.2)	19 (5.4)	114 (32.6)	66 (18.9)	7 (2.0)	94 (26.9)
Fresh cheeses (cottage cheese, mozzarella, etc.)	11 (3.2)	159 (46.4)	61 (17.5)	45 (12.9)	22 (6.3)	33 (9.5)	3 (0.9)	12 (3.4)
Semi-soft cheeses (Gouda, Cheddar, etc.)	20 (5.7)	183 (52.4)	74 (21.2)	32 (9.2)	11 (3.2)	19 (5.4)	1 (0.3)	9 (2.6)
Hard cheeses (Cheddar, Parmesan, etc.)	24 (6.9)	47 (13.5)	35 (10.0)	38 (10.9)	166 (47.6)	15 (4.2)	4 (1.1)	35 (10.0)
Blue cheeses (Gorgonzola, Roquefort, etc.)	1 (0.3)	5 (1.4)	13 (3.7)	17 (4.9)	27 (7.7)	97 (27.8)	1 (0.3)	115 (33.0)
Sour turnip	2 (0.6)	8 (2.3)	26 (7.4)	29 (8.3)	55 (15.8)	97 (27.8)	83 (23.8)	49 (14.0)
Sauerkraut	2 (0.6)	7 (2.0)	16 (4.6)	40 (11.5)	39 (11.2)	42 (12.0)	177 (50.7)	26 (7.4)
Sourdough bread	8 (2.3)	11 (3.2)	13 (3.7)	14 (4.0)	7 (2.0)	84 (24.1)	2 (0.6)	210 (60.2)
Water kefir	2 (0.6)	4 (1.1)	5 (1.4)	3 (0.9)	5 (1.4)	32 (9.2)	5 (1.4)	293 (83.9)
Kombucha	2 (0.6)	1 (0.3)	4 (1.1)	3 (0.9)	3 (0.9)	42 (12.0)	2 (0.6)	292 (83.7)
Wine	9 (2.6)	23 (6.6)	39 (11.2)	44 (12.6)	29 (8.3)	165 (47.3)	5 (1.4)	33 (9.5)
Legend: n – frequency, % - percentage								

	Daily n (%)	Several times per week n (%)	Once a week n (%)	Several times per month n (%)	Once a month n (%)	Rarely n (%)	Seasonally n (%)	Never n (%)
Beer	10 (2.9)	21 (6.0)	44 (12.6)	41 (11.7)	22 (6.3)	163 (46.7)	5 (1.4)	43 (12.3)
Legend: n – frequency, % - percentage								

Next, we assessed the acquaintance of participants with the foreign fermented foods and the results are presented in figure 2. Generation difference was evident in the awareness of foreign fermented foods. For example, 20.3% of participants knew about kimchi and most of them (47.2%) were from 21 to 30 years of age ($p < 0.091$). It was a similar situation with skyr and kombucha where 31.8% and 44.4% of the participants respectively knew what skyr and kombucha were, and again most of them were in the age group between 21 and 30 years of age ($p < 0.001$). In addition, 119 (34.1%) of the participants tried at least one of the mentioned fermented foods (i.e. Kimchi, Natto, Dadih, Skyr, Pulque, etc.).

Finally, associations between participants characteristics (i.e. age, sex, education, etc.) and preparing fermented foods at home are presented in Table 4. Our results showed that having a chronic disease ($OR=2.81$, $95\%CI=1.36-5.81$, $p=0.004$) was positively associated with preparing fermented foods at home. Explanatory variables included in the multivariable regression model explained 32.8% of the variation (Nagelkerke $R^2=0.328$, model $\chi^2 = 91.817$, $df=19$, $p<0.001$).

Table 4
Multivariable associations between participant characteristics and preparing fermented foods at home

	OR (95% CI)	p
Age (years)		
≤ 20	1.00 (reference)	
21 do 30	1.76 (0.30-10.41)	0.531
31 - 40	2.07 (0.28-15.18)	0.475
41 - 50	4.82 (0.67-34.84)	0.119
≥ 51	7.20 (0.89-58.45)	0.065
Sex		
male	1.00 (reference)	
female	0.51 (0.25-1.04)	0.062
Education		
primary school	1.00 (reference)	
high school	0.62 (0.12-3.30)	0.573
vocational school	1.14 (0.27-4.87)	0.857
university	2.08 (0.44-9.91)	0.356
Master's degree or higher	4.18 (0.86-20.43)	0.077
Monthly income (EUR)		
≤ 840	1.00 (reference)	
841 – 1.260	2.10 (0.88-5.01)	0.094
1.261 – 1.680	1.65 (0.52-5.23)	0.397
1.681 – 2.380	0.84 (0.24-2.91)	0.781
≥ 2.380	1.64 (0.45-5.98)	0.451
Place of living		
Urban	1.00 (reference)	
Rural	1.37 (0.76-2.46)	0.293
Employment status		
Nagelkerke R ² =0.328, OR: odds ratio, 95% CI: 95% confidence interval		

	OR (95% CI)	p
High school pupil	1.00 (reference)	
student	1.77 (0.27-11.63)	0.552
employed	1.89 (0.21-16.77)	0.568
unemployed	4.38 (0.48-39.79)	0.190
retired	1,06 (0.09-12.43)	0.961
Chronic disease		
no	1.00 (reference)	
yes	2.81 (1.36-5.81)	0.004
Nagelkerke R ² =0.328, OR: odds ratio, 95% CI: 95% confidence interval		

At the end, 252 (72.2%) of participants expressed they feel safe when consuming fermented foods and 119 (92.3%) of the participants did not feel any fear before trying a new fermented foodstuff. In addition, 259 (74.2%) of participants thinks that older people know more about fermentation process and 258 (73.9%) of them expressed their interest in learning more about the process.

Discussion

Fermented foods represent approximately 30% of total food intake around the world and fermentation plays a significant role in conferring health and functional benefits to the consumer. The importance of the latter motivated us to investigate and provide an insight into use and knowledge about health benefits of fermentation and fermented foods in Slovenia. To the best of our knowledge this is the first study in Slovenia to assess that topic, even though, we do not deny the possibility of the existence of smaller, provisional studies or projects the results of which are not publicly available. For the purpose of this study, we developed our questionnaire adopted from previously published studies (Camire et al., 2019; Chaiyasut et al., 2018; Hekmat and Koba, 2006; Sahoo et al., 2017; Sobharani Devi et al., 2019) covering demographic data of respondents, knowledge of fermentation and overall health of those included in the study.

We included people of all ages as children and young adults many times provided help with household fermentation practices and were involved to a certain degree in the process. We also included people regardless the degree of education since it is often the case that people with lower degree of education, people living in rural areas know more about and practice more of food preservation. In Slovenia as in other countries through the history, people have used fermentation to store and preserve food for millennia even though they didn't know much about the process and used fermentation to preserve foods and increase the nutritional value following a "recipe" they had in their family. This has led to a very vast

and heterogenous list of fermented foods that follow traditions and cultural preferences in different geographic areas throughout the world (Bell, et al., 2017; Whelan & Jones, 2021). Children in Slovenia grew up with local fermented foods, including sauerkraut, sour turnip and sour milk in rural areas, etc. accepting them as part of their traditional dishes and learning to like them as they were told it was good and healthy for them. In addition, fermentation was extremely important in Slovenia during the periods of famine in the first half of the last century. In the recent past, a renewed interest in health promoting potential of fermented foods, especially in developed countries among health concerned individuals motivated many to try preparing fermented foods at home (most frequently kombucha, kefir, sourdough, etc.) making fermented foods a part of their diet (Torres et al., 2020).

Most respondents included in our study were above 20 years of age and up to 89 years of age. Almost 54% of them were educated above graduation and 62.5% living in urban area.

Our results showed that almost one-third of participants included in the study did not have any knowledge regarding the microorganisms involved in the fermentation process even though they declared they were familiar with the term fermentation and used it in their everyday life.

Our findings are in accordance with the results of Hekmat and Koba study (2006), where nearly two-thirds of 233 college students attending Brescia University College were unfamiliar with the concept of fermentation. In the same study, about the same percent were unsure that cultured dairy products were fermented (Hekmat and Koba, 2006). In our study, the participants were mostly aware of the role of lactic acid bacteria which is not surprising since these are commonly referred to as probiotics and are heavily advertised predominantly for intestinal health. Besides, LAB occur naturally on many fruits and vegetables and are a typical autochthonous microbiota that is utilized in the traditional (spontaneous) fermentation process (Quave and Pieroni, 2014). In addition, our respondents were aware of the role of yeasts that are used in fermentation processes to produce alcoholic beverages such as wines, beers and ciders. The latter are traditionally carried out with *Saccharomyces cerevisiae* strains, the most common and commercially available yeast (Maicas, 2020). However, most of the respondents were unaware of the role of the molds that are used for the manufacture of many Asian fermented foods and in ripening of cheeses. The molds *Aspergillus oryzae* and *Aspergillus sojae* play a pivotal role in some Asian food processing, through their use as the starter for preparation of *koji*, a source of fungal enzymes necessary for assimilation of nutrients by other microorganisms in subsequent fermentations (Copetti, 2019). In addition to Asian foods, there are two major types of mold ripened cheeses. The first type are surface mold-ripened cheeses (such as Camembert and Brie, that are generally ripened by *Penicillium camemberti*, forming a white rind). The other type are internal mold-ripened cheeses (such as Roquefort and Gorgonzola, that are ripened by *Penicillium roqueforti*, and have the look of blue-veined cheeses) (Copetti, 2019).

Generation difference was evident in the understanding of fermentation process. Our respondents in their 30.-ies were the age group that most frequently had the correct understanding and knowledge of the process. This age group and younger participants were also the ones that were acquainted with and also

tried different foreign fermented foods (i.e. Kimchi, Natto, Skyr, etc). This is not so surprising as many commercially produced variants of fermented foods that were before rather unknown in our area are now widely available including kefir, kimchi, skyr, miso, tempeh, kombucha, etc. Our results are contrary to Sahoo et al (2017) where middle age group or older preferred to consume fermented foods in comparison to younger ones. The food market of fermented products has proved increasingly popular and growing its offer responding to the global trend and younger participants are seeking out for novel taste and texture experiences, experimenting with international cuisines. This is also reflected in the finding that only about a quarter of our participants have become acquainted with preparing their own fermented foods at home. More participants became acquainted with fermented foods at school, through the internet or commercials. On the other hand, important aspects of retired people consuming more fermented foods compared to younger respondents were observed by Camire et al (2019), where the respondents had an increased interest in food fermentation because of limited food budgets and food insecurity, interest in health-promoting foods, or availability of more time for food preservation.

Fermentation plays an important role in conferring health promotion and functional benefits through fermented foods to consumer and some fermented foods are marketed as functional foods, claiming health benefits beyond their basic nutritional composition. Owing to these health-promoting attributes many people are motivated to try and consume fermented foods. For that reason, we subsequently assessed the opinion of participants regarding the health benefits of fermented foods. More than a half of participants were aware of health benefits of fermented foods, but mostly regarding its beneficial effect on gastrointestinal health and immune system. Our study population showed better knowledge about the presence and role of LAB in fermented foods than the population in the study of Sahoo et al. (2017). Less knowledge was observed of the potential beneficial effect of fermented foods on allergy and depression symptoms. This lack of knowledge of potential benefits of fermented foods in other aspects of human health offer a field where improvement could be made especially when considered that more than 80% of our study population declared they would consume more fermented foods if they had more insight into health benefits of such foods. Similarly, the study by Sobharani Devi et al., (2019) found although the respondents preferred fermented foods in their diet, their attitude about fermented foods was poor due to the lack of knowledge.

Regular consumption of yogurt is frequently included in dietary guidelines, however, recommendations for other fermented foods are mostly lacking (Rezác et al., 2018). In Slovenia, however, the newest dietary guidelines and food pyramid recommend the consumption of fermented foods such as sauerkraut and sour turnip in addition to yogurt, and cheese, although the term 'fermented foods' is not used (National Institute of Public Health of Slovenia, 2014). As epidemiological studies (Ke et al., 2002; Martinez-Gonzales et al., 2019; Sonedstedt et al., 2011) indicate that diets with abundance of fermented foods might enhance health and longevity and reduce disease risk, more clinical research should be performed to assess the potential health benefits of the plethora of fermented foods besides yogurt and dairy products to include these fermented foods into dietary guidelines of countries around the globe (Marco et al., 2021).

Yogurt and other cultured dairy products are generally perceived by consumers as good sources of live and health-promoting organisms (Panahi et al., 2016). In our study, yogurt, fresh and semi-soft cheeses were most frequently consumed by respondents (i.e. several times per week). Both yogurt and soft cheeses serve as a source of live bacteria as many studies showed these products contained relevant counts of different LAB, ranging from 10^4 to 10^9 cfu/g (Rezac et al., 2018). Milk kefir and hard cheeses were consumed by majority of participants only once per month while sour turnip, wine and beer were consumed rarely. Sauerkraut was consumed seasonally by most respondents. Furthermore, blue cheeses, sourdough bread, water kefir and kombucha were the least consumed among fermented foods.

The ability of diet to modulate the gastrointestinal microbiota, improve or prevent dysbiosis, and enhance human health is now well-established (David et al., 2014; Graf et al., 2015; Sonnenburg and Bäckhed, 2016). Besides supplementation with probiotics and food components known to influence the composition of the gastrointestinal microbiota are fermentable fibers and prebiotics that enrich particular members of the gut microbiota (Rezac et al., 2018). Numerous studies showed evidence for the potential health benefits of fermented foods either associated with improvement of health status or reductions in disease risk (Babio et al., 2015; Kim et al., 2017; Marco and Golomb, 2016; Larsson et al., 2008; Chaiyasut et al., 2017). For that reason, consumption of fermented foods should be encouraged as possibly the easiest way to introduce beneficial microorganisms to the gastrointestinal tract and investment in future health as can be seen from our results that those who had a chronic disease were more likely to use fermented foods or prepare their own fermented foods at home.

Conclusion

The indigenous fermented foods are gradually decreasing from the staple diet of people living in developed countries due to the urbanization and industrialization. Consequently, as people today live predominantly in urban areas and incline towards westernized foods rich in sugar, salt and saturated fat, they often lack the knowledge of fermentation and awareness regarding the nutritional value of fermented foods and their preparation. Fermentation is not only a method of preservation but also an approach to improve quality, digestibility of foods and nutrition of people who consume it. In addition, fermented foods in the diet can improve consumer well-being and reduce the risk of diseases. There is a renewed interest in traditional fermented foods among younger generations who like to try new foods and flavors. However, those having a chronic disease where also those who fermented food at home mainly driven by the supposed health benefits of fermented foods. Steps should be taken to educate younger generations regarding the health benefits of fermented foods especially taking into account that most of them expressed their interest in learning more about the process. Fermented foods should become again a part of their diet to reduce or postpone the occurrence of chronic disease and improve their overall health.

Declarations

Ethics approval, guidelines and consent to participate

The study was approved by the Ethic Committee of Faculty of Health Sciences University of Maribor (038/2020/1786-04/504). All methods were performed in accordance with relevant guidelines and regulations. Informed consent to participate was obtained from the respondents.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

The concept was drafted by DMT and SF; SF and MŠP contributed to the analysis design; MŠP, DMT and SF advised on the paper and assisted in paper conceptualization; MŠP and SF contributed to the comprehensive writing of the article. All authors read and approved the final manuscript.

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Figures

Figure 1

Knowledge of the fermentation process among participants of the study. Y axis represents the average percentage of correct answers.

Figure 2

Acquaintance of study participants with the foreign fermented foods. Columns represent the percentage of participants acquainted with a particular fermented food.