



Exploring food shopping, consumption and waste habits in North Macedonia during the COVID-19 pandemic

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ABSTRACT

Household food waste (FW) has huge environmental and socio-economic impacts. During the COVID-19 pandemic, a survey was carried out in North Macedonia to explore perceptions and attitudes towards FW at the household level. A self-administered questionnaire was available online from 15th of May until June 30, 2020 and the sample size was 754. A very high percentage of the respondents (94.16%) expressed a high awareness of food waste and declared to worry about this issue trying to avoid food waste as much as possible. Moreover, the results showed that 41.38% of the respondents think to waste a low amount of food while 27.98% state not to throw almost anything. Meanwhile, 52.39% of the respondents believe that they do not throw away food that is still consumable. About 22.54% of them think to throw less than 250 g followed by those who think to throw between 250 and 500 g (18.04%). The survey showed that the most wasted food groups are cereals and bakery products, fruit, vegetables, and milk and dairy products. Concerning economic value, most of the respondents (53.18%) believe to spend less than 5 EUR on food wasted while 42.04% of them think to spend between 5 and 25 EUR. Regarding shopping behaviour during COVID-19, only about a half of the respondents (48.28%) stated to go shopping like they used to do. The respondents declared that they have bought during COVID-19 more vegetables (72.30%) and fruits (68.60%), which might imply that they are moving towards healthier diets. It seems that food wastage has increased during the COVID-19 for about a third of the respondents (34.70%). The survey showed that the COVID-19 pandemic affected food purchase, wastage and consumption behaviours in North Macedonia. Such a finding should inform future policies and initiatives relating to agriculture, food and health during the recovery period.

1. Introduction

Food loss refers to the decrease in quantity or quality of food and is the agricultural or fisheries products intended for human consumption that are ultimately not eaten by people or that have incurred a reduction in quality reflected in their nutritional value, economic value or food safety [1]. According to FAO [1], an important part of food loss is “food waste” at the consumer level, which refers to the discarding or alternative (non-food) use of food that was fit for human consumption – by choice or after the food has been left to spoil or expire as a result of

negligence. Since significant resources are required for food production, processing, transportation, storage, retailing and preparation, food wastage is a waste of valuable resources with obvious economic, environmental and moral implications [2]. The wastage of food occurs at all stages of the food life cycle, starting from harvesting, through processing and distribution restaurants and food services and finally consumption, but the largest contribution to food waste in developed countries occur at home [3] and shall be measured separately for each stage once every four years [4]. Indeed, household food waste is around 30% of total food waste [5]. Having in mind the importance of this issue, previous studies

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have been focusing on consumers' behaviour, awareness and attitudes toward food waste as well as the causes of food waste in many countries such as Albania [6], Morocco [7], Egypt [8], Italy and Germany [9,10], Finland [11], Denmark [12], Holland [13], USA [14], Canada [15,16], UK [17], Turkey [18], Tunisia [19], Algeria [20], Greece [21], Serbia [22], Bosnia and Herzegovina [23], Montenegro [24] and North Macedonia [25]. All these studies used different methodologies to estimate food waste. Although self-administrated questionnaires are less accurate in comparison to large-scale surveys using diaries, Waste Composition Analysis (WCA) and combined methods [26–28], they can be a good starting point for further more reliable surveys.

The Coronavirus Disease 2019 (COVID-19), a respiratory illness caused by a virus first identified at the end of 2019 in Wuhan (China) [29], has become in a short time one of the most pressing challenges facing humanity [30]. The virus is now present worldwide, North Macedonia included. In fact, the recent statistics of the World Health Organisation (WHO) – dating back to August 7, 2020 – show that there are 11,399 confirmed cases of COVID-19 in North Macedonia and the country suffered so far 517 deaths [31]. In this context, North Macedonia ranked 35th worldwide in terms of the number of confirmed cases (cf. 10,503 cases in total or 506 cases per 100,000 inhabitants) and 26th in terms of the number of active cases (4096 in total or 197.4 cases per 100,000 inhabitants) as of 30 July. The presidency and the government of North Macedonia took many measures to contain the spread of the virus. On 18 March, the presidency declared the state of emergency. In response to the declaration of the global COVID-19 pandemic by WHO, the government imposed a curfew on 23 March and introduced a nationwide travel ban for all citizens on 8 April. At the beginning of the coronavirus outbreak, the government closed all educational institutions (schools, universities), cultural premises, restaurants as well as 'non-essential' stores; only supermarkets, food stores and pharmacies remained open. Meanwhile, the wearing of facemasks is mandatory in the public space. From 8 May, the government began a gradual, cautious process for opening up the economy. However, preparation is underway for a possible second wave of COVID-19 in the autumn [32].

The COVID-19 pandemic is expected to have dire effects on the socio-economic development of societies and people's livelihoods across the world [30]. The far-reaching disruptive effects of the COVID-19 pandemic also regard food systems and global food security [33–38]. Although very limited, recent papers show that the COVID-19 pandemic induced changes in food-related behaviours [34] including food wastage [39,40]. Indeed, the COVID-19 pandemic may have implications over the short and long term for food loss and waste. Supply chain losses may increase in the short term because of logistical bottlenecks and a contraction in the demand for perishables that are often consumed away from home (cf. Restaurants, catering services). Consumer waste may be increased by hoarding and panic buying, although most of these purchases have been for longer life items, such as flour and pasta [41]. OECD [41] indicates that over the longer term, the food sector may identify better ways to manage inventories, and consumers may also reassess their shopping and consumption habits, with a view to reducing waste. Coming up with previous studies focused on consumer awareness, attitudes and behaviours related to food wastage during COVID-19 lockdown [39] and modified eating habits and lifestyle changes during COVID-19 [42,43], this paper aims at exploring changes in consumers' food-related behaviours and attitude towards food waste at households in North Macedonia during the COVID-19 pandemic.

2. Material and methods

The present paper is based on the results of a voluntary survey conducted in North Macedonia from the 15th of May until the June 30, 2020. An online self-administered questionnaire used in previous studies on FW by Bogevska et al. [25], has been slightly modified by adding several questions connected to consumers' behaviour during the COVID-19 pandemic. A similar questionnaire was used by Jribi et al.

[39] to analyse the impacts of the COVID-19 outbreak on household food wastage in Tunisia. All participants were fully informed about the study objective and gave their informed consent for data sharing and privacy policy.

Participation was entirely on a voluntary basis and responses were analysed only in aggregate.

The questionnaire was composed of 30 questions and conducted in a local language (Macedonian). It included a combination of one-option and multiple-choice questions. The questionnaire was developed into an introductory part and seven sections:

- **Introductory part:** The concept of food losses and waste (FLW) was introduced to inform the respondents, and the objective and the context of the survey were stated;
- **Section 1 - Food purchase behaviour:** Respondents were asked about shopping habits and frequency, and food expenditure estimation;
- **Section 2 - Knowledge of food labelling information:** Respondents were asked whether they were familiar with the "use by" and "best before" food labels;
- **Section 3 - Attitudes towards food waste:** Respondents' awareness of food waste and frequency of throwing consumable food as well as handling of food waste in their households were analysed in this questionnaire section;
- **Section 4 - Extent of household food waste:** Respondents were asked about the quantity and food groups that were thrown away;
- **Section 5 - Economic value of household food waste:** Respondents were asked to estimate the value of food that they throw away;
- **Section 6 - Willingness and information needs to reduce food waste:** Respondents' behaviour, willingness and information needs towards reducing food waste were addressed in this questionnaire section;
- **Section 7 - Food purchase and wastage behaviours during the COVID-19 pandemic:** The last section included a comparison of COVID-19 and pre-COVID situations.

Various communication channels and networks were used for the dissemination of the questionnaire, such as social media (Facebook, Viber, WhatsApp) and mailing lists.

The data, collected through the Survey-Monkey platform (www.surveymonkey.com), was downloaded into the Statistical Package for Social Sciences (SPSS) version 25.0 for analysis. Means, standard deviation, frequencies, and percentages were calculated for descriptive data. Wherever respondents were allowed to have more than one answer, multiple response analysis was run and percent of responses and percent of cases were drawn from it. Due to the measurement scale of variables, which were nominal and ordinal, non-parametric tests were applied. In this regard, the chi-square test was applied to assess the association between variables. In addition, statistical significance was set a priori at a p -value of 0.05. In addition, to assess the link between socio-demographic variables with perceptions of food wastage as an output, Artificial neural network (ANN) was applied in the multivariate analysis part.

The artificial neural network is the preferred tool for many predictive data mining applications because of its power, flexibility and ease of use. ANN has been widely applied to examine the complex links between input and output variables. In recent years, ANN has become a very powerful and practical method to model complex nonlinear systems. This model is used for prediction and classification in situations where classic statistical models have restricted application when some or all of their assumptions are not met. Neural networks in predictive applications, such as the multilayer perceptron (MLP) and radial basis function (RBF) networks, are supervised in the sense that the model-predicted results can be compared against known values of the target variables. A typical ANN consists of three layers, i.e., input, hidden, and output layers [44]. In this study, we employed perception of food wastage (without food wastage = 0, with food wastage = 1) as output (dependent variable) in data mining known as artificial neural networks multilayer

perceptron to quantify the relationships between predictors and variable criterion. Also, an MLP was utilized to evaluate the relative importance of the predictor variables (gender, age, level of education, occupation, household composition, food shopping frequency, estimation for household food expenditure, using a shopping list, age and family members).

The study has limitations due to the methods used in representing the phenomenon from qualitative and quantitative points of view. The major limitation of this study is the non-probabilistic sampling design used in the cross-sectional survey, which has implications in terms of the representativeness of the sample with regard to the adult population in North Macedonia. This limitation relates to the self-administration of the questionnaire as well as the tool used (i.e. online). The first aspect is that self-administrated questionnaires, such as the one used in the present survey, are run on unpaid volunteers, who are mainly motivated to take part in the survey by their interest in the topic of food wastage and its reduction. This might induce the problem of a self-selected, biased sample. The second limitation of the study is that it is based on an online questionnaire. This might imply that only web-literate, generally young and well-educated people, take part in the survey, which might explain the under-representation of old people and those living in rural, remote areas, who do not have good, affordable access to internet services. A further limitation relates to the use of the survey instrument for the collection of data on household food waste. Indeed, it is widely admitted that household food waste surveys are methodologically simple, but mainly useful to provide qualitative information, because quantification of food waste is prone to error as respondents/consumers often tend to underestimate their waste/food waste (and, consequently, also the value of the wasted food) when self-reporting (e.g. Refs. [14,45–49]). Indeed, the respondents' answers reflect their personal beliefs, predictions and approximate valuation of food waste. Although the amount of household food waste by self-assessment methods considerably underestimates the actual amount [46,49], it can distinguish respondents' awareness and attitudes toward food waste.

Table 1 presents the profile of the respondents. The sample does not represent the entire population of the country. The number of valid answers was 754. The sample was not gender-balanced (76.39% female and 23.61% male), which is quite normal as women are responsible for cooking and food management in North Macedonian households. Furthermore, most of the respondents (42.84%) were aged from 35 to 44 years. More than a half of the respondents (58.62%) have a high educational level and 82.23% of the respondents are in paid work. Regarding family status, most of the respondents are married with children (57.16%) followed by those who live with their parents (21.22%). In this survey, 4 person-households have the highest share (37.40%).

It should be noted that there are differences between our sample and the Macedonian average population. The share of women and men in the total North Macedonian population is almost equal; 49.9% of the population are women and 50.1% are men [50]. The difference with our sample is not only obvious but also normal as women are more involved in food management in households. Most of the respondents in our sample live in cities, which are more densely inhabited. For example, Skopje region is the most densely populated area of the country with 338 inhabitants/km², and where almost a third (29.7%) of the population of North Macedonia lives [50]. Regarding the age structure, the Republic of North Macedonia is in a relatively favorable situation for the able-bodied population (from 15 to 64 years) whose share of about 70% is predominantly in relation to the other two age groups (0–14 and > 65) [50]. In this context, our sample reflects the age structure of the average population except for the elderly people whose share is about 12.4%. The small share of elderly people can be attributed to a lack of IT skills. Regarding the level of education, our sample is not representing the average population but confirms that educated people are more computer-literate and have better access to internet services. According to the data of the State Statistical Office, in the third quarter of 2020, the

Table 1
Respondents' profile.

Variable (n = 754)	Item	Percentage
Gender	Female	76.39
	Male	23.61
Age (years)	18–25	8.89
	25–35	22.68
	35–45	42.84
	45–55	17.64
	55 and over	7.96
Level of education	No formal schooling	0.40
	Primary school	0.13
	Secondary school	15.38
	Technical qualification	1.33
	University degree (bachelor)	58.62
	Higher degree (MSc or PhD)	24.14
Occupation	In paid work (full-time or part-time)	82.23
	Student	7.03
	Unemployed and looking for work	5.57
	Home duties	1.86
	Retired/Age pensioner	3.32
Household composition	Single person household	5.44
	Living with parents	21.22
	Partnered	10.74
	Married with children	57.16
	Shared household, non-related	1.99
	Other	3.45
Family members	1 Person	3.85
	2 Persons	17.64
	3 Persons	25.73
	4 Persons	37.40
	5 Persons or more	15.19

active population in the Republic of Northern Macedonia was 941,136 persons, of whom 785,561 (83%) were employed and 155,575 (16%) unemployed [51]. Our sample is representing the national quota of employed people but not that of students and unemployed and retired people.

The respondents' answers are according to their beliefs, predictions and approximate valuation of food waste.

3. Results and discussion

3.1. Food purchase behaviour during COVID-19 pandemic

The online survey showed that more than two-thirds of the respondents (76.13%) buy food products in supermarkets followed by those who buy their food in small markets (14.19%) (Table 2). The wide range of available food products at the same location would be also a positive feature that persuades consumers to choose these shopping locations. Besides, this high percentage might also be because supermarkets are considered 'critical services' and were kept open even during the lockdown. Around 8.09% of the respondents buy their products at the market while only 1.59% of the respondents buy directly from farms. These findings on grocery shopping are in line with those obtained by Jribi et al. [39] during the lockdown in Tunisia; they found that 64.3% of the respondents buy their foods from supermarkets, whereas 29.0% buy their foods from small retailers, 2.1% from hard discount stores and only 2.5% from traditional local markets ("souks"). In Italy, Di Renzo et al. [43] found that during COVID-19 lockdown, most of the population purchased food at the supermarket (75.8%), 26.0% at the grocery shops, 14.8% at farms, organic or local markets or using Solidarity Purchasing Groups, and only 9.0% used online delivery. The results of Chi-square analysis showed that the location of buying food is associated with the level of education ($p < 0.01$), so respondents with higher

Table 2
Food purchase behaviour (n = 754).

Variables	All (%)	Gender	Age	Education	Occupation	Family member
Where generally do you buy food?		2.37	8.39	198.24**	26.35*	7.59
Hypermarket/supermarket	76.13					
Mini market/small market	14.19					
At the market	8.09					
Directly from producers/farmers	1.59					
How often you do food shopping?		4.12	18.53	66.09	20.40	53.82**
Every day	21.00					
Once every 2 days	21.90					
Twice a week	33.20					
Once a week	19.60					
Every 2 weeks	3.70					
Once a month	0.70					
How much would you estimate your household food expenditure each month?		3.70	86.07**	28.43	58.42**	90.67**
Up to 50 euros	1.33					
50–100 euros	8.62					
100–150 euros	26.53					
150–300 euros	41.25					
More than 300 euros	22.28					
When buying food, do you use a list?		2.81	10.32	19.97*	14.69	29.83**
Yes	47.35					
No	12.33					
Sometimes	40.32					
Do you feel attracted to the special offers when you buy food?		33.57**	21.64**	15.67	15.28	11.15
Yes	43.77					
No	9.68					
Sometimes	46.55					

** $p < 0.01$, * $p < 0.05$.

education had more tendency to shop from hypermarkets/supermarkets, and occupation ($p < 0.05$) of the respondents. All groups of occupation had a willingness to buy food from hypermarkets/supermarkets.

One-third of the respondents (33.20%) buy their products twice a week, followed by those who buy once every 2 days (21.90), every day (21.0%) and once a week (19.60%). It is obvious that big supermarkets influence the frequency of buying the food, which is relatively rarely twice a week. Also in Tunisia, this trend is obvious as food shopping was performed once a week by 39.8% of respondents, two or three times a week by 31%, daily by 15% [39]. The frequency of shopping is highly associated with family structure ($p < 0.01$); families with more than two members prefer to have shopping twice a week.

Regarding expenses on food each month or food budget, most North Macedonian households spend 150–300 euro per month (41.25%), which is relatively high, followed by those who spend 100–150 euro per month (26.53%). It should not be neglected that 22.28% of the respondents spend more than 300 euros per month. In comparison to Tunisians, most of the respondents (36%) affirmed to spend monthly on food between US\$ 100 and 175, 32% over US\$ 175, 27% between US\$ 35 and 100 and 5% less than US\$ 35 [39]. Household food expenditure is significantly dependent on age, occupation and family members ($p < 0.01$). The highest amount of expenses on food was for level 150–300 euros per month and age groups of 35–44 and 45–54 had the highest level of expenditure.

Pre-shop planning and the use of shopping lists represent good practices for minimising food waste [52]. The survey results show that the shopping list is always used by most interviewees (47.35%); 40.32% of the respondents sometimes use a list while 12.33% never use it. Our findings are better than those of Jribi et al. [39] where 42% of respondents declared to use a shopping list in Tunisia. A much higher percentage of using the shopping list was found in Karlsruhe (Germany) as well as in Ispra (Italy) where about 70% of households use a shopping list [53]. Using a shopping list is dependent on education ($p < 0.05$) and family members ($p < 0.01$). Respondents in age group of 45–54 were more eager to have a shopping list during their shopping.

Supermarkets are shopping spots where special offers are available to customers. In this survey, 46.55% of the respondents declared that they are sometimes attracted while 43.77% said they are attracted by special offers. The influence of these offers would have sometimes a great impact to purchase a big quantity of food, which may lead to higher wastage. In Greece, the majority of the respondents organise their shopping through checking cupboards, making shopping lists and planning meals [2]. In Italy, almost all the respondents plan their purchases by preparing a shopping list (92%), and buy foodstuffs mainly when special offers are available (99%) [54]. Attraction to special offers in this survey is significantly dependent on gender ($p < 0.01$) and age ($p < 0.01$). Women are more attracted by special offers as well as those aged 35–44.

3.2. Knowledge of food labelling information

Concerning the “use by” food label, 56.63% of the respondents seem to understand and have good knowledge about the meaning of this label as they think that food should be consumed or discarded by this date (Table 3). Some of them (35.94%) consider that the food is still safe to eat after that date if it is not damaged or spoiled while 7.43% think, erroneously, that food must be sold at a discount after this date. In the case of the “best before” label, more than two-thirds of the respondents (75.46%) mix up this label with “use by”, as they think that food should be discarded after this date. Only around 18.44% of answers showed a good understanding of this label meaning, which is, anyway, relatively high in comparison to previous research (9.0%) [25]. Similar to Algeria, a very high percentage (70%) of the respondents still have confusion with the “best before” date label as they consider that food must be consumed before or discarded after that date [20]. Understanding of “use by” and “best before” food labels is highly associated with age ($p < 0.01$), which indicates that respondents aged 35–44 are more familiar with the meaning of these labels.

Table 3
Knowledge of food labelling information (n = 754).

Variables	All (%)	Gender	Age	Education	Occupation	Family member
In regard to food labels, which of the following do you think best describes what is meant by the “use by” date?		0.53	34.94**	18.12	25.18**	21.11*
Foods must be eaten or thrown away by this date	56.63					
Foods are still safe to eat after this date as long as they are not damaged, deteriorated or perished	35.94					
Foods must be sold at a discount after this date	7.43					
In regard to food labels, which of the following do you think best describes what is meant by the “best before” date?		0.55	21.56**	5.78	10.96	13.49
Foods must be eaten or thrown away by this date	75.46					
Foods are still safe to eat after this date as long as they are not damaged, deteriorated or perished	18.44					
Foods must be sold at a discount after this date	6.10					

** $p < 0.01$, * $p < 0.05$.

3.3. Attitudes towards food waste

A very high percentage of the respondents (94.16%) expressed a high awareness of FW. They worry about this issue and try to avoid wasting food as much as possible (Table 4). This could be because the North Macedonian culture, customs and traditions make the act of throwing

food something outrageous. However, also the COVID-19 emergency might have contributed to this high awareness about the importance of food and, consequently, how vital is not to waste it. Meanwhile, about 4.51% of the respondents are aware of the problems associated with FW, but they do not think they will change their behaviour in the near future; and a very low percentage (0.67%) did not consider that food waste is a

Table 4
Attitudes towards food waste (n = 754).

Variables	All (%)	Gender	Age	Education	Occupation	Family member
Which of the following descriptions represents you better?		6.72	21.07	11.61	17.43	27.33
I worry about food waste and I try to avoid it whenever I can	94.16					
I am aware of the problems associated with food waste but I do not think I will change my behaviour in the near future	4.51					
I was interested in the issue of food waste in the past, but now I do not care	0.66					
I do not consider food waste as a crucial problem	0.67					
In general, how much uneaten food your household usually throws away?		6.89	63.04**	35.36*	15.69	20.82
Much more than it should	1.99					
More than it should	7.03					
A reasonable amount	21.62					
Very little	41.38					
Almost nothing	27.98					
How often do you throw away leftovers or food that you consider not good?		0.78	25.43*	20.36	23.34*	21.65
Never	12.47					
Less than one time a week	58.49					
From 1 to 2 times a week	22.94					
More than twice a week	6.10					
How many times does your household cook a main meal from raw main ingredients?		7.54	17.69	26.56	25.11	47.03**
Never	1.70					
Less than twice a week	11.60					
Three to six times a week	61.00					
Seven to ten times a week	19.40					
More than ten times a week	6.30					
How many times does your household eat a meal left over from a previous day?		9.36	29.93*	121.74**	45.53**	20.73
Never	14.37					
Less than twice a week	68.73					
Three to six times a week	15.49					
Seven to ten times a week	0.99					
More than ten times a week	0.42					
How many times does your household eat out or eat a takeaway (as a main meal)?		7.38	34.23**	35.24**	19.48	28.62*
Never	34.47					
Less than twice a week	58.40					
Three to six times a week	5.98					
Seven to ten times a week	0.57					
More than ten times a week	0.57					
How many times does your household eat store-purchased readymade meals e.g. frozen dinners?		3.89	33.90**	184.22**	16.97	33.79*
Never	58.40					
Less than twice a week	36.18					
Three to six times a week	4.56					
Seven to ten times a week	0.28					
More than ten times a week	0.57					

** $p < 0.01$, * $p < 0.05$.

crucial problem nowadays and they do not care about wastage issue. Also Jribi et al. [39] showed that during the COVID-19 outbreak a large majority (91.9%) of Tunisian respondents affirmed that they worry about FW and try to avoid it when they can.

Regarding how much food is wasted, 41.38% of the respondents declared that the amount of FW is quite low while 27.98% do not throw almost anything. Meanwhile, 21.62% of the respondents think that they throw away a reasonable amount of food and 7.03% that they throw more than they should, while the lowest percentage (1.99%) of the respondents affirmed that they waste food much more than it should. In Tunisia, about 58% of the respondents declared that they usually discard low percentages of food they purchased, 29.7% claimed that they did not discard any food, and 8.2% reported they discarded a reasonable amount of purchased food while only 3.9% affirmed they discarded too much food [39]. The results of Chi-square analysis showed that wastage of food is associated with age ($p < 0.01$) and level of education ($p < 0.05$) of the respondents. Highly educated respondents are more aware of food wastage issue.

About handling uneaten food, more than a half of the respondents (51.20%) declared feeding it to animals while 37.70% of respondents answered that they throw it away in the garbage bin. Very few of them (3.20% and 2.70%) do compost or give uneaten food as a donation, respectively. Jribi et al. [39] found that only 10% of the respondents declared to discard uneaten food, which is much lower in comparison to our findings. Meanwhile, in Hungary, 62.83% of the total food waste was disposed of to the trash, 18.45% was used for animal feeding and 18.72% for composting [55]. Differences might be due to different factors such as cultures, tradition, customs and income/purchasing power.

Regarding the frequency of throwing away leftovers or food considered as not good, the results showed that only 12.47% of the respondents say not to throw leftovers in comparison with 58.49% of them who declared throwing leftovers less than one time a week (Table 4). The frequency of throwing leftovers is significant at level $p < 0.05$ by age and occupation.

As regard activities of the respondents that affect the households' food waste, about 60.10% of the respondents declare to cook 3–6 times a week a main meal from raw main ingredients, and 68.73% eat a meal left over from a previous day. Similar results were obtained in Montenegro [24] and Greece [21]. More than a half of the North Macedonian respondents (58.40%) eat out or eat a takeaway (as a main meal) and eat store-purchased readymade meals (e.g. frozen dinners), which is a result of the very dynamic way of living nowadays and dependent at a level $p < 0.01$ by age and education showing that relatively younger and highly educated respondents are more prone to eating out or ready to eat meals. Interestingly, it seems that these habits have not been affected by the COVID-19 pandemic.

The results of the study showed that the main reasons for throwing food at the household level were that the food was not edible as a result of the expiration date (44.40%), which is a consequence of bad food management at home especially during COVID-19 when a surplus of food is bought by some households and left uneaten. Almost the same percentage, 35.90% and 35.50%, of the respondents answered that food has mould and the food was left in the fridge for a long time, respectively. About 32.1% of them throw leftovers. Jribi et al. [39] revealed that the reasons for discarding food in Tunisian households were overcooking (35%) and too long storage in the refrigerator (30%) while in Finland [56] the main reasons for disposing of food were spoilage [e.g. mould (29%), past "best before or use by" date (19%)], leftovers from dining (14%), and preparing food over needs (13%). In Canada, the most common reasons for waste were the appearance of food, followed by its smell and expiration of best before date [15].

The case-processing summary (Table 5) depicts the number of cases included and excluded in the analysis, in total and by training and holdout samples. It is based on randomly assigning cases based on the relative number of cases. In the results for the independent variables,

Table 5
Case-processing summary to classification.

Sample	Observed	Predicted		
		No wastage	Wastage	Percent Correct
Training	No wastage	225	52	81.2
	Wastage	62	197	76.1
	Overall Percent	53.5%	46.5%	78.7
Holdout	No wastage	75	43	63.6
	Wastage	58	42	42.0
	Overall Percent	61.0%	39.0%	53.7

Dependent variable: Food wastage.

case processing summary showed that 536 samples and 218 samples were in two groups of training samples and testing samples, respectively (Table 5) and based on the entered independent variables into analysis, 78.7% of perception of food wastage could be explained by these variables (Table 6). The importance of the independent variables defines the point showing how much of the amounts predicted by the network will change with variation of the independent variable values. Normalizing this importance is a simple procedure achieved by dividing the importance value by its larger value and expressed as a percentage [57]. It seems that the variables occupation, family members, and estimation for household food expenditure respectively had the greatest impact on the system classifying the subjects (Table 6).

3.4. Extent of household food waste during COVID-19 pandemic

Regarding how much food is thrown per week, 52.39% of the respondents declare not to throw away food that is still consumable; about 22.55% of them think to throw less than 250 g followed by those who declare to throw between 250 and 500 g (18.04%) (Table 7). Similar results were obtained in Egypt [8] and Montenegro [24]. On contrary, when direct measurement of food waste is done, the quantity of food waste is much higher. In Ontario (Canada), on average households disposed of 2.40 kg/week [16]. The results of Chi-square analysis showed that throwing of edible food is associated with gender ($p < 0.05$) and family members ($p < 0.05$). Females and households with 3–4 members are more aware of throwing still consumable food. Similarly, Koivupuro et al. [11] declared that in Finnish households the amount of food wasted is associated with the size of the households and the gender while in Danish households the food waste mass is significantly influenced by households size [12]. In the USA, the estimation of average household food waste was significantly associated with gender, household income quintile and education [14].

The survey results showed that most households declare to throw less than 2% of purchased food. The most wasted food groups are cereals and bakery products, fruit, vegetables, and milk and dairy products (Table 8). Meanwhile, meat and meat products and fish and seafood are the least wasted food products. This might be due to the higher prices of meat and seafood, which implies that people buy low quantities and pay more attention to them through proper handling and storage at home.

Table 6
Importance of predictor variables in predicting the perception of food wastage.

	Importance	Normalized importance
Gender	0.038	23.1
Level of education	0.136	83.2
Occupation	0.163	100.0
Household composition	0.086	52.9
Food shopping frequency	0.104	63.8
Estimation for household food expenditure	0.145	88.9
Using a shopping list	0.079	48.2
Age	0.091	56.0
Family members	0.157	96.4

Table 7
Extent of household food waste (n = 754).

Variables	All (%)	Gender	Age	Education	Occupation	Family member
Approximately, how much of still consumable food your household throws away in a week?		12.60*	25.81	21.90	17.42	38.14*
I do not throw away food that is still consumable	52.39					
Less than 250 gr	22.55					
Between 250 and 500 gr	18.04					
Between 500 gr and 1 kg	5.31					
Between 1 kg and 2 kg	1.06					
More than 2 kg	0.66					

**p < 0.01, *p < 0.05.

Table 8
Percentage of the purchased commodity groups that household throws away.

	Less than 2%	3–5%	6–10%	11–20%	Over 20%
Cereals and bakery products (bread, rice, pasta, etc.)	71.53	14.45	9.00	1.77	3.24
Roots and tubers (potatoes, etc.)	71.23	18.07	6.02	3.16	1.51
Pulses and oil seeds (e.g. peas, chickpeas, olives, sunflowers)	80.85	13.03	4.40	0.78	0.94
Fruits	62.46	21.70	10.12	3.37	2.35
Vegetables	60.15	25.15	9.55	3.33	1.82
Meat and meat products	75.55	16.51	5.92	1.25	0.78
Fish and seafood	86.91	9.21	2.42	0.65	0.81
Milk and dairy products	70.79	17.77	7.57	2.16	1.70

Similar results on discarded food groups were obtained in the Netherlands [13], Finland [56], Morocco [7], Egypt [8], Turkey [18], Algeria [20], as well as in Italy [58,59], Hungary [55] and Tunisia [19, 39].

3.5. Economic value of household food waste

Most of the respondents (53.18%) declare that they spend less than 5 EUR on food wasted while 42.04% of them say to spend between 5 and 25 EUR (Table 9). In Montenegro, about 52.80% of the respondents answered that the value of wasted food was between 5 and 25 EUR per month [24]. In Italy, during the economic crisis, the majority (60.50%) of the respondents indicated that they spend less than 5 EUR while only 5% of waste was thought to exceed € 21 per week [58]. The economic value of household food waste is significantly associated with age (p < 0.01) and occupation (p < 0.05). Respondents aged from 25 to 54 as well as in paid work respondents have higher economic values of household food waste. Interestingly, family size did not affect significantly the economic value of food wastage, which might imply that it is rather a question of management than the quantity of food that is purchased and handled (that is generally positively correlated with the number of family members).

3.6. Willingness and information needs to reduce food waste

Respondents believe that they would be more aware and responsible to avoid wasting food if they had more information on the negative

Table 9
Economic value of household food waste (n = 754).

Variables	All (%)	Gender	Age	Education	Occupation	Family member
Please indicate the economic value of food waste generated each month by your household		6.07	33.49**	10.81	24.36*	15.66
Less than 5 euros	53.18					
Between 5 and 25 euros	42.04					
Between 25 and 50 euros	3.85					
More than 50 euros	0.93					

**p < 0.01, *p < 0.05

impacts of food waste on the environment (38.10%), suitable packaging of food (35.10%) and if they would pay higher taxes on the basis of what is thrown away (21.60%). In addition, most of the respondents (42.70%) are willing to get more information about the tips on how to conserve food properly followed by those (39.30%) who want to get information for organizations and initiatives that deal with food waste prevention and reduction (e.g. food banks). About a third of the respondents (33.40%) would like to be informed about the freshness of products and 27.10% of them to get information for recipes with leftovers. In Tunisia, respondents want to be better informed about the negative impacts of food waste on the environment (24.00%) and the economy (10.00%). Also, 16.00% of the respondents stated that they would reduce food wastage if they had to pay taxes on generated food waste. Tunisian respondents also expressed concerns about the packaging, specifically for the size (18%) and clear labels (7%) [39]. van Geffen et al. [60] argue that people will implement a goal to lower waste levels more easily when they simultaneously can act upon other valued goals and without spending too many resources (e.g. turning leftovers into tasty new meals in a short amount of time).

3.7. Food purchase and wastage behaviours: comparison of COVID-19 and pre-COVID situations

About shopping behaviours during COVID-19 (Table 10), most of the respondents (48.28%) go shopping like they used to, followed by those (45.76%) who rarely go shopping. Only 5.97% buy food online. Therefore, it might be argued that the COVID-19 pandemic changed the shopping behaviours and habits of about a half of the sample. Interestingly, more people are buying food online, which was not the case in North Macedonia before the COVID-19 emergency.

About changes in the extent of daily purchase during COVID-19, more than a half of the respondents (51.99%) answered that they buy food as they used to while 32.10% of the respondents buy more than usual, this might be due to some panic buying and food stockpiling behaviours and/or that people for concerns about the virus contagion prefer to go out of home and to go shopping as less as possible. The results of Chi-square analysis showed that shopping behaviours and extension of daily purchase during COVID-19 are highly associated with the level of education (p < 0.01), so respondents with higher education are more prone to conscious behaviour during COVID-19.

Concerning the most purchased types of food during COVID-19, which had multiple answers, answers were: vegetables (72.30%), fruits (68.60%), milk and dairy products (57.40%), cereals and bakery products (57.00%) and meat and meat products (49.90%).

Table 10

Food purchase and wastage behaviours in North Macedonia during the COVID-19 emergency and in the pre-COVID situation (n = 754).

Variables	All (%)	Gender	Age	Education	Occupation	Family member
What has changed in your shopping behaviour during COVID-19?		2.94	13.32	23.88**	14.36	13.91
I buy online	5.97					
I rarely go shopping	45.76					
I'm going shopping like I used to	48.28					
What has changed in the extent of your daily purchase during the COVID-19?		3.89	27.21*	51.40**	37.80**	25.19
I buy a lot less than usual	1.72					
I buy less than usual	4.77					
I buy as same as usual	51.99					
I buy more than usual	32.10					
I buy a lot more than usual	9.42					
How has your food wastage changed during the COVID-19?		4.07	26.50*	14.94	27.49*	47.67**
It has become much less	1.10					
It has become less	4.10					
It has not changed	57.20					
It has become more	34.70					
It has become much more	2.90					

** $p < 0.01$, * $p < 0.05$.

Regarding the changes in food wastage during the COVID-19, 57.20% of the respondents answered that there are no changes in wastage of food while 34.70% of them answered that they throw more, which can be attributed to that they spent more time at home or working from home as this is associated to the occupation of the respondents ($p < 0.05$).

4. Conclusions

The present cross-sectional survey suggests that the COVID-19 pandemic affected perceptions about food purchase, consumption and wastage in North Macedonia. Shopping behaviour during the COVID-19 crisis has changed dramatically when it comes to buying food. Under normal circumstances, before the outbreak of the pandemic, North Macedonian consumers bought reasonable food quantities as needed for two or three days. During the COVID-19 pandemic, consumers bought larger quantities of food in supermarkets, but purchases were less frequent. The most purchased groups of food during the COVID-19 outbreak are vegetables and fruits, which is obvious bearing in mind the big health concerns during the pandemic. Before the crisis, food waste management at the household level showed that care was not taken about unused food and the percentage of food thrown away. Awareness individually and at the household level changed during the pandemic. Namely, the percentage of unused and discarded food is much lower, and this is due not only to restricted family budget (due, among others, to the economic effects of the pandemic), but also to the more developed food awareness. Food loss and waste is a large and complex problem that has dual relationships with national and corporate policies, natural resources, climate change, economies and markets, human behaviour and culture, social conditions, technology, infrastructure and investment. In order to solve this problem, there is a need for further more precise surveys (waste composition analysis or a diary study). This will help to develop a national strategy for food waste and loss reduction tailored to the specific needs of the country and harmonized with the relevant national legislation.

Author statement

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References

- [1] Global FAO. Initiative on food loss and waste reduction. 2015. 2015, <http://www.fao.org/3/a-i4068e.pdf>. [Accessed 15 July 2020].
- [2] Abeliotis K, Lasaridi K, Chroni C. Attitudes and behaviour of Greek households regarding food waste prevention. *Waste Manag Res* 2014;32:237–40. <https://doi.org/10.1177/0734242X14521681>.
- [3] Gustavsson J, Cederburg C, Sonesson U, van Otterdijk RMA. Global food losses and food waste: extent, causes and prevention. 2011. <http://www.fao.org/docrep/014/mb060e/mb060e00.pdf>.
- [4] European Commission. Commission delegated decision (EU) 2019/1597 of 3 may 2019 supplementing directive 2008/98/EC of the European parliament and of the council as regards a common methodology and minimum quality requirements for the uniform measurement of levels of food waste. *Off J Eur Union* 2019;248:77–85.
- [5] Stenmarck Å, Jensen C, Quested T, Moates G. Estimates of European food waste levels. Report FUSIONS EU project; 2016. ISBN 978-91-88319-01-2.
- [6] Preka R, Berjan S, Capone R, El Bilali H, Allahyari MS, Debs P, et al. Household food wastage in Albania: causes, extent and implications. *Futur Food J Food, Agric Soc* 2020;8:1–20. <https://doi.org/10.17170/kobra-202002281029>.
- [7] Abouabdillah A, Capone R, El Youssfi L, Debs P, Harraq A, El Bilali H, et al. Household food waste in Morocco: an exploratory survey. *VI Int Sci Agric Symp "Agrosym 2015 October, 2015;15–18. https://doi.org/10.7251/AGSY15051353A. Jahorina, Bosnia Herzegovina 2015:1353–60.*
- [8] Elmenofi AGG, Capone R, Waked S, Debs P, Bottalico F, El Bilali H. An exploratory survey on household food waste in Egypt. *B Abstr VI Int Sci Agric Symp "Agrosym 2015" October, 2015;15–18. https://doi.org/10.7251/AGSY15051298E. Jahorina, Bosnia Herzegovina 2015:533.*
- [9] Giordano C, Alboni F, Falasconi L. Quantities, determinants, and awareness of households' food waste in Italy: a comparison between diary and questionnaires quantities. *Sustain* 2019;11. <https://doi.org/10.3390/su10023381>.
- [10] Herzberg R, Schmidt TG, Schneider F. Characteristics and determinants of domestic food waste: a representative diary study across Germany. *Sustain* 2020; 12:1–17. <https://doi.org/10.3390/su12114702>.
- [11] Koivupuro HK, Hartikainen H, Silvennoinen K, Katajajuuri JM, Heikintalo N, Reinikainen A, Jalkanen L. Influence of socio-demographical, behavioural and attitudinal factors on the amount of avoidable food waste generated in Finnish households. *Int J Consum Stud* 2012;36:183–91.
- [12] Edjabou ME, Petersen C, Scheutz C, Astrup TF. Food waste from Danish households: generation and composition. *Waste Manag* 2016;52:256–68.
- [13] van Dooren C, Janmaat O, Snoek J, Schrijnen M. Measuring food waste in Dutch households: a synthesis of three studies. *Waste Manag* 2019;94:153–64.
- [14] Neff RA, Spiker ML, Truant PL. Wasted food: US consumers' reported awareness, attitudes, and behaviors. *PLoS One* 2015;10(6):e0127881. <https://doi.org/10.1371/journal.pone.0127881>.
- [15] Parizeau K, von Massow M, Martin R. Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario. *Waste Manag* 2015;35:207–17.
- [16] van der Werf P, Seabrook JA, Gilliland JA. The quantity of food waste in the garbage stream of southern Ontario, Canada households. *PLoS One* 2018;13.
- [17] Quested TE, Parry AD, Eastaer S, Swannell R. Food and drink waste from households in the UK. *Nutr Bull* 2011;36:460–7. <https://doi.org/10.1111/j.1467-3010.2011.01924.x>.
- [18] Yildirim H, Capone R, Karanlik A, Bottalico F, Debs P, El Bilali H. Food wastage in Turkey: an exploratory survey on household food waste. *J Food Nutr Res* 2016;4: 483–9. <https://doi.org/10.12691/jfnr-4-8-1>.

- [19] Sassi K, Capone R, Abid G, Debs P, El Bilali H, Bouacha OD, et al. Food wastage by Tunisian households, vol. 1; 2016. <https://doi.org/10.7251/agreng1601172s>. Agrofor.
- [20] Arous SA, Capone R, Debs P, Haddadi Y, El Bilali H, Bottalico F, et al. Exploring household food waste issue in Algeria. *Agro Sur* 2018;2. <https://doi.org/10.7251/agreng1701055a>.
- [21] Ponis ST, Papanikolaou PA, Katimertzoglou P, Ntalla AC, Xenos KI. Household food waste in Greece: a questionnaire survey. *J Clean Prod* 2017;149:1268–77. <https://doi.org/10.1016/j.jclepro.2017.02.165>.
- [22] Djekic I, Miloradovic Z, Djekic S, Tomasevic I. Household food waste in Serbia – attitudes, quantities and global warming potential. *J Clean Prod* 2019;229:44–52. <https://doi.org/10.1016/j.jclepro.2019.04.400>.
- [23] Vaško Z, Berjan S, El Bilali H, Allahyari MS, Ostojčić A, Bottalico F, et al. Attitude and behaviour of Bosnian households towards food waste. *Agric For* 2020;66:139–50. <https://doi.org/10.17707/AgricultForest.66.4.11>.
- [24] Berjan S, Mrdalj V, Bilali HEL, Velimirovic A, Blagojevic Z, Bottalico F, et al. Household food waste in Montenegro. *Ital J Food Sci* 2019;31:274–87.
- [25] Bogevska Z, Berjan S, Capone R, Debs P, Bilali HEL, Bottalico F, et al. Household food wastage in North Macedonia. *Agric For* 2020;66:125–35. <https://doi.org/10.17707/AgricultForest.66.2.12>.
- [26] Giordano C, Piras S, Boschini M, Falasconi L. Are questionnaires a reliable method to measure food waste? A pilot study on Italian households. *Br Food J* 2018;120:2885–97. <https://doi.org/10.1108/BFJ-02-2018-0081>.
- [27] Elimelech E, Ert E, Ayalon O. Exploring the drivers behind self-reported and measured food wastage. *Sustain* 2019;11:1–19. <https://doi.org/10.3390/su11205677>.
- [28] van der Werf P, Seabrook JA, Gilliland JA. Food for thought: comparing self-reported versus curbside measurements of household food wasting behavior and the predictive capacity of behavioral determinants. *Waste Manag* 2020;101:18–27.
- [29] WHO. Naming the coronavirus disease (COVID-19) and the virus that causes it. 2020 [Retrieved 26 April], [https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-\(covid-2019\)-and-the-virus-that-causes-it](https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it).
- [30] United Nation. Shared responsibility, global solidarity: responding to the socio-economic impacts of COVID-19. New York. 2020 [Retrieved 26 April], <https://unsdg.un.org/sites/default/files/2020-03/SG-Report-Socio-Economic-Impact-of-Covid19.pdf>.
- [31] WHO. WHO coronavirus disease (COVID-19) dashboard. 2020. <https://covid19.who.int/region/euro/country/mk>. 2020a. [Accessed 7 August 2020].
- [32] OECD. The COVID-19 crisis in North Macedonia. 2020. <https://www.oecd.org/south-east-europe/COVID-19-Crisis-in-North-Macedonia.pdf>. [Accessed 7 August 2020].
- [33] FAO. Coronavirus disease 2019 (COVID-19) - addressing the impacts of COVID-19 in food crises. Rome. Retrieved from, <http://www.fao.org/3/ca8497en/ca8497en.pdf>; 2020. 2020. [Retrieved 7 August 2020].
- [34] Galanakis CM. The food systems in the era of the coronavirus (COVID-19) pandemic crisis. *Foods* 2020;9:523. <https://doi.org/10.3390/foods9040523>.
- [35] HLPE. Interim issues paper on the impact of COVID-19 on food security and nutrition (FSN) by the high-level panel of experts on food security and nutrition (HLPE). Rome. 2020. Retrieved from, <https://agrifood.net/documents/covid-19/377-hlpe-impact-report-of-covid-19-on-food-security-and-nutrition/file> [Retrieved 26 April].
- [36] IPES Food. COVID-19 and the crisis in food systems: symptoms, causes, and potential solutions. 2020. Retrieved from, http://www.ipes-food.org/_img/upload/files/COVID-19_CommuniqueEN.pdf. 2020. [Accessed 7 August 2020].
- [37] One Planet Network. SFS programme statement on the COVID-19 (coronavirus) crisis and food systems. One planet network's sustainable food systems (SFS) programme. 2020. <https://www.oneplanetnetwork.org/sfs-programme-statement-covid-19-coronavirus-crisis-and-food-systems>. 2020. [Accessed 26 April 2020].
- [38] UNSCN. Food Environments in the COVID-19 Pandemic - impacts and positive policy actions to deliver sustainable healthy diets for all 2020. <https://www.unscn.org/en/news-events/recent-news?idnews=2040>. 2020. [Accessed 26 April 2020].
- [39] Jribi S, Ben Ismail H, Doggui D, Debbabi H. COVID-19 virus outbreak lockdown: what impacts on household food wastage? *Environ Dev Sustain* 2020;22:3939–55. <https://doi.org/10.1007/s10668-020-00740-y>.
- [40] Aldaco R, Hoehn D, Laso J, Margallo M, Ruiz-Salmón J, Cristobal J, et al. Food waste management during the COVID-19 outbreak: a holistic climate, economic and nutritional approach. *Sci Total Environ* 2020;742:140524. <https://doi.org/10.1016/j.scitotenv.2020.140524>.
- [41] OECD. COVID-19 and the food and agriculture sector: issues and policy responses. 2020. https://read.oecd-ilibrary.org/view/?ref=130_130816-9uut45lj4q&title=Covid-19-and-the-food-and-agriculture-sector-Issues-and-policy-responses. [Accessed 15 July 2020].
- [42] Scarmozzino F, Visioli F. Covid-19 and the subsequent lockdown modified dietary habits of almost half the population in an Italian sample. *Foods* 2020;9. <https://doi.org/10.3390/foods9050675>.
- [43] Di Renzo L, Gualtieri P, Pivari F, Soldati L, Attinà A, Cinelli G, et al. Eating habits and lifestyle changes during COVID-19 lockdown: an Italian survey. *J Transl Med* 2020;18:1–15. <https://doi.org/10.1186/s12967-020-02399-5>.
- [44] Sim JJ, Tan GWH, Wong JCJ, Ooi KB, Hew TS. Understanding and predicting the motivators of mobile music acceptance - a multi-stage MRA-artificial neural network approach. *Telematics Inf* 2014;31:569–84. <https://doi.org/10.1016/j.tele.2013.11.005>.
- [45] Beretta C, Stoessel F, Baier U, Hellweg S. Quantifying food losses and the potential for reduction in Switzerland. *Waste Manag* 2013;33:764–73. <https://doi.org/10.1016/j.wasman.2012.11.007>.
- [46] Elimelech E, Ert E, Ayalon O. Bridging the gap between self-assessments and measured household food waste: a hybrid valuation approach. *Waste Manag* 2019;95:259–70. <https://doi.org/10.1016/j.wasman.2019.06.015>.
- [47] Simunek J, Derflerova-Brazdova Z, Vitu K. Food wasting: a study among Central European four-member families. *Int Food Res J* 2015;22:2679–83.
- [48] Ventour L. The food we waste. *Food Waste Rep V2* 2008;2:1–237.
- [49] van Herpen E, van Geffen L, Nijenhuis-de Vries M, Holthuysen N, van der Lans I, Quedest T. A validated survey to measure household food waste. *Methods (Duluth)* 2019;6:2767–75. <https://doi.org/10.1016/j.mex.2019.10.029>.
- [50] Ministry of labor and social policy of the Republic Macedonia. Strategy for demographic policies of the Republic of Macedonia (2015-2024). 2015.
- [51] State Statistical Office. Active population in the republic of North Macedonia results from the labour force survey. III quarter 2020. https://www.stat.gov.mk/pdf/2020/2.1.20.34_mk.pdf; 2020.
- [52] Zainal D, Hassan KA. Factors influencing household food waste behaviour in Malaysia international journal of research in business, economics and management. *Int J Res Bus, Econ Manag* 2019;3:56–71.
- [53] Jörissen J, Priefer C, Bräutigam KR. Food waste generation at household level: results of a survey among employees of two European research centers in Italy and Germany. *Sustainability* 2015;7:2695–715. <https://doi.org/10.3390/su7032695>.
- [54] Setti M, Falasconi L, Segrè A, Cusano I, Vittuari M. Italian consumers' income and food waste behavior. *Br Food J* 2016;118:1731–46. <https://doi.org/10.1108/BFJ-11-2015-0427>.
- [55] Szabó-Bódi B, Kasza G, Szakos D. Assessment of household food waste in Hungary. *Br Food J* 2018. <https://doi.org/10.1108/BFJ-04-2017-0255>.
- [56] Silvennoinen K, Katajajuuri JM, Hartikainen H, Heikkilä L, Reinikainen A. Food waste volume and composition in Finnish households. *Br Food J* 2014;116:1058–68. <https://doi.org/10.1108/BFJ-12-2012-0311>.
- [57] Nadaf Fahmideh S, Allahyari MS, Damalas CA, Daghighi Masouleh Z, Ghazi M. Predicting adoption of double cropping in paddy fields of northern Iran: a comparison of statistical methods. *Paddy Water Environ* 2017;15:907–17. <https://doi.org/10.1007/s10333-017-0601-3>.
- [58] Fanelli RM, Florio A Di. Domestic food waste, gap in times of crisis. *Ital Rev Agric Econ* 2016;71:111–25. <https://doi.org/10.13128/REA-20075>.
- [59] Giordano C, Alboni F, Cicatiello C, Falasconi L. Do discounted food products end up in the bin? An investigation into the link between deal-prone shopping behaviour and quantities of household food waste. *Int J Consum Stud* 2019;43:199–209. <https://doi.org/10.1111/ijcs.12499>.
- [60] van Geffen L, van Herpen E, van Trijp H. Household food waste - how to avoid it? In: Närvänen E, Mesiranta N, Mattila M, Heikkinen A, editors. *Food waste manag. Basingstoke: Palgrave Macmillan*; 2020. <https://doi.org/10.1007/978-3-030-20561-4>.