

Beyond the Bin: Dissecting Factors and Barriers in Food Waste Sorting Among Czech Households

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Abstract

The study is based on primary questionnaire research, conducted using the CAWI method (N = 1332), and it determines the factors influencing the sorting of food waste (FW) in Czech households. By employing exploratory factor analysis, fourteen key areas were identified, including the availability of sorting options, handling of FW, and financial motivations. Although 86% of respondents expressed a willingness to sort FW, nearly half of them declared that they had no options how to sort it. Significant barriers remain with the lack of containers and the complexity of the FW sorting process. This study contributes to a better understanding of consumer behaviour in the field of waste sorting and provides insight into this issue for future policymaker decisions. The results show that after the introduction of the FW sorting system by policymakers, it is further important to ensure the availability of containers for sorting and to motivate households for this waste sorting, by both raising environmental awareness and providing financial motivations, and minimising the barriers associated with FW sorting.

Keywords: food waste sorting, sorting motivation, sorting barriers, consumer preferences, waste sorting factors

Introduction

Food waste comprises all food discarded from the food chain that is to be disposed of due to the actions of retailers, food service providers, and consumers¹. Predominantly found components of FW are fruits, vegetables, and bakery products, denoting avoidable FW, and other waste primarily of biological nature, often referred to as unavoidable FW³. In addition to raw food, thermally processed food in the form of prepared meals is also discarded⁴. Food waste is a subject of research interest primarily due to the environmental burden it creates, both during food production, where natural resources such as water and soil are consumed, and during its disposal, when landfilling or incineration have detrimental impacts on the environment⁵.

However, FW could be viewed as a resource, aligned with the principles of the circular economy, and reutilized, for instance, for energy production or in biogas production^{6, 7}. The concept of life cycle thinking is considered key to sustainable production and consumption patterns⁸. In order to use FW as a resource, separation from other types of waste would be required as well as its storage in a form that would facilitate its usage as a resource.

Existing research studies confirm that FW occurs in all links of the entire food chain^{9, 2}. Many studies conclude that consumers and households discard FW most frequently and in the greatest quantities, compared to other links in the food chain^{2, 10, 11}. Measurements from the Czech Republic show that on average, an individual discards 37.4 kg of FW into municipal solid waste (MSW) annually¹². Another study, which builds on this measurement, states that even though households produced less FW during the Covid-19 pandemic, households subjectively perceive that they discarded more FW⁴.

More FW produced by consumers is generated in urban areas (most notably in multi-apartment buildings and particularly in apartment buildings on housing estates) compared to rural areas, where there are options to feed food leftovers to animals or to start their own compost in the garden^{12, 13}. Owing to this, there occurs the possibility to utilize the potential of sorting the consumer FW at the place of its origin that implies households, and thus ensure the possibility to use the arising FW as a resource according to the principles of the circular economy.

If consumers are suitably motivated and informed about subsequent waste utilisation, they are willing to participate in the system of FW sorting⁷. Another study emphasises the crucial role of consumer motivation for sorting, as naturally, without special motivation and targeted communication, only half of consumers are willing to engage in waste sorting¹⁴. It is therefore necessary to motivate consumers to participate in the collection and sorting of FW as much as possible so that the sorting system is effective. Motivating consumers to sort waste requires a holistic approach¹⁰.

Consumer handling of FW is determined by their subjective attitudes and the setting of personal values¹⁵. This corresponds to another study, which confirmed that personal beliefs motivate the minimisation of FW production¹⁶. Encouraging the re-evaluation of personal values in the context of handling FW is appropriately highlighted by emphasising environmental values¹⁷. Awareness of how food is produced and processed appears to be another effective motivator. As individuals who are knowledgeable about the food production process, from crop cultivation, appreciate food more¹⁸. A strong motivator for sorting FW is also social pressure from society¹⁹.

Household FW should not be understood as a problem of individual consumer behaviour but as a behaviour of the entire household²⁰. To motivate consumers to sort, it is important to know the barriers that would prevent them or would prevent them in the case of the introduction of a FW collection system and to design a sorting system that would avoid these barriers, or at least minimise them. There are four fundamental barriers against consumer involvement in the FW sorting system: lack of awareness, space limitation, inadequate policy, and lack of time/priority¹⁰. Another study agrees with the consumers' lack of time as a significant barrier working against FW sorting²¹.

Policymakers' support is essential for initiatives involving the sorting of FW. In circumstances where FW collection has not yet been implemented in a particular area, it is desirable for policymakers to establish conditions that would be acceptable and suitable for consumers and ensure the highest possible degree of household engagement in the collection^{10, 22}. Policies and interventions regarding FW handling targeted at consumers should focus on social and income conditions²⁰. A well-designed waste sorting collection system, in accordance with consumer preferences, is decisive for its success and operation²³.

The aim of this paper is to identify the determining factors that influence the willingness of consumers to participate in the FW sorting system and to find connections between the influences of examined variables. An integral finding of this study is also the identification of barriers preventing consumers from sorting FW and, conversely, finding suitable consumer motivation for sorting FW.

Materials and methods

The research instrument employed to discern consumers' willingness and preferences regarding participation in FW sorting is a questionnaire survey. Primary data collection took place in the Czech Republic between September and December 2022 using the Computer-Assisted Web Interviewing (CAWI) method. The target group of respondents were consumers living in urban residential areas without a garden. This target group is seen as the one possessing the greatest potential for involvement in central FW collection. A representative sample (N = 1332) was obtained by applying quota sampling with seven quota characteristics (Table 1). The structure of the sample and basic set was verified according to the microeconomic data of EU-SILC (EU-Statistics on Income and Living Conditions), which representatively mirrors the structure of the Czech population²⁴.

Primary data obtained from the questionnaire survey is processed using descriptive statistics and exploratory factor analysis, enabling the reduction of observed factors and identification of resultant determinants impacting consumer behaviour regarding FW. Ordinal variables, specifically scale questions where respondents utilised a 1-7 scale to express the preferences for given options or the effectiveness of motivation (1 being the least, 7 being the most), were included in the factor analysis. This analysis includes respondents who expressed a positive willingness to sort FW. This amounted to 1,145 respondents (86%).

Table 1: Respondent Identification

	Questionnaire survey N = 1332, %	EU-SILC %
Gender		
Male	47.9	46.6
Female	52.1	53.4
Aged group		
18-24 years	8.5	9.3
25-34 years	17.2	17.8
35-44 years	17.4	20.1
45-54 years	18.8	16.2
55-64 years	15.0	12.9
65 years and older	23.1	23.7
Economic Activity		
Employees	56.7	48.8
Self-Employed	8.0	7.6
Retirees	24.1	25.7
Unemployed	2.0	3.7
Students	4.4	6.5
Maternity or parental leave	3.4	5.3
Others	1.4	2.4
Household Disposable Income		
Less than 30,000 CZK	24.5	22.9
30,001 to 45,000 CZK	30.3	25.7
45,001 to 60,000 CZK	24.4	20.4
60,001 to 75,000 CZK	12.2	13.0
More than 75,000 CZK	8.6	18.0
Number of Household Members		
1	18.5	20.9
2	39.5	35.7
3	21.6	21.4
4	17.2	17.5
5 or more	3.2	4.5
Number of Children in the Household		
0	67.7	67.5
1	19.1	15.7
2	11.8	13.9
3	1.2	2.4
4 or more	0.2	0.5
Highest Level of Education Attained		
Primary	1.7	0.1
Secondary without graduation	12.5	12.6
Secondary with graduation	54.9	63.8
University degree	30.9	23.5

Source: Own questionnaire survey, N = 1332 and²⁴

The suitability of factor analysis application is assessed through the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test. If the KMO value is higher than 0.8, the result is considered excellent and the data is suitable for factor analysis application²⁵. According to Bartlett's Test, factor analysis is suitable if the null hypothesis test of independence among the questionnaire variables is rejected²⁵. The first phase of the factor analysis is a principal component analysis, which determines the number of resultant components. This is followed by factor rotation and the subsequent computation factor loadings, which allocate particular factors to components²⁶. All statistical analyses are conducted using IBM SPSS Statistics version 29.

Results and discussion

Despite consumers in the Czech Republic being among the conscientious when it comes to sorting, they are not yet accustomed to sorting food and biological waste. The rate of sorting was determined in the questionnaire survey on a scale of 1-7, where a value of 7 represented the highest level of sorting for the given waste category (Figure 1). It is evident that consumers are accustomed to sorting plastics, paper, and glass, but they minimally sort biological and FW. 10% of respondents selected the highest level of FW sorting. On average, respondents evaluated the level of FW sorting at 3, compared to plastics, paper, and glass, where the average value of sorting was 6. Meanwhile, 86% of respondents stated that they would like to sort FW, but 46% of them declare that they do not have the facilities to do so.

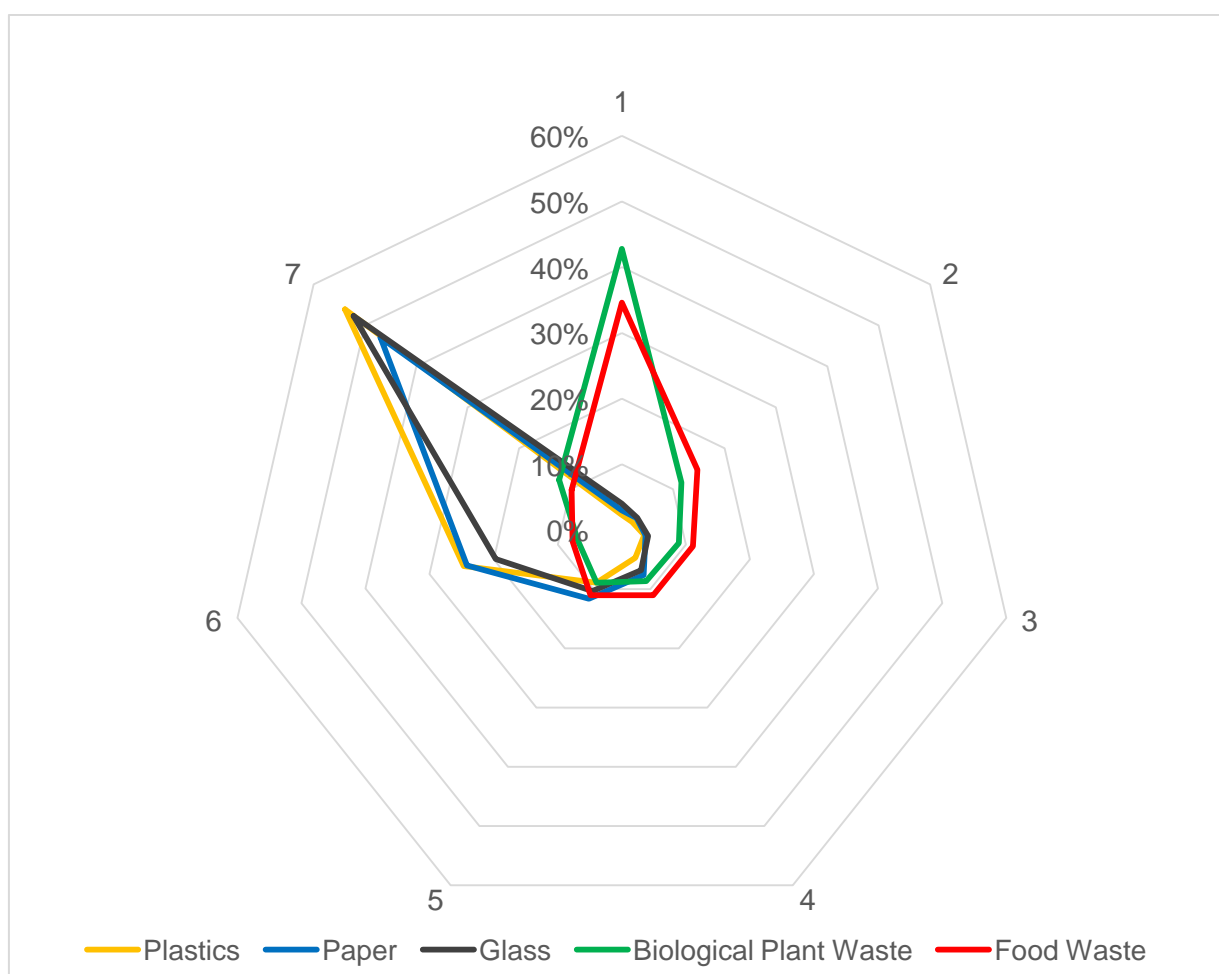


Figure 1: Degree of waste category sorting
Source: Own questionnaire survey (N = 1332)

In more detailed results of consumer willingness to sort FW (Figure 2), it is visible that a third of consumers (31%) are already sorting to some extent. A very low percentage of consumers does not want to sort FW and does not plan to. Only for 5% of respondents, it is not important, and only 2% of respondents are reluctant to handle FW. The highest representation of respondents (39%) indicates that the introduction of a FW sorting system needs to be addressed, as they would like to sort, but do not have the option of how and where to sort. These results are therefore in line with a study conducted in Poland⁷.

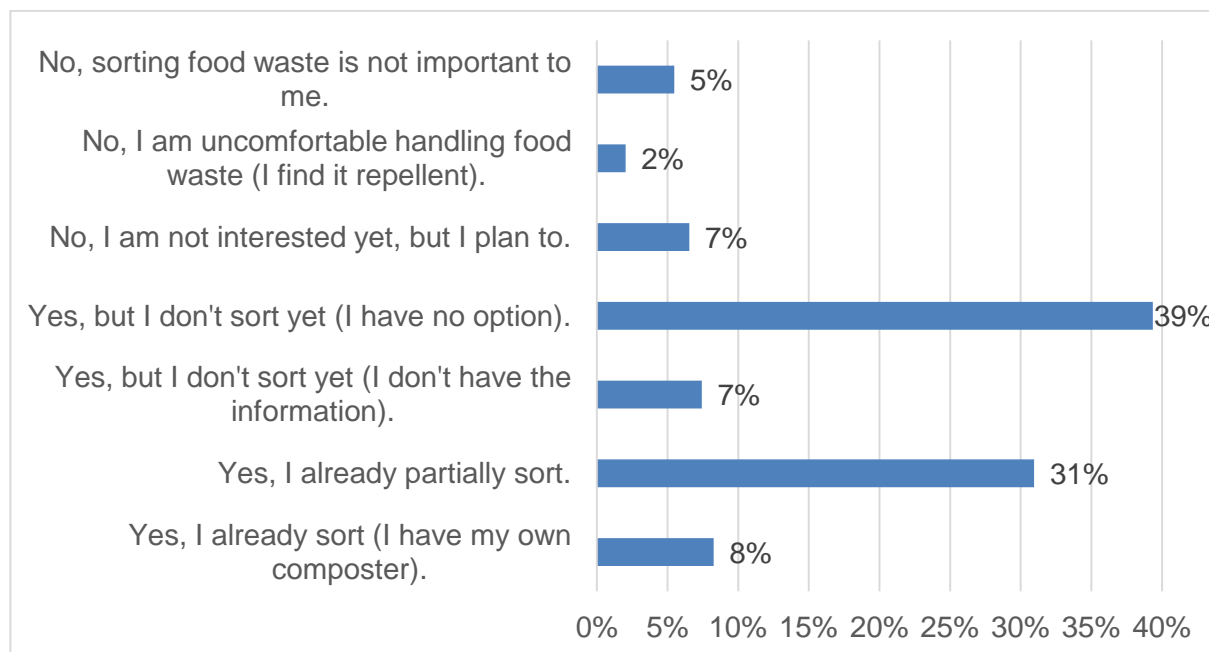


Figure 2: Willingness to sort food waste
Source: Own questionnaire survey (N = 1332)

It is apparent that FW sorting has not yet been given as much attention in the Czech Republic as, for example, the sorting of non-biological waste (plastic or paper). Consumer education in environmental education has been pursued by organizations and schools in the Czech Republic for more than twenty years, and these efforts are bearing visible results. Currently, the Czech Republic is among the successful countries where waste is sorted by 73% of the population according to data for 2020²⁷, which is 45% more compared to 1997.

However, biological waste sorting is a separate category. Several negative externalities occur during its creation, making it more complicated for households. While paper, glass, or plastic can lay in an apartment for several months, FW needs to be discarded regularly to avoid smell and the multiplication of unwanted pathogens. This involves a time-consuming task for consumers, and without sufficient motivation and simplification of FW handling, it can be assumed that they would rather not sort biological waste¹⁴. The question remains, which factors associated with FW sorting by households can be considered key for the Czech consumer?

In order to make recommendations for approaching households, it is essential to minimise the large number of variables that influence consumer in sorting FW by identifying those that determine consumer behaviour in handling FW. For this purpose, multidimensional factor analysis is used, which is a suitable method for reducing data dimensionality with the least loss of information carried by the original variables.

Factor analysis is therefore used to evaluate the perceived importance of 54 observed variables that can influence the FW sorting process in households. Respondents who expressed a willingness to sort FW expressed the importance and effectiveness of individual factors on a scale from 1 to 7. The suitability of this method is verified using the Kaiser-Meier-Olkin criterion (KMO) and Bartlett's test of sphericity, the results of which are shown in Table 2.

Table 2: Verification of the suitability of factor analysis application

Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy		0.847
Bartlett's Test of Sphericity	Approximate Chi-Square	21850.66
	Degrees of Freedom (df)	1431
	Significance (p-value)	0

Source: Own processing of questionnaire survey data in IBM SPSS Statistics

With a KMO value approaching 0.85 and a statistically significant result of Bartlett's test of sphericity at the 1% significance level, allowing for the rejection of the null hypothesis of no correlation between input variables, it can be concluded that the necessary criteria for the use of factor analysis have been fulfilled.

Based on the results of the analysis, the optimal number of newly created latent variables, or extracted factors, has been established at fourteen. This selection is in line with the Kaiser criterion, according to which fourteen components have an eigenvalue greater than one. These extracted factors explain a total of 64.3% of the response variability of all respondents, as can be seen in Table 3.

Table 3: Extracted factors

Extracted Factors	Original Variables	Factor Loadings	Eigenvalue	% of Total Variance
1. Level of household food waste	Bread - frequency of discarding	0,572	7,941	13,103
	Whole fruit or vegetables - frequency of discarding	0,566		
	Milk - frequency of discarding	0,786		
	Dairy products - frequency of discarding	0,829		
	Raw meat and meat products - frequency of discarding	0,819		
	Soups and sauces - frequency of discarding	0,802		
	Ready meals (plant origin) - frequency of discarding	0,806		
	Ready meals (animal origin) - frequency of discarding	0,806		
	Cooked side dishes - frequency of discarding	0,739		
	Fats (oil, butter) - frequency of discarding	0,636		
	Eggs - frequency of discarding	0,778		
	Durable food - frequency of discarding	0,783		
2. Responsibility for food management	Responsibility for buying food	0,900	4,034	19,228
	Responsibility for storing food	0,913		
	Responsibility for preparing meals	0,840		
	Responsibility for waste management	0,794		
3. Pest-related barrier	Odour	0,800	3,624	24,728
	Insects	0,825		
	Rodents	0,768		
	Spread of harmful microorganisms	0,765		
4. Degree of non-biological waste sorting	Degree of waste sorting	0,753	3,323	30,176
	Degree of plastic sorting	0,838		
	Degree of paper sorting	0,836		
	Degree of glass sorting	0,794		

Extracted Factors	Original Variables	Factor Loadings	Eigenvalue	% of Total Variance
5. Motivation in the form of a clean environment	Improvement of the environment	0,713	2,537	34,847
	FW is subsequently processed	0,697		
	Sorting FW among people in the neighbourhood	0,616		
	Sufficient quantity of bins	0,616		
	Clean environment and non-overfilled bins	0,637		
6. Availability of packaging for FW sorting	Biodegradable bag (purchased in store)	0,592	2,237	39,038
	Biodegradable bag (free to pick up)	0,874		
	Biodegradable bag (free at collection point)	0,797		
	Sealable container (small bucket for free)	0,560		
7. Engagement in waste sorting	Degree of biological waste sorting	0,705	2,036	43,140
	Degree of FW sorting	0,729		
	Attention paid to FW sorting	0,615		
	Lack of collection points for FW	-0,561		
8. Environmental motivation	Improvement of the environment	0,828	1,579	47,114
	Helps protect natural resources	0,842		
	FW for energy production, fertilisers or livestock farming	0,774		
9. Savings for MSW collection	Less frequent collection of MSW	0,860	1,498	50,334
	Limiting the number or volume of MSW bins	0,860		
10. Frequency of meal preparation at home	Frequency of meal preparation	0,725	1,330	53,523
	Frequency of hot meal preparation	0,774		
	Frequency of FW disposal	0,443		
11. Obstacles to efficient FW sorting	Lack of knowledge about FW use	0,720	1,284	56,294
	Lack of time for sorting	0,435		
	Health barrier (e.g., immobility)	0,571		
12. Discarding FW in own packaging	Ordinary bag or plastic bag	0,808	1,136	58,973
	Possibility of discarding food in original packaging	0,494		
13. Amount of necessary FW at home	Amount of FW per week	0,510	1,096	61,651
	Amount of crusts and peels	-0,601		
14. Own container for FW	Sealable container (small purchased bucket)	0,619	1,065	64,296
	Own container or packaging (whatever I find at home)	0,646		

Source: Own processing of questionnaire survey data in IBM SPSS Statistics

The extracted factors are as follows: Level of household food waste (1), Responsibility for food management (2), Pest-related barrier (3), Degree of non-biological waste sorting (4), Motivation in the form of a clean environment (5), Availability of packaging for FW sorting (6), Engagement in waste sorting (7), Environmental motivation (8), Savings for MSW collection (9), Frequency of meal preparation

at home (10), Obstacles to efficient FW sorting (11), Discarding FW in own packaging (12), Amount of necessary FW at home (13), Own container for FW (14).

Some of the identified factors have already been discussed in studies carried out in existing food waste sorting systems. The study performed in Denmark showed that the level of sorting of other types of waste, determined by consumer habits, affects the amount of sorted food waste²⁸. Another study explored the barriers and motivations for consumers to separate food waste¹⁰. Similarly, as here in the factor analysis results they mentioned the important role of the environmental awareness, financial considerations related to savings for MSW collection and obstacles like lack of time for sorting¹⁰. A case study from Sweden, where the implementation of separate food waste collection contributed to a reduction in total household waste, found that increased environmental awareness and the convenience of sorting food waste were the main factors motivating consumers to sort food waste²⁹.

In comparison with previous studies^{10, 15, 16}, our analysis allows for a deeper and more comprehensive insight into this issue. The authors here largely focus on individual variables influencing FW sorting, such as lack of awareness, space limitation, inadequate policy and lack of time/priority¹⁰. Our analysis verifies these variables for the conditions of the Czech consumer and also expands upon other dimensions that may be significant for the willingness to sort FW and allow for a more comprehensive view of this issue. The importance of a holistic approach to this issue is also pointed out by another study¹⁰.

Table 3 lists the individual input variables, identified latent variables (factors), factor loads, eigenvalues of the extracted factors, and the percentage of variability each factor explains. These factors can be understood as key indicators of willingness to sort FW, which reduce the dispersion of 54 observed variables that entered the factor analysis to a smaller number of latent variables with minimal information loss from observations. The exploratory factor analysis managed to reduce the original amount of variables to fourteen areas that should be monitored and worked with to understand and possibly influence consumer behaviour in a sustainable direction when dealing with FW.

Key factors such as the **rate of FW** in the household^{2, 10, 11} and **responsibility for food management**, time restrictions for FW sorting²¹ are often highlighted in other studies³⁰. Here we can confirm that they are also decisive for the Czech consumer. It is extremely important to educate consumers on the proper handling of food, especially focusing on the shelf life of perishable food and on adhering to the 'first in, first out' storage principles. In addition, it is crucial to routinely check inventories, carefully organize purchases, and become familiar with methods of dealing with surplus food³¹. We recommend further monitoring of the **rate of non-biological waste sorting, engagement in package sorting**^{19, 15}. To achieve behavioural alterations in the consumer, it is imperative to acquaint them with the merits of recycling, thereby ensuring they comprehend the ramifications of their food handling practices. Similarly, the ability to strategically plan both the quantity of food and the **frequency of food preparation** in households becomes crucial, a factor that fundamentally affects the extent of food sorting. It is of utmost importance to target mainly those **households that eat mainly at home** and therefore produce more waste. Another criterion that is considered important for waste sorting is the **availability of suitable containers** for sorting or the incentive of a pristine environment. These conclusions confirm the results of the study, which talks about the need for a well-designed waste collection system in line with consumer preferences to support FW sorting from households²³. If we endeavour to bolster waste sorting within households, it is prudent to focus extensively on the reduction of malodour and curtail the presence of rodents at collection sites. Maintaining a sanitary environment can preempt the emergence of various pathogens, and a sensation of cleanliness and safety further augments a consumer's propensity to sort³² (Li et al, 2017). Exploring the influence of containers on the volume of food waste produced by households found that the presence of a bio-waste container promotes environmentally conscious behaviour among individuals³³. Furthermore, our study also focuses on newly identified variables, for example, the factor of savings for MSW collection, which was not sufficiently emphasised in previous papers. However, in the current time of inflation, financial motivation in the form of savings may also affect consumer behaviour change. For example, government subsidies awarded for careful waste sorting can subsequently have a major positive impact¹⁰. The results of data processing also offer a different view on commonly overlooked factors. For example, the factor of discarding FW in one's **own containers**, which has so far been absent in studies on this topic. The analysis suggests that even the possibility of a rudimentary consumer choice, pertaining to the means of storing and disposing of organic waste at home (be it a bucket, a biodegradable bag, etc.), warrants significance.

Conclusions

This study underscores the complexity and multifaceted nature of the factors that influence the sorting of FW in households. Based on a factor analysis, fourteen key areas are identified that are crucial to monitor and work with if we aim to understand and influence consumer behaviour when handling FW. People so far do not perceive this highly valuable resource as significant. However, with the increasing pressure on environmental resource management and the transition to the concept of a circular economy, it is clear that sorting FW will become a challenge not only for municipalities but primarily for end consumers. From the primary survey it can be concluded that the Czech consumer is already prepared for this change, with the vast majority (86%) of respondents declaring their willingness to sort FW. The problem remains, however, that many of them currently do not have the facilities to do so. Several studies point out that little attention is paid by the governments to food waste sorting. They comment that the governments should set the direction and coordinate the sorting of food waste^{10, 22, 34}. The European Union regulates sorting and recycling targets through the Waste Framework Directive³⁵. It states that by 2035, the preparing for re-use and the recycling of municipal waste shall be increased to a minimum of 65 % by weight. This implies the need for new recycling facilities in municipalities. For instance, in Italy, it is reported that the number of recycling facilities has increased by 2–3% annually over the past 15 years³⁶. Once a system for sorting food waste is implemented, education of citizens is necessary, as the results of a study conducted in Denmark, shows that citizens often sort incorrectly, which makes subsequent recycling impossible²⁸.

We can conclude that it will be necessary to work with information, educating consumers in the area of FW sorting, emphasizing its benefits. To promote sustainable behaviour, it is particularly important to ensure a sufficient number of collection containers. Households could dispose of FW more frequently and maintain a clean environment free of odours, insects and unwanted pathogens in their homes and at the collection point. Interventions to promote FW sorting should also be directed towards consumers who frequently prepare meals at home, targeting specifically those responsible for the household's food management. Generally, it can be stated that the Czech consumer is open to this change and willing to sort FW. Therefore, citizens should be supported in this task, preferably by reducing the identified FW sorting barriers.

Identified factors such as the level of FW in the household, responsibility for food management, time constraints, the degree of non-biological waste sorting, involvement in sorting packaging, frequency of meal preparation at home, availability of bins for sorting, and motivation in the form of a clean environment should be the main focus for policymakers and educational efforts in waste sorting. Our study also reveals that financial motivation, for example, savings on MSW (Municipal Solid Waste) collection fee, could play a crucial role in consumers' willingness to sort FW. In the context of the current economic situation, financial motivation may be a strong stimulus for changing consumer behaviour. Another significant finding is the need to provide consumers with various options for FW sorting containers. This factor, which has been overlooked in previous studies, may represent a simple and effective solution to increase households' willingness to sort FW. For example, allowing consumers to discard food in its original packaging (yoghurt in a cup). In sum, our results confirm that for successful implementation of FW sorting systems, it is essential to comprehensively understand the needs of households and subsequently reflect these in the methodology of FW collection and communication on this issue.

List of symbols

FW	Food Waste
MSW	Municipal Solid Waste

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Za hranicí koše: Rozbor faktorů a bariér třídění potravinového odpadu v českých domácnostech

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Souhrn

Studie je založena na primárním dotazníkovém šetření provedeném metodou CAWI (N = 1332) a zjišťuje faktory ovlivňující třídění potravinového odpadu v českých domácnostech. Pomocí explorační faktorové analýzy bylo identifikováno čtrnáct klíčových oblastí, včetně dostupnosti možností třídění, nakládání s potravinovým odpadem a finanční motivace. Přestože 86 % respondentů vyjádřilo ochotu třídít potravinový odpad, téměř polovina z nich deklarovala, že nemá žádné možnosti, jak tento druh odpadu třídít. Přetrvávají významné bariéry spojené s nedostatkem kontejnerů a složitostí procesu třídění. Tato studie přispívá k lepšímu pochopení chování spotřebitelů v oblasti třídění odpadu a poskytuje vhled do této problematiky jako podklad pro budoucí rozhodování tvůrců politik. Výsledky ukazují, že po zavedení systému třídění potravinového odpadu ze strany tvůrců politik je dále důležité zajistit dostupnost kontejnerů pro třídění a motivovat domácnosti k tomuto třídění odpadů, a to jak zvyšováním environmentálního povědomí, tak poskytnutím finanční motivace a minimalizací překážek spojených s tříděním potravinového odpadu.

Klíčová slova: třídění potravinového odpadu, motivace k třídění, bariéry třídění, spotřebitelské preference, faktory třídění odpadu