Selected Factors Determining the Disposal of Stale Bread by Polish Consumers

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Article

Selected Factors Determining the Disposal of Stale Bread by Polish Consumers

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Abstract: Bread is one of the most popular products consumed almost daily and, simultaneously, the most frequently wasted product in large quantities. The factors determining this phenomenon in a household must first be known in order to develop and implement effective programmes to combat consumers throwing away bread. Minimizing bread waste contributes to achieving the UN's Sustainable Development Goal 12 of "halting food waste by 2030". The aim of the study was to examine the influence of selected sociodemographic, economic and behavioural characteristics of consumers on the methods of managing stale bread. The study was conducted on a nationwide, random, and representative group of 1115 adult respondents. Over 15% of respondents admitted throwing stale bread into the waste container. Statistical analysis showed that the highest percentage of younger people, residents of large cities, and working people declared throwing unused bread into the waste container. More than 1/3 of respondents declared that they process stale bread into breadcrumbs. A higher percentage of the oldest people, residents of rural areas, and families with more than four adults declared that they manage bread this way. There was no significant relationship between the frequency of bread purchase and all methods of managing stale bread (except for feeding animals). The place of purchase influenced four methods of handling stale bread.

Keywords: bread waste; bread waste utilization; disposal paths; sustainable development; consumers; driving factors

1. Introduction

Bread is one of the primary cereal products, providing consumers with many valuable nutrients [1,2]. Its main ingredient is flour, affecting nutritional value and quality [3]. Bread production is one of human history's most traditional food processing methods. Bread is the world's most widely consumed food product and has been part of the human diet for thousands of years due to its taste, portability, convenience, and eating habits [4]. It also plays an important symbolic role in religions such as Judaism and Christianity and is still used in various rituals [5].

Global annual bread production is around 100 million tonnes, including around 32 million tonnes in the EU27. Today, bread is also the most widely consumed product, although EU countries differ in consumption habits. In most EU countries, an average of 50 kilograms is consumed per capita per year. The highest consumption levels were recorded in Bulgaria (around 95 kilograms/person) [6]. In Flemish Belgium, an average person consumes around 38 kg per year [7], and in the UK, around 32 [6]. In Poland, there has been a decline in bread consumption; in 2015, the average monthly bread consumption per person was 3.74 kg (approx. 44.9 kg/year); in 2020 – 2.75 kg (approx. 33 kg/year), and in 2022 - 2.58 kg (approx. 31 kg/year) [8].

At the same time, this product is one of the most frequently and in the most significant quantity wasted food in the world [9–14], although it is difficult to determine the exact scale, it is estimated that about 10% is wasted globally [15]. For example, in Great Britain, bread is the second most frequently wasted food, with an annual loss of 292,000 tonnes [16]. According to estimates by the

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Waste and Resources Action Programme (WRAP), bread waste constitutes 10% of all food waste generated in Great Britain [17]. In Norwegian households, bakery products (mainly bread) comprise 27% of food waste [18]. Den Boer et al. [19] found that bread waste in Polish households constitutes the most significant stream of mixed food waste (23.9%). On average, one Swedish resident wastes about 8.1 kg of bread annually [20]. Based on research using a diary, Bilska et al. [21] found bread waste at the level of 33.47 g/day/1 household, which in annual terms gives about 12.2 kg/household and about 5 kg per person. At the same time, it should be noted that bread was the most frequently thrown-away product by almost a quarter of Polish respondents [22].

The leading cause of waste of bakery and confectionery products in the supply chain is the speed at which they lose their freshness [23,24] and consumer interest [25]. Bread is a perishable product, and adverse physicochemical changes appear immediately after baking. These processes cause a relatively rapid deterioration of sensory quality, and sometimes, after just a few hours, consumers may consider bread stale. For this reason, over the centuries, its baking technology has undergone changes aimed at increasing its durability and adapting its properties to changing consumer preferences [1].

Reducing bread loss will diminish the use of resources, reducing the environmental burden of agricultural production [26]. Bread loss reflects the loss of products and various natural resources, such as water, land, and energy used for raw material production, transportation, and production. Bread and other materials lost during these processes have a significant impact on society, the environment, and the economy [27].

Accurate demand forecasting is a complex task because many factors influence it. Hence, bread waste is inevitable in the supply chain – it can be minimized but not eliminated. It is essential to develop methods to reduce bread surpluses. One solution to reduce waste may be to provide consumers with better knowledge and information to better manage food from an economic and environmental perspective [28]. Possible solutions to utilize bread waste include supplementation as animal feed [29], incineration [30], anaerobic fermentation [31], and as a carbon source for beer and ethanol production [20,32].

The possibilities of using unconsumed bread largely depend on the place of origin in the food chain. At the supplier-retailer level, bread waste is not contaminated with other food waste, is easier to manage and is more suitable for valorization [26]. The most frequently discussed strategy for recycling bread waste is fermentation. Bread waste is an excellent raw material for microorganisms such as bacteria, fungi and yeast. Processing stale bread to create a new product or adding stale bread to a new batch is already used in production. Scientists have also started using this waste to produce textiles and graphene [33].

Wasted bread in households is mixed with other wasted food or municipal solid waste; therefore, it requires segregation for specific treatment. Thus, the main obstacle to the efficient use of domestic bread waste is the need to introduce separate waste containers to separate bread from other waste, increasing the costs and complexity of the operations in the process [34]. According to Brancoli et al. [32], reducing bread waste at source would bring the most significant environmental benefits, followed by feed production, donation, beer production and ethanol production, with no clear preference between these last four valorization paths. The circular economy is attracting more and more attention, as it is a crucial concept for integrating food waste into biological cycles using new technologies [35].

It is worth understanding consumer behaviour in dealing with stale bread so that effective programs can be developed to reduce the waste of this product and to use waste to minimize the negative impact on the environment. At the same time, to our knowledge, few studies have focused on consumer behaviour related to the management of stale bread. Our study fills this gap.

The aim of the study was (1) to present the method of managing stale bread, (2) to examine the influence of socio-demographic and economic characteristics of households on the methods of managing this product, (3) to determine the influence of the frequency of bread purchases and the place of its purchase on the method of managing stale bread.

2. Materials and Methods

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2.1. Study Design and Participants

The study was part of a more extensive study aimed at examining the behaviour of Polish consumers in terms of food waste. The study was conducted in February and March 2019. The sample consisted of 1,115 adult respondents. The method of computer-assisted personal interviews (CAPI) was used. The selection of the sample from the address survey of the Central Statistical Office met the condition of representativeness of the general population of Poles over 18 in terms of gender, age and size of the place of residence (6 size classes). The detailed sociodemographic characteristics of respondents are presented in Table 1.

Table 1. Sociodemographic characteristic of consumers' groups, %.

Variable	Characteristics	%
Gender	Women	51.12
	Men	48.88
Age	18-24	8.70
	25-34	19.46
	35-44	18.65
	45-59	27.26
	over 60 years old	25.92
Inhabitancy (place of origin)	Villages	38.21
	Cities up to 50,000	24.75
	Cities over 50,000 up to 100,000	7.35
	Cities over 100,000 up to 200,000	9.15
	Cities over 200,000 up to 500,000	8.97
	Cities over 500,000	11.57
Education level	Primary	8.43
	Basic vocational	31.93
	Secondary	41.97
	Higher	17.67
No. of people over 18 years in household	1	17.22
	2	61.17
	3	16.32
	4 or more	5.29
No. of children in household	0	74.62
	1	16.32
	2	7.62
	3 or more	1.43
Portion of the household budget for food expenditure	Large (100–61%)	12.29
	Average (60–40%)	50.22
	Small (39–0%)	26.73
	Hard to say	10.76
Employment status of the person	Working	66.37
	Not working (unemployed, homemaker, including maternity/parental leave, pensioner/disability pensioner, student)	33.63

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2.2. Questionnaire

The study was conducted using an original questionnaire consisting of two parts. The first part contained questions about consumer behaviour regarding stale bread. Respondents could choose any number of answers from the following options: (1) preparing so-called bread crumbs, (2) using it for other dishes, (3) throwing it away with other dishes, (4) putting it in a special place in the garbage , (5) feeding animals, (6) giving it to people who have animals, (7) not allowing bread to become stale. This part of the questionnaire contained questions about the frequency of buying bread, where a 6-point scale was used: every day; every other day on average; 1-2 times a week on average; 1-2 times a month on average; less than once a month; I do not buy bread; I do not know/hard to say. The next question concerned the most common place to buy bread. The following answer options were available: marketplace/bazaar; small shop, e.g. local; small chain of shops; discount store; large-scale store; specialist shop, e.g. bakery; online, farm; self-supply. The second part included questions about the demographic and social affiliation of the respondents: gender, age, place of residence (place of origin), level of education, number of people over 18 years of age in the household, number of children in the household, part of the household budget allocated to food expenses, employment status.

2.3. Statistical Analysis

The percentage share of responses in the scope of management of stale bread in Polish households was calculated. One-way ANOVA calculations were performed to determine whether selected socio-demographic characteristics of respondents and households differentiate responses in the scope of management of stale bread. The percentage occurrence of indications in a given response category was used to interpret statistically significant relationships by comparing segments of respondents. Based on the probability p-value test, the decision was made to reject or accept the null hypothesis on the influence of a socio-demographic feature on the examined factor. A post-hoc analysis was conducted using the LSD test (least significant difference), which allowed for the indication of homogeneous groups of arithmetic means. To verify the relationship between two independent factors, i.e. frequency and place of purchase of bread and the method of management of stale bread, the Chi-squared (X2) test of independence was used.

All statistical tests were done using Statistica 12 software. Significance was identified when $p < 0.05$.

3. Results

3.1. Ways of Managing Stale Bread Taking into Account Sociodemographic and Economic Characteristics of Respondents

Less than 15% of the surveyed respondents declared they did not allow bread to become stale (Table 2). The most popular way of managing such bread was to prepare bread crumbs and feed animals (67% of responses in total). Almost the same percentage of respondents (i.e. approx. 15% each) indicated throwing it into a waste container, giving it to people with animals, and putting it in a special place in the garbage. The least popular method among the surveyed people was to use stale bread to prepare other dishes.

Among the analysed sociodemographic and economic characteristics concerning the individual characteristics of respondents (Table 3) and characteristics related to the household (Table 4), the respondents' place of residence turned out to have the most significant impact on the management of stale bread. It determined six of seven analysed methods of managing stale bread (Table 3). A significantly higher ($p<0.05$) percentage of rural residents compared to urban residents, regardless of their size, declared the use of stale bread to feed animals (46.01% vs 14.73-27.00%, respectively). Residents of rural areas and cities up to 200,000 more often than in the towns above 200,000 also reported giving such bread to people with animals. It turned out that residents of rural areas and cities with a population of 200,000 to 500,000 (LSD test - homogeneous group) significantly more often than respondents living in other location categories prepared the so-called stale bread crumbs.

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At the same time, the smallest percentage of rural residents declared the remaining analysed methods of managing stale bread, i.e. using it for other dishes, putting it in a particular place prepared for stale bread in the garbage.

Table 2. Methods of managing stale bread declared by respondents.

Abbreviation	Declared method of managing stale bread	Yes		No	
		n	%	n	%
HM.1	preparing the so-called breadcrumbs	390	35.0	727	65.0
HM.2	using it for other dishes	154	13.8	961	86.2
HM.3	throwing it away with other dishes	171	15.3	944	84.7
HM.4	putting it in a special place in the garbage can	168	15.1	947	84.9
HM.5	feeding the animals	357	32.0	758	68.0
HM.6	giving it to people who have animals	172	15.4	943	84.6
HM.7	don't allow bread to go stale	161	14.4	954	85.6

Based on the research, we found that a significantly higher percentage of residents of large cities, i.e. over 200,000 (44.6%), than in other size classes threw stale bread into the waste container. At the same time, the lowest percentage of residents of the largest cities (12% in total) declared that they gave it to people with animals.

The influence of other individual characteristics of respondents, such as gender, age and level of education, on stale bread management was analysed (Table 3). It was found that each of them determined two of the seven analysed methods of stale bread management. Thus, breadcrumbs were prepared significantly more often ($p<0.05$) by women compared to men, as well as by middle-aged and mature respondents compared to young consumers, i.e. up to 34 years of age. According to the declarations of the people taking part in the study, stale bread was used more willingly ($p<0.05$) to prepare other dishes by women. Young consumers, i.e. up to 34 years of age, significantly more often indicated throwing away stale bread with other waste than respondents over 45 (heterogeneous groups). Putting stale bread in a particular place in the garbage was significantly more often declared by respondents with higher and secondary education than those with lower education. On the other hand, consumers with the lowest education substantially more often than the other groups indicated feeding animals with stale bread . Gender, age or level of education had no significant effect on the frequency of giving stale bread to people with animals or preventing it from going stale.

Among the household characteristics, such as the number of adults over 18 years of age, the number of children, the share of food expenditure, or employment status, the respondents' professional activity proved to have the most significant impact on stale bread management. It determined three out of the seven analysed methods of stale bread management (Table 4). Professionally active people, including farmers, declared significantly less frequently than unemployed respondents that they prepared bread crumbs or fed animals. At the same time, they were much more likely to throw away stale bread with other waste. The number of adults in the household proved to have an impact on the use of stale bread to prepare so-called bread crumbs and to feed animals. Thus, in households with a more significant number of adults (3 and above), the preparation of bread crumbs was much more often declared than in households with 1 or 2 adults. In households with four or more adults, stale bread was much more often used to feed animals than in smaller households (1-3 persons).

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Table 3. Results of one-way ANOVA considering the individual respondents' characteristics, post-hoc analysis was performed using the least significant difference (LSD) test.

Group	Classification	HM.1		HM.2		HM.3		HM.4		HM.5		HM.6		HM.7	
		%	F-ratio	%	F-ratio	%	F-ratio	%	F-ratio	%	F-ratio	%	F-ratio	%	F-ratio
Gender	Women	41.75^{a}	24.01*	17.19^{a}	11.29*	13.86	1.96	16.49	1.85	32.81	0.33	15.61	0.03	13.16	1.55
	Men	27.88^{b}		10.27^{b}		16.88		13.58		31.19		15.23		15.78	
Age	18-24	27.83^{bc}	3.76*	11.34	1.25	21.65^{a}	4.87*	14.43	0.94	28.87	1.98	11.34	1.78	16.50	1.05
	25-34	26.27^{c}		11.06		21.66^{a}		13.82		30.88		15.21		16.59	
	35-44	34.61^{abc}		15.38		17.79^{ac}		18.75		27.88		12.50		12.50	
	45-59	38.49^{ab}		16.78		12.17^{bc}		15.79		30.59		19.74		11.84	
	over 60 y.o.	40.48^{a}		12.46		10.04^{b}		12.80		38.41		14.53		16.26	
Inhabitancy	Villages	42.49^{a}	4.16*	12.91	1.70	10.56^{c}	3.79*	5.63^{c}	11.43*	46.01^{a}	15.18*	17.84^{a}	4.04*	10.56^{b}	2.97*
	C. up to 50,000	32.25^{b}		16.30		17.75^{b}		19.20^{b}		26.09^{c}		18.84^{a}		15.22^{bc}	
	C. over 50,000 up to 100,000	26.83^{b}		18.29		15.85^{abc}		18.29^{ab}		30.49^{c}		17.07^{a}		19.51^{ac}	
	C. over 100,000 up to 200,000	24.51^{b}		10.78		13.73b^{c}		21.57^{ab}		17.65^{bc}		15.69^{ab}		21.57^{ac}	
	C. over 200,000 up to 500,000	35.00^{a}		7.00		26.00^{a}		18.00^{b}		27.00^{c}		5.00^{cd}		11.00^{b}	
	C. over 500,000	29.46^{b}		16.28		18.60^{ab}		27.91^{a}		14.73^{b}		6.98^{bd}		19.38^{ac}	
Education level	Primary	36.17	0.19	12.77	0.34	7.45	2.41	7.45^{b}	2.69*	48.94^{a}	4.74*	17.02	0.14	13.83	0.65
	Basic vocational	33.43		12.64		17.42		13.48^{ab}		31.74^{b}		15.45		12.92	
	Secondary	35.47		14.96		16.45		16.03^{a}		29.96^{b}		15.60		14.53	
	Higher	36.04		13.71		12.69		19.29^{a}		30.96^{b}		14.21		17.26	

* P-value<0.05.

The lowest percentage of people who spend more than 60% of their budget on food purchases (L) declared that they do not allow purchased bread to become stale.

3.2. Method of Managing Stale Bread and Frequency of Its Purchase

The vast majority of respondents (over 80%) bought bread every day or every other day on average. Table 5 presents the frequency of bread purchases declared by respondents, taking into account the method of management (HM.1 - HM.7). Among people who declared preparing so-called bread crumbs (HM.1; n=390), the most significant percentage, i.e. 46.15%, bought bread on average every other day. Consumers who indicated using stale bread to prepare different dishes (HM.2; n=154) also often indicated buying bread on average every other day. It was found that respondents who declared throwing away stale bread with other waste (HM.3; n=171), putting it in a particular place prepared in the garbage (HM.4; n=168), feeding animals (HM.5; n=357), giving it to people with animals (HM.6; n=172), or not allowing it to become stale (HM.7; n=161) most often indicated daily purchases of fresh products, respectively: 46.20%, 48.81%, 42.30%, 43.02%, 42.24%.

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Table 4. Results of one-way ANOVA taking into consideration the characteristics of the households, post-hoc analysis was performed using the least significant difference (LSD) test.

Group	Classification	HM.1		HM.2		HM.3		HM.4		HM.5		HM.6		HM.7	
		%	F-ratio	%	F-ratio	%	F-ratio	%	F-ratio	%	F-ratio	%	F-ratio	%	F-ratio
No. of people over 18 years in household	1	29.69^{b}	8.06*	14.58	0.28	17.71	1.97	12.50	0.62	29.69^{b}	4.86*	14.58	1.31	16.67	0.82
	2	31.96^{b}		14.08		15.84		15.98		29.91^{b}		15.54		14.37	
	3	45.60^{a}		13.19		14.29		13.74		35.71^{b}		13.19		14.29	
	4 or more	54.24^{a}		10.17		5.08		16.95		52.54^{a}		23.73		8.47	
No. of children in household	0	34.98	0.51	14.42	0.73	15.63	0.10	13.82^{b}	4.62*	32.09	2.58	14.42	1.35	14.90	0.23
	1	37.36		12.64		14.29		23.63^{a}		26.92		16.48		12.64	
	2	31.76		9.41		15.29		10.59^{b}		37.65		22.35		14.12	
	3 or more	25.00		18.75		12.50		6.25^{ab}		56.25		18.75		12.50	
Portion of the households budget for food expenditure	Large	33.58	1.39	16.79	1.85	18.25	2.53	8.76	2.10	40.88	1.95	18.98	0.79	8.03^{c}	7.07*
	Average	35.00		12.68		17.32		16.07		31.25		14.46		14.82^{b}	
	Small	38.59		16.44		10.74		17.11		30.54		16.44		11.74^{bc}	
	Hard to say	28.33		9.17		14.17		12.50		29.17		13.33		26.67^{a}	
Employment status of the person	Working	32.43^{b}	6.29*	15.00	2.61	17.57^{a}	8.49*	16.22	2.27	29.59^{b}	5.96*	14.73	0.82	14.19	0.11
	Not working	40.00^{a}		11.47		10.93^{b}		12.80		36.80^{a}		16.80		14.93	

Table 5. The frequency of bread purchases declared by respondents, taking into account the type of management.

Abbreviation	Frequency of shopping bread													
	every day		every other day on average		1-2 times a week on average		1-2 times a month on average		less frequently than once a month		I do not buy bread		I do not know/hard to say	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
TOTAL	465	41.70	452	40.54	158	14.17	16	1.43	3	0.27	8	0.72	13	1.17
HM.1	146	37.44	180	46.15	55	14.10	4	1.03	0	0.00	3	0.77	2	0.51
HM.2	57	37.01	66	42.86	26	16.88	4	2.60	0	0.00	1	0.65	0	0.00
HM.3	79	46.20	70	40.94	17	9.94	3	1.75	0	0.00	0	0.00	2	1.17
HM.4	82	48.81	66	39.29	17	10.12	0	0.00	0	0.00	1	0.60	2	1.19
HM.5	151	42.30	142	39.78	52	14.57	5	1.40	2	0.56	3	0.84	2	0.56
HM.6	74	43.02	56	32.56	36	20.93	5	2.91	0	0.00	0	0.00	1	0.58
HM.7	68	42.24	64	39.75	19	11.80	2	1.24	1	0.62	2	1.24	5	3.11

Based on the Chi-square test, the results of which are presented in Table 6, it can be concluded that there is no significant relationship between the frequency of bread purchases and most of the analyzed methods of managing stale bread. Only among people declaring that they gave this type of bread to people with animals did a significantly higher percentage of respondents indicate daily purchases of the discussed product (Tables 5 and 6).

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Table 6. Chi-square test results for stale bread management methods and purchase frequency.

Statistics	HM.1	HM.2	HM.3	HM.4	HM.5	HM.6	HM.7
Chi-squared	11.82	6,37	5,67	8,17	3,60	15,51	8,50
df	df=6	df=6	df=6	df=6	df=6	df=6	df=6
p-value	0.07	0.38	0.46	0.22	0.73	0.02*	0.20

$p \leq 0.05$.

3.3. Method of Disposal of Stale Bread and Place of Purchase

Table 7 presents the places of purchase of bread declared by respondents, taking into account the method of disposal of stale bread (HM.1 - HM.7). Over 1/3 of respondents declared that they purchased bread in a small shop. In contrast, almost the same percentage of respondents (approx. 19% each) indicated a discount store and a specialized store, e.g. a bakery. The place of purchase had an impact on two methods of disposal, i.e. throwing away bread (HM.3) and putting it in a special place in the garbage (HM.4). The highest percentage of respondents who purchased bread in a small shop and a discount store declared that they threw stale product into a container (37.93%, 33.10%, respectively).

The fewest respondents buying bread in a small chain store and a large-scale store threw away stale bread. The highest percentage of people buying in a small store and a specialized store (bakery) declared that they put bread in a special place in the garbage. Based on the Chi-square test, the results of which are presented in Table 8, it can be concluded that the place of purchase of bread determined the way of managing stale bread to a greater extent than the purchase frequency.

Table 7. The place of purchase of bread declared by respondents, taking into account the type of management.

Abbreviation	Place of purchase*																	
	Marketplace/bazaar		Small shop, e.g. local		Small chain of shops		Discount store		Large-scale store		Specialist shop, e.g. bakery		Online		Farm		Self-supply	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
TOTAL	16	1.43	421	37.76	63	5.65	214	19.19	17	1.52	204	18.30	0	0	2	0.18	3	0.27
HM.1	3	0.85	176	49.86	23	6.52	66	18.70	3	0.85	79	22.38	0	0	1	0.28	2	0.57
HM.2	1	0.72	67	48.20	16	11.51	29	20.86	2	1.44	24	17.27	0	0	0	0.00	0	0.00
HM.3	8	5.52	55	37.93	7	4.83	48	33.10	6	4.14	20	13.79	0	0	0	0.00	1	0.69
HM.4	2	1.30	69	44.81	6	3.90	23	14.94	2	1.30	52	33.77	0	0	0	0.00	0	0.00
HM.5	2	0.65	151	49.35	21	6.86	61	19.93	6	1.96	61	19.93	0	0	1	0.33	3	0.98
HM.6	1	0.69	69	47.92	11	7.64	28	19.44	3	2.08	31	21.53	0	0	0	0.00	1	0.69
HM.7	3	2.63	52	45.61	4	3.51	26	22.81	2	1.75	27	23.68	0	0.00	0	0.00	0	0.00

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* Respondents who declared purchasing bread are included (n=940).

Table 8. Chi-square test results for stale bread management methods and purchase locations.

Statistics	HM.1	HM.2	HM.3	HM.4	HM.5	HM.6	HM.7
Chi-squared	14,01	9,71	36,59	20,90	13,86	3,62	3,58
df	df=7	df=7	df=7	df=7	df=7	df=7	df=7
p-value	0.05*	0.21	0.00*	0.00*	0.05*	0.82	p-value

$p \leq 0.05$.

4. Discussion

As stated by Mihajlovski et al. [36], stale bread can be used as a renewable resource, but the primary condition is the segregation of the raw material. According to Kumar et al. [37], segregation in households is most likely not feasible due to the high complexity and cost of adding waste fraction to the national collection system. Using bread waste as a raw material to create high-value products is a potential way to achieve a circular economy [37]. The condition is to develop alternative methods of waste reuse [38,39], which will minimize their negative impact on the environment and promote the long-term sustainability of our food production system [40,41]. In our study, every seventh respondent declared that stale bread is thrown away with other waste, which means that such waste cannot be used in an environmentally beneficial way. An analysis of bread disposal paths by Ananda et al. [42] showed that 55% of bread and bakery products are thrown into waste containers in Australian homes and ultimately end up in landfills. According to Brancoli et al. [32], feed, beer and ethanol production are the best alternatives for recycling bakery waste with donations, while anaerobic fermentation and incineration are the worst recycling options. Feed production saves 0.53 kg CO_2 equivalent per 1 kg of bread, while beer production saves 0.46 kg CO_2 equivalent [32]. A study conducted in Australia showed that 22% of unconsumed bread at home is used to feed animals [Ananda et al., 2024]. Almost one-third of the surveyed people declared that they fed animals stale bread. The leaders in the management of the discussed product were rural residents. This observation is unsurprising because, as Nath et al. [43] stated, using leftovers to feed farm animals is standard practice. However, such a possibility is significantly limited in cities. As our study showed, many city residents gave stale bread to people with animals or put it in a special place in the garbage. Also, in their study, Korzeniowska-Ginter et al. [44] observed the tendency of Polish society to separate bakery and pastry waste and place it in waste collection places despite the lack of special containers. The use of wasted food as animal feed can partially replace the production of traditional animal feed [45] and contribute to the creation of a circular economy, as well as achieving sustainable development [43].

According to Brancoli et al. [32], waste prevention is the path with the most significant environmental savings. According to Pietrangeli et al. [46], prevention and redistribution should be considered the most desirable options for bread surpluses, while alternative destinations for surplus products should be used only when prevention is impossible. Our study shows that less than 15% of the surveyed respondents do so, i.e., do not allow bread to go stale. An interesting observation is that the lowest percentage of rural residents and people spending more than 60% of their budget on food do not allow bread to go stale. At the same time, it should be emphasized that many rural residents process stale bread into bread crumbs and feed it to animals. However, the fact that people who spend a large part of their income on food are likely to avoid trying to prevent the bread from going stale may be because they are more price-conscious and buy lower-quality bread. In the study by Li et al. [47], Mallinson et al. [48], Setti et al. [49], and Bilska et al. [21] also, households with lower incomes wasted more food.

More than one-third of the respondents in our study declared that they prepare bread crumbs, and less than 14% use them to prepare other dishes. In the survey conducted by Śmiechowska and Chrzanowska [50], 38% of consumers declared that they process bread into bread crumbs, 18% into toasts, and 14% into croutons.

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The lowest percentage of people from the two youngest age groups declared that they had prepared breadcrumbs. In contrast, the highest rate of the youngest respondents threw away uneaten bread in the waste container. Ananda et al. [51] reported that people over 65 years of age throw away less bread and bakery waste than younger age groups in Australia. This observation is consistent with our results. Researchers have shown that younger consumers waste more food [22,47,52–56]. According to Li et al. [47], older people in China waste less food because they remember the famine of the 1960s. Bravi et al. [57–59] noted that many young consumers need help storing and recycling uneaten food due to their lack of cooking experience. Tomaszewska et al. [60] showed that almost 3/4 of respondents declared compliance with the storage conditions of food products recommended by manufacturers. In another study, as many as 96% of Polish respondents indicated correct storage conditions for bread. Therefore, in the case of this product, the critical factor may be the mismatch between the purchased quantity and the actual consumption [61]. The ability to plan purchases based on what is missing at home [62] allows avoiding excessive amounts of food [63]. Jörissen et al. [64] and Smith and Landry [65] observed that households that shop more often usually waste less food. The vast majority of respondents in our study bought bread every day or every other day on average. At the same time, no significant relationship was found between the frequency of bread purchase and most of the analyzed methods of managing stale bread, including throwing it away and preventing its staling. Ananda et al. [42] showed a positive relationship between the frequency of grocery shopping and the waste of bread and baked goods, except for sliced bread. Frequent visits to the store may lead to excessive buying of bread and baked goods. A similar conclusion was drawn by Østergaard and Hanssen [66], who found that people who waste more bread buy it more often and in larger quantities.

The results of our study showed that over 1/3 of the respondents declared that they bought bread in a small shop, while about 20% indicated a discount store and a specialized store, e.g. a bakery. The highest percentage of respondents who bought bread in a small shop and a discount store declared that they threw stale products into a container. Śmiechowska and Chrzanowska [50] stated that the most common causes of waste included low-quality bread and baking it from frozen dough, which quickly loses its taste. The fewest respondents who bought bread in a small chain store and a large-scale store threw away stale bread.

Limitation of this Study and Future Research

This study was based on interviews with respondents. The limitation is that respondents may not have declared their actual behaviour towards the discussed problem. The risk is that people filling out the questionnaire may have concealed important information and be ashamed of wasting bread.

Further research on consumer behaviour in bread wasting should include consumer motivations (e.g. pro-ecological) and consider, for example, lifestyle, use of catering, and pet ownership. Future research should be extended to include other socio-demographic factors not covered by this study, e.g., household structure.

5. Conclusions

The results of our study indicate that socio-demographic characteristics such as age, place of residence and employment status of the person influence the respondents' bread waste. It is a worrying observation that a significant percentage of young people behave in this way. It should be expected that these people will also manage bread in this way later in their lives. For this reason, it is essential to develop and implement various educational programs and campaigns to raise awareness of the problem of food waste, including bread, and to show how to counteract this phenomenon. Eliminating bread waste 100% is impossible, but showing consumers the most beneficial ways of managing it is essential. Many respondents, especially city dwellers, do not throw bread away with other waste but put it in a special place in the garbage. Private individuals can take such bread, but waste collection companies do not have such an option. Perhaps a good solution would be to introduce separate containers for bread to separate it from other waste fractions, enabling its management in a more environmentally beneficial way by the recommendations of the circular

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economy. However, it should be remembered that the most optimal solution is to reduce bread waste at the source.

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