

Article

The Role of Labels and Perceived Health Risk in Avoidable Food Wasting

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Abstract: An understanding of the consumer perception of health risks related to food expiration is a prerequisite for future food labeling system improvement in order to reduce environmental burdens. The aim of the study was identification, analysis, and assessment of consumer behavior in the context of food waste in households. The study was conducted using the direct interview method (face to face interviews) among a group of 1145 Polish consumers of food. The results show that consumers do not understand the differences between the concept of “use by” and “best before” labeling. Although rice, tea, and coffee were correctly perceived as safe during storage, there is a dissonance between consumer attitudes and behavior. The highest health risk was perceived as being due to consumption of expired “use by” dated milk (out of UHT milk, rice milk dessert, “best before” ready-to-eat meals and “use by” ready-to-heat meals, canned fruits, and fresh-cut salad). However, 51% of respondents still considered consuming it. Irrational consumer behavior poses a health threat as well as contributing to avoidable food waste. Social awareness campaigns are necessary to inform consumers about the monetary value of wasted food as well as about the environmental, social, and ethical impact of their behavior.

Keywords: health risk; food labeling; date labeling; consumer behavior; consumer attitudes; consumer perception; rationality; food expiration; food waste; sustainability

1. Introduction

In the “2030 Agenda for Sustainable Development”, a plan of actions to be tackled over the next years in the areas of people, planet, prosperity, peace, and partnership was established. Sustainable consumption and production were highlighted to support the needs of the present and future generations. Economic, social, and technological progress should occur in harmony with nature and the environment. In Goal 12 of Sustainable Development Goals (SDGs), regarding sustainable consumption and production patterns, halving per capita global food waste at retail and consumer levels by 2030 was postulated, as well as reducing food losses along production and supply chains [1]. The need for undertaking interventions at local and global levels arises based on existing data showing the scale of the problem of food waste and baring the inefficiency of the food system [2,3]. According to FAO estimates, one-third of edible parts of food produced for consumption is lost or wasted globally, constituting about 1.3 billion tons per year [4]. The level of food waste along the supply chain in the European Union covers one-fifth of its food production, reaching 88 million tons yearly worth 143 billion euros. The sector contributing the most to food waste (53% of cases) are households [5].

Apart from social, economic, and ethical implications, food waste also has a considerable environmental impact. Production of food that is not consumed causes inefficient use of resources

such as land, water, labor, and energy and unnecessary emission of greenhouse gases such as methane, which contribute to global warming. It was estimated that environmental footprints in average daily food waste per capita cover 58 L freshwater use, 124 g CO₂-eq, 0.36 m² cropland use, 2.90 g nitrogen, and 0.48 g phosphorus use [6]. Food waste has a contribution to fossil resource and water depletion, terrestrial acidification, aquatic eutrophication both in relation to nitrogen and phosphorus, ecotoxicity, mainly because of the use of herbicides and pesticides during farming, photochemical ozone formation, and global warming [7,8]. Kummur et al. [9] estimated that the production of lost and wasted food crops accounts for nearly one-quarter of total freshwater resources used in production (27 m³/cap/yr), 23% of total global cropland area (31×10^{-3} ha/cap/yr), and 23% of total global fertilizer use (4.3 kg/cap/yr). Scherhauser et al. [10] found that 186 Mt CO₂-eq, 1.7 Mt SO₂-eq, and 0.7 Mt PO₄-eq can be attributed to food waste in Europe, which covers up to 16% of the total impact of the entire food supply chain. Preventive actions and solutions regarding food processing, wholesale and retail, foodservice, and households are implemented to reduce the environmental burden of food waste [3,11,12].

During the storage of food products, several changes that have an impact on their quality and safety occur. Depletion of sensory attractiveness, physiochemical deterioration, microbial growth, and decreasing nutritional value in function of time negatively affects usability and fitness for consumption [13,14]. The shelf life of food is a function of many variables, which include the composition, properties, and quality of the raw material, conditions, and methods of processing, preservation and packaging, distribution, time and conditions of storage, displaying, and consumer use. Storage stability of similar products may be different according to technological parameters of production and intrinsic factors on the product side [15,16]. For example, fruits, milk, rice, or convenience food during storage may be microbiologically stable or not, according to the technology of their preservation. Drying or sterilization makes food microbiologically stable, but the use of the modified atmosphere or mild thermal conditions only helps to a certain degree (pasteurized milk has a shorter shelf life than milk subjected to UHT sterilization) [17]. An idea grew from this concept to distinguish microbiologically stable foods from highly perishable products. In situations where pathogen microorganism growth can take place, leaving food beyond a certain date can result in the food being dangerous to eat and raising the risk of food poisoning. However, in most cases, food stored for a long time does not immediately become dangerous for human consumption, despite the fact that it may no longer conform to a set of given quality requirements and its attributes may not be satisfactory for consumers [18]. Along with the expansion of industrial production, consumers were deprived of much information on the manufacturing process such as the means of processing or the date of food production. Moreover, their knowledge about food properties and storage stability may be limited, existing threats very often are not perceivable by human senses, therefore consumers experience difficulties in assessing the health risk. The first activities in the area of informing consumers about the shelf life of food have been taken by producers on a voluntary basis a long time ago, but over time, appropriate food labeling schemes have been developed—initially at the level of retail chains, up to the relevant legislation adopted at national or international levels [19]. In line with the presented concept of safety risk, some national and European regulations imposed a system in which perishable food is labeled with the “use by” date, in contrast to microbiologically stable foods, which are marked with the “best before” date (minimum durability date). The assumption of this system was that the label helps the consumer to gain knowledge on the food that may pose health risks after expiration [20].

There are differences in perception and understanding of shelf life dates, even between countries in which food law is unified. The percentage of people believing that food should not be eaten past the “best before” date was in the range from 5–6% (in Finland and Sweden) to 64% in Romania, 54% in Greece and Cyprus, and 48% in Poland [21]. Demographic, socioeconomic, psychographic, and behavioral factors were considered in the literature as predictors of shelf life date perception, mainly in the context of emerging interest in reducing food waste [22–24]. The current approach toward consumer perception of the shelf life of food assumes that there is an interaction between the consumer and the food product in relation to time [25]. Earlier studies show that loss of food acceptance

during storage depends on consumer knowledge of the dating system, preferences, and attitudes [26]. Uncertainty about freshness and safe consumption is considered an important factor in deciding about discarding food past the “best before” date. It was found that parents pay special attention to food quality, and in consequence, if they are not sure of its safety, they are more careful and willing not to eat outdated foods [11,27]. In Poland, uncertainty about freshness of food and its suitability for consumption was identified by 28% of consumers [28].

Quite a large percentage of European consumers think that the meaning of “best before” date depends on the type of food: such a declaration was made by 45% of consumers in Austria, 37% in Luxemburg, and 35% in Finland and Denmark [21]. The results of the previous studies suggest that consumer assessment of fitness for consumption depends on the food category. Some food categories such as cookies, chocolate, and cereals are perceived as safe past expiration. On the other hand, consumers have doubts and see health risk in the consumption of overdue milk, meats, juices, and ready-to-eat foods [14,29–31]. Consumers rarely refer their judgments to technological aspects of food production or preservation and make no distinction between, for example, fresh and sterilized milk. Existing data suggest that lack of education in the area of food labelling concepts and lack of knowledge about technical aspects of food production contribute to individual interpretation of on-pack information [32]. Greek schoolchildren indicated that they were never informed about the difference between “best before” and “use by” terms, even though they find the “best before” label on almost every product they usually purchase themselves [33].

Confusion in interpreting labels may lead consumers to reject and throw away edible food [11,34–37]. Hall and Shah [38] highlighted the role of expiration dates as important point-of-purchase information. The study showed the inconsistencies of expiration date labeling in the United States, the negative consequences of the confusion it can cause, but also demonstrated that expiration dates impact how consumers iteratively think, feel, and act on the path to purchase.

Additionally, other studies and reports proved that the existing solutions are not clear for consumers [21,39–41]. Some of them exhibit restrictive treatment of the “best before” term and believe that passing the minimum durability date is related to health risk. This attitude was shown by 10–20% of respondents in the USA and UK, while in Europe, consumers were more restrictive [21]. In addition, it has been noted that some consumers impose safety margins on the dates indicated on the packaging, reducing the time limits compared to those set by the manufacturer [40,41]. Research results show that consumers are more likely to throw out expired products when the perceived health risk is higher (e.g., when they are afraid of food poisoning) [29,40]. For this reason, consumers’ health care, in combination with the lack of understanding the conceptional differences between “use by” and “best before” date formats, contributes to unnecessary discarding of edible food, which indeed does not pose a risk to human health [42]. It is estimated that at least 380,000 t of food are discarded in the UK after “best before” expiration [43]. Correct perception of health risk in relation to food expiration can make a significant contribution to reducing food wastage, which in turn can contribute positively towards the Sustainable Development Goals (SDGs). The role of perceived health risk in avoidable food wasting, regarding the situation when the food is still fit to eat and safe, is not well known. Understanding of consumer perception of health risks related to food expiration is a prerequisite for future food labeling system improvement in order to reduce environmental burdens. Therefore, the main aim of the study was identification, analysis, and assessment of consumer behavior on the food market in the context of its waste in the household. The specific research objectives concerned perceived health risk in relation to expired food, in particular:

- Identifying the attitudes of consumers (members of households) in relation to selected food products (whose packaging has not been opened) whose shelf life has expired (past minimum durability or “use by” date);
- Identification of consumer attitudes toward selected food products (whose packaging has not been opened) whose shelf life has expired (past minimum durability or “use by” date) in relation to knowledge and correct interpretation of shelf life labeling;

- Diagnosis and assessment of health risk perceived by consumers (members of households) associated with the consumption of expired perishable and shelf-stable foods, including identification of health risk determinants of expired food.

2. Materials and Methods

Empirical research on consumer behavior in the context of food waste was conducted using the face to face interview method in the period from April to May 2019. The research tool was an interview questionnaire prepared and verified in piloting. The interview questionnaire contained 20 questions thematically divided into the following sections related to determinants of consumer purchasing behavior on the food market in Poland: perception and understanding of information about food durability by consumers, consumer behavior related to food waste in households, and perception of health risk of food consumption in the context of food waste in households. In addition, the interview questionnaire included questions allowing the identification of respondents in terms of demographic, economic, and social characteristics (e.g., sex, age, place of residence, material status, education, number of household members, number of children in the household).

Nominal and ordinal scales were used in the questionnaire, including the Likert scale, i.e., a bipolar interval scale. The questionnaire uses nominal scales of multiple and single choice. The reliability of the construction of the questionnaire was verified by the Alpha-Cronbach test (the coefficient α oscillated between 0.7–0.9).

The research population was consumers declaring the systematic purchase of food products. The selection of the research sample (N = 1145) was carried out by the quota method (selection criteria: sex, age, and place of residence), which met the demand for maintaining the relative representativeness of the research population. In the process of empirical data analysis, the IBM SPSS Statistics tool was used, which allowed the analysis of the results of the statistical description, correlation analysis, and exploratory factor analysis. The detailed structure of the research sample is presented in Table 1.

Table 1. Structure of the research sample.

Variable	Characteristic	Frequency (%)
Gender	female	45.3
	male	54.7
Age	under 19	2.2
	20–29	17.3
	30–39	20.0
	40–49	13.4
	50–59	14.8
	60+	32.4
Material status	definitely above the national average	8.2
	above the national average	18.1
	the national average	35.5
	below the national average	24.8
	definitely below the national average	13.4
Place of residence	traditional village	12.3
	village by the city	7.1
	city up to 20,000	5.2
	city 21,000–50,000	4.9
	city 51,000–100,000	12.4
	city over 100,000	58.1
Number of household members	1	13.5
	2	32.3
	3	22.2
	4	21.3
	5+	10.7
Number of children in the household	0	3.3
	1	54.3
	2	20.8
	3	15.6
	4+	6.0

Source: own research.

3. Results and Discussion

3.1. Consumer Attitudes Toward Expired Food

As already mentioned, one of the specific objectives of the study was to identify and evaluate the attitudes of consumers in Poland toward food products that have expired. The above referred to selected food products whose packaging has not been opened and that were labeled with the minimum durability date (“best before” for UHT milk, rice (dry, for cooking), ready-to-eat meals, canned fruits) and “use by” date (for pasteurized fresh milk, rice milk dessert, ready-to-heat meals, fresh-cut fruit salad). The research issues were:

- Identification of consumer behavior in Poland regarding expired food products (provided that they have not been opened);
- Diagnosis of whether and to what extent there are differences in the behavior of consumers in Poland with expired perishable food products versus shelf-stable foods (within the same food category).

For foods labeled with a minimum durability date, the results of the study are presented in Table 2.

Table 2. Handling of unopened foods whose minimum durability (‘best before’) date passed a month ago.

Product	Course of Action	Total (%)	Women (%)	Men (%)
UHT milk	consume	3.1	2.9	3.1
	throw out	67.1	68.6	65.6
	process	3.5	4.0	2.9
	donate	2.5	3.1	1.8
	will taste and consume if it will not raise concerns	23.7	21.4	26.6
rice	consume	24.7	25.3	23.5
	throw out	25.5	25.2	26.4
	process	7.6	9.4	5.7
	donate	4.2	3.9	4.5
	will taste and consume if it will not raise concerns	38.0	36.3	39.9
ready-to-eat meal	consume	3.2	2.9	3.5
	throw out	58.8	61.3	55.9
	process	4.2	3.9	4.3
	donate	4.0	4.5	3.3
	will taste and consume if it will not raise concerns	29.8	27.4	32.9
canned fruits	consume	5.0	4.8	4.7
	throw out	45.3	44.3	47.0
	process	6.4	7.4	5.1
	donate	3.7	4.5	2.5
	will taste and consume if it will not raise concerns	39.7	39.0	40.7

Source: own research.

Analyzing the results in Table 2 regarding consumer behavior with shelf-stable foods (UHT milk, rice for cooking, ready-to-eat meal, and canned fruit) whose minimum durability date has passed a month ago, it can be concluded that consumer behavior depends on the type of food product. Therefore, for milk, ready meals, and canned fruits whose minimum durability date has passed a month ago, only a small percentage of consumers declare that they will consume such a product (respectively: 3.1%, 3.2%, 5.0%); also a small percentage of consumers indicate that they will process

these products (3.5%, 7.6%, and 6.4%, respectively) or give them to others (respectively: 2.5%, 4.2%, and 3.7%). However, in the case of rice for cooking, as much as 24.7% of consumers surveyed declare that they will consume this product. A small percentage of consumers declare that they will process it (7.6%) or donate it (4.2%). Consumers also declare that they will taste the products, and if they do not raise concerns, they will decide on consumption. This is true for 39.7% of consumers surveyed in the case of canned fruit and 38% of consumers in the case of rice for cooking, while it is true for a slightly smaller percentage, 29.8%, in the case of ready-made meals and the lowest, 23.7%, in the case of UHT milk. As for consumers who declare that they will throw away products, the highest percentage of such consumers occurs in the case of UHT milk (67.1%), slightly lower in the case of the ready-to-eat meal (58.8%) and canned fruits (45.3%), and the smallest for cooking rice (only 25.5% of consumers, which is the smallest percentage of indications for tested products).

Analyzing the declared behavior of the surveyed consumers in Poland by gender (Table 2), it can be stated that sex does not differentiate consumer behavior in the studied area—differences between women and men in the treatment of selected food products whose date of minimum durability has passed are insignificant and oscillate at a maximum of five percentage points.

The results presented in Table 2 suggest that consumers are not able to correctly interpret the date of minimum durability (“best before”) food. Shelf-stable products that have exceeded the date of minimum durability by a relatively short period (one month) may lose sensory qualities (change in smell, consistency), but their consumption is not related to health risk [44], so the best way to handle such products is to taste and consume them if they are not objectionable. Throwing them out is unreasonable, uneconomical, and highly unethical.

As already mentioned, the study also analyzed consumer declarations regarding the handling of perishable foods labeled with the “use by” dates. The results of the study in the above scope are presented in Table 3. Analyzing the results in Table 3 regarding consumer behavior regarding perishable foods (pasteurized fresh milk, rice milk dessert, ready-to-heat meals, and fresh-cut fruit salad, which expired three days ago), it can be seen that consumer declarations do not differentiate within the product category, as was the case with shelf-stable food products (Table 2). It seems that the surveyed consumers are aware of the risk posed by the consumption of food whose expiry date has passed—a small percentage of consumers in Poland declares that they would eat the tested food products three days after the expiration date (for fresh milk, milk-rice dessert, ready-made meal, and fruit salad: 5.6%, 8.8%, 7.2%, and 5.2%, respectively). Additionally, a small percentage of consumers declare that they would process these food products (respectively: 5.9%, 1.0%, 3.1%, 3.9%) or give them to others (respectively: 1.7%, 2.3%, 2.7% and 1.7%).

In the case of consumers who declare that they would not consume the tested food products when they exceed the expiry date, it should be noted that the largest percentage of those products are fresh-cut fruit salad and fresh milk (respectively, 49.9% and 49% positive indications) and milk-rice dessert and ready-to-heat meals (slightly smaller, 42.7% and 41.6% responses, respectively). Thus, it can be assumed that consumers perceive greater risk in the consumption of milk and fruit whose shelf life has expired, and definitely lower risk in the case of ready meals and milk-rice desserts. The result is in agreement with the study of other authors who noticed that the safety of milk is usually a matter of health concern during the consideration of shelf life dates [29,45]. Visschers et al. [27] noticed that higher perceived health risks were related to more waste from dairy products. Liem et al. [46] in turn noticed that the consumer perception of UHT and pasteurized milks is affected by cross-cultural differences. In turn, analyzing consumer declarations, i.e., “I will taste and consume if it will not raise concerns”, it can be stated that the largest percentage of consumers will do this in the case of milk-rice dessert and ready-to-heat meals (respectively: 45.3% and 45.4%), with a slightly lower percentage for pasteurized fresh milk and fresh-cut fruit salad (39.6% and 37.8%). These results testify to the lack of consumer knowledge about the composition and properties of food, as well as the risks associated with the consumption of food whose expiration date has expired, as fresh food whose expiration date has passed should not be tried and consumed at all. Rahelu [47] noticed that there were many articles

in the daily press which tried to educate consumers by encouraging them to use the smell, texture, and color of food as a means of determining its safety after its “use by” date, even though bacteria such as *Salmonella*, *E. coli*, and *Listeria* cannot be detected in this way.

Table 3. Handling of unopened foods whose “use by” date passed three days ago, %.

Product	Course of Action	Total (%)	Women (%)	Men (%)
pasteurized fresh milk	consume	5.6	4.4	7.0
	throw out	49.0	51.9	45.6
	process	5.9	6.6	4.9
	donate	1.7	1.9	1.6
	will taste and consume if it will not raise concerns	37.8	35.2	40.9
rice milk dessert	consume	8.8	7.8	9.8
	throw out	42.7	44.6	40.9
	process	1.0	1.5	0.4
	donate	2.3	2.6	1.8
	will taste and consume if it will not raise concerns	45.3	43.6	47.2
ready-to-heat meal	consume	7.2	6.5	8.0
	throw out	41.6	45.8	37.1
	process	3.1	3.4	2.7
	donate	2.7	2.9	2.3
	will taste and consume if it will not raise concerns	45.4	41.5	49.8
fresh-cut fruit salad	consume	5.2	4.7	5.8
	throw out	49.6	53.7	45.2
	process	3.9	4.7	2.7
	donate	1.7	1.6	1.8
	will taste and eat if it will not raise concerns	39.6	35.3	44.4

Source: own research.

Analyzing the declared handling of food of the surveyed consumers in Poland by gender (Table 3), it can be stated that gender does not, in principle, differentiate consumer behavior in the examined area. Only in the case of the answer “throw out” in relation to the studied categories of perishable food products whose expiry date has passed three days ago, a higher percentage of women in relation to men declare such behavior (e.g., in the case of fruit salad, 53.7% women and 45.2% men, and in the case of ready-to-heat meals, 45.8% women and 37.1% men). The results may suggest that women perceive greater health risk related to consuming of expired perishable foods than men. For the other options, the differences in the behavior of women and men are insignificant.

A highly interesting research issue is to compare consumer behavior regarding expired shelf-stable food products (marked with the minimum durability date) and perishable foods (marked with the “use by” date). Having in mind the case of expired shelf-stable products, it is rational to consume, process, and donate the food, while throwing it away is completely unreasonable. On the other hand, in the case of perishable products whose shelf life has expired, the only rational way for consumers is to throw away this food, while tasting, consuming, processing, or donating it to others involves a high health risk.

A comparative analysis of rational and irrational consumer behavior in relation to food that has expired has been included in Table 4.

Table 4. Rationality of consumer behavior during the handling of foods with different date types, %.

Behavior	Milk		Rice		Ready Meal		Fruits	
	UHT Milk	Pasteurized Fresh Milk	Rice	Rice Milk Dessert	Ready-to-Eat Meal	Ready-to-Heat Meal	Canned Fruits	Fresh-Cut Fruit Salad
rational	32.9	49.0	74.5	42.7	41.2	41.6	54.7	49.6
irrational	67.1	51.0	25.5	57.3	58.8	58.4	45.3	50.4

Source: own research.

Analyzing the results contained in Table 4 regarding consumer declarations regarding rational or irrational behavior related to food products whose shelf life has expired, it can be seen that in the case of most of the tested products, a much higher percentage of consumers in Poland declare behavior that is unreasonable. The above applies to UHT milk, pasteurized fresh milk, rice milk dessert, ready-to-eat meal, ready to-heat-meals, and fresh-cut fruit salad. The product within the categories analyzed, for which a significantly higher percentage of rational behavior is noticeable, is cooking rice—as many as 74.5% of consumers declare that they would taste, consume, and donate this product to others, even if it was one month overdue. Additionally, in the case of outdated canned fruit, a higher percentage of consumers declaring rational behavior can be observed (albeit definitely lower than in the case of rice). Consumer confusion about different kinds of labels that lead people to discard edible food and accept products that may pose a health threat was earlier presented in studies conducted in other countries [11,35,48,49]. In the study of Van Boxtael [29], 40% of respondents stated that they would have thrown out UHT milk after expiration. More rational behavior toward outdated rice and canned foods, in comparison to UHT milk, may be a result of common knowledge and conviction that these products have a relatively long shelf life due to applied technological processes [50].

Improper, irrational behavior of consumers towards expired food has the following consequences:

- in the case of perishable food products, it is associated with a high health risk (e.g., 57.3% of consumers would taste, consume, or donate an expired rice milk dessert; 50.4% of consumers would do the same with an expired fresh-cut fruit salad);
- in the case of shelf-stable products, it is associated with the generation of food waste, and at the same time, an increase in food waste in households (e.g., 67.1% of consumers would not consume expired UHT milk, which is synonymous with its disposal; 58.8% of consumers would do the same with the expired ready-to-eat meal).

The results of the study in relation to the above issues indicate that consumers in Poland do not know how to properly handle food products that have expired. It is worrying that the knowledge and awareness of consumers in this area is at a low level. In addition—the vast majority of food consumers in Poland are not able to correctly interpret the concept of a “best before” date, which is indicated by a high percentage of consumers who declare that they will discard a product that has exceeded this date by a month (e.g., in the case of UHT milk, as much as 67.1% of indications). Consumers in Poland are also unable to interpret the concept of “use by” correctly, as indicated by a relatively high percentage of consumers who declare their willingness to taste and consume an expired product (e.g., in the case of a ready-to-heat meal, 58.4%). Analyzing the results of the study, it can be assumed that consumers are not aware that the term “best before” means the same in the case of all categories of food products, which in turn indicates the diversity of consumer attitudes towards products that exceed this date by a month (in the case of rice for cooking, 24.7% of consumers declare consumption, while in the case of UHT milk, only 3.1%). In addition, it can be seen that a small percentage of consumers in Poland (3.5–7.6%) declare that they will process a food product whose date of minimum durability has been exceeded by a month (and what is important—the product has not been opened), which may indicate a great deal of concern for the qualities of the product, including health aspects.

3.2. Perceived Health Risk Related to Consuming of Expired Foods

Due to the fact that a relatively high percentage of consumers act irrationally with food products whose shelf life has expired, it seems reasonable to diagnose whether and to what extent consumers perceive the health risks associated with expired food. As already mentioned, the irrational behavior of consumers manifests itself in two ways: not consuming (throwing away) shelf-stable food that has expired and consuming (possibly tasting, donating) expired perishable food. In view of the above, the following research questions were posed:

1. Do consumers perceive, and to what extent, the health risk related to expired perishable and shelf-stable food products?
2. In what areas do consumers perceive the risk associated with the consumption of expired food?

Table 5 presents the results related to the consumer perceived risk regarding expired food. The risk perceived by consumers was assessed on a Likert scale. The values on the Likert scale were: value 1 meant “low risk”, value 2 was “rather low risk”, 3 was “medium risk”, value 4 “rather high risk”, while value 5 was “high risk”.

Table 5. Perceived health risk related to expired perishable and shelf-stable foods (mean values and standard deviations).

Risk		Milk		Rice		Ready Meal		Fruits		s
		UHT Milk	Pasteurized Fresh Milk	Rice	Rice Milk Dessert	Ready-to-Eat Meal	Ready-to-Heat Meal	Canned Fruits	Fresh-Cut Fruit Salad	
the product's decreased health safety	\bar{x}	3.93	4.24	2.19	3.86	3.68	3.74	3.28	3.79	3.59
	s	1.179	1.034	1.122	1.051	1.161	1.139	1.051	1.171	1.049
a change in the product's appearance	\bar{x}	3.36	3.86	2.09	3.61	3.42	3.54	3.14	3.80	2.91
	s	1.287	1.122	1.251	1.051	1.214	1.209	1.258	1.155	1.121
a change in the product's taste, smell, or consistency	\bar{x}	3.98	4.31	2.39	3.91	3.79	3.79	3.46	3.97	3.70
	s	1.141	0.976	1.334	1.051	1.122	1.150	1.228	1.129	1.142

Source: own research.

Analyzing the results contained in Table 5 regarding the perceived risk associated with expired food in terms of areas and the value of this risk, it can be seen that the highest risk among the indicated is associated with a change in the taste, smell, or consistency of the product ($\bar{x} = 3.70$) and a decrease in the product's health safety ($\bar{x} = 3.59$); the smallest is the risk of the change in product appearance ($\bar{x} = 2.91$). In turn, taking into account storage stability, it turns out that consumers perceive the highest risk associated with an expired product in relation to perishable foods with short shelf life and a slightly smaller risk in the case of shelf-stable food products that are marked with minimum durability dates.

When analyzing in detail the risk perceived by consumers in relation to food categories (milk, rice, ready meals, fruits), storage stability (perishable or shelf-stable) and risk indicators (reduction of health safety, change in product appearance, change in taste, smell or consistency), it can be seen that:

- The surveyed consumers in Poland perceive the highest health risk in the case of pasteurized fresh milk, fearing mainly the change in taste/smell/consistency ($\bar{x} = 4.31$) and the reduction of the product's health safety ($\bar{x} = 4.24$). A high risk is also seen for fresh-cut fruit salad and relates to changes in taste, smell, and consistency ($\bar{x} = 3.97$).
- The smallest risk is seen in the case of rice for cooking and relates to a change in the appearance of the product ($\bar{x} = 2.09$). Consumers' concerns regarding the change in the taste, smell, and consistency of rice for cooking and the reduction of its health safety are slightly higher—the average is 2.39 and 2.19, respectively (although the values are low compared to other products tested).
- In the category of shelf-stable products, consumers perceive the greatest risk associated with expired products in the case of UHT milk, followed by ready meals and canned fruit (average over 3), with the smallest, as already mentioned, in the case of rice.

- In the category of perishable foods, consumers perceive the greatest risk associated with expired products in the case of pasteurized fresh milk (average above 4), and in the case of other products (rice dessert, fresh-cut fruit salad, ready-to-heat meals), the level of risk is similar and oscillates around $\bar{x} = 3.7$.
- The analysis of the results presented in Table 5 indicates that two of the product categories examined show significant deviations in terms of health risk perceived by consumers—these are pasteurized fresh milk and rice.

In the case of expired pasteurized fresh milk, consumers perceive the greatest risk to be the decreased health safety ($\bar{x} = 4.24$). In turn, rice is a product characterized by—according to the study—the smallest perceived risk associated with a change in appearance ($\bar{x} = 2.09$) and a reduction in the health safety of the product ($\bar{x} = 2.19$).

In conclusion, it can be stated that in the context of expired food, consumers are most afraid of changes in taste, smell, and consistency, which significantly affect the quality of food. These attributes usually cannot be assessed at the moment of purchase, especially if food is packed. Alongi et al. [51] and Wilson et al. [52] proved that foods with approaching expiration dates are more likely to be wasted than products with a later expiration date. According to the research of Williams et al. [53], food that has passed its best before date was the reason for almost half of the milk wastage. In light of the previous data, the results of our study suggest that due to the inability to undertake a sensory quality assessment during purchase, consumers are willing not to buy food products that are near expiration. As we proved, the health risk perceived by Polish consumers related to expired food products is relatively high for the products tested—the average is above 3 (except for rice). The risk perceived by consumers is higher in the category of perishable food products with a short shelf life, which is the most reasonable. In turn, the relatively high health risk perceived in the case of expired shelf-stable food is unfounded. As already mentioned, shelf-stable products whose date of minimum durability has expired may be characterized by reduced sensory attributes (change of smell, consistency), but their consumption does not pose a threat to consumer health. Thus, the attitudes of consumers in this area are highly worrying and testify to the low level of knowledge and low awareness about the characteristics and properties in the field of food quality.

The standard deviation indicate a large differentiation of the risk assessments related to expired food (Table 5). For that reason, an exploratory factor analysis was performed, which helped identify the key determinants of risk perceived by consumers in relation to the expired perishable and shelf-stable foods. In accordance with the procedure for verifying the correctness of the application of this method, Bartlett sphericity tests were carried out, and the Kaiser–Meyer–Olkin index was calculated (Table 6). The obtained KMO value is 0.854, which justifies the advisability of using exploratory factor analysis (it can be assumed that in this case the level of correlation between the factors is high).

Table 6. Table KMO index and Bartlett’s test.

Measure of Kaiser–Meyer–Olkin Drawing Adequacy	0.854	
Bartlett sphericity test	Approximate Chi-square value	14,038.641
	Degrees of freedom (df)	256
	Significance	0.000

Source: own research.

Identification of the number of factors (components) was obtained based on the Kaiser criterion, which says that if the eigenvalue of a given factor is not greater than 1, then it should not be taken into account. In further analysis, this means that the variance explained is not greater than that explained by a single input variable [54]. Then, using the principal components method with varimax rotation, factor loadings were calculated. The minimum value of the factor load was adopted at the level of 0.6.

Table 7 provides detailed results for the first seven main components that explain more than 70% of the common variation, while the other components were removed as insignificant.

Table 7. The most important risk related to expired perishable and shelf-stable foods (value of factor loadings obtained by exploratory factor analysis).

Risk Related to Expired Perishable and Shelf-Stable Foods	Components/Values of Factor Loadings						
	1	2	3	4	5	6	7
UHT milk—the product’s decreased health safety		0.749					
UHT milk—A change in the product’s appearance			0.696				
UHT milk—A change in the product’s taste, smell or consistency				0.716			
rice—the product’s decreased health safety							0.693
rice—A change in the product’s appearance							0.836
rice—A change in the product’s taste, smell or consistency							0.841
ready-to-eat meal—the product’s decreased health safety							
ready-to-eat meal—A change in the product’s appearance	0.602						
ready-to-eat meal—A change in the product’s taste, smell or consistency							
canned fruits—The product’s decreased health safety	0.631						
canned fruits—A change in the product’s appearance	0.754						
canned fruits—A change in the product’s taste, smell or consistency	0.760						
pasteurized fresh milk—The product’s decreased health safety		0.767					
pasteurized fresh milk—A change in the product’s appearance			0.746				
pasteurized fresh milk—A change in the product’s taste, smell or consistency				0.680			
rice milk dessert—The product’s decreased health safety		0.665					
rice milk dessert—A change in the product’s appearance			0.651				
rice milk dessert—A change in the product’s taste, smell or consistency				0.646			
ready-to-heat meal—The product’s decreased health safety							
ready-to-heat meal—A change in the product’s appearance						0.680	
ready-to-heat meal—A change in the product’s taste, smell or consistency						0.635	
fresh-cut fruit salad—The product’s decreased health safety					0.735		
fresh-cut fruit salad—A change in the product’s appearance					0.729		
fresh-cut fruit salad—A change in the product’s taste, smell or consistency					0.743		

Source: own research.

The results of exploratory factor analysis included in Table 7 allow the identification of the following key determinants of risk related to the consumption of expired perishable and shelf-stable foods:

- Factor 1: overall risk (both for the product’s decreased health safety and a change in the product’s appearance, taste, smell, or consistency) for canned fruits and risk of change in the product’s appearance related to ready-to-eat meals
- Factor 2: the risk of the product’s decreased health safety for dairy products (UHT milk, pasteurized fresh milk, and rice milk dessert).
- Factor 3: the risk of a change in the product’s appearance for dairy products (UHT milk, pasteurized fresh milk, and rice milk dessert).
- Factor 4: the risk of change in the product’s taste, smell, or consistency for dairy products (UHT milk, pasteurized fresh milk, and rice milk dessert).

- Factor 5: overall risk (both for the product's decreased health safety and a change in the product's appearance, taste, smell, or consistency) related to fresh-cut fruit salad.
- Factor 6: the risk of deterioration in sensory quality (a change in the product's appearance and product's taste, smell, or consistency) for ready-to-heat meals.
- Factor 7: overall risk (both for the product's decreased health safety and a change in the product's appearance, taste, smell, or consistency) for rice.

The risk determinants for expired foods identified in exploratory factor analysis indicate that in the case of ready-to-eat meals, fresh-cut fruit salad, and rice, consumers perceive the risks associated with expired food consumption in general. Such risk applies to the appearance of these products, changes of sensory quality, and the product's decreased health safety (in addition, in the case of rice, the identified factor is the least significant). In contrast, in the case of an expired ready-to-heat meal, consumers perceive the risk of deterioration in sensory quality (a change in the product's appearance, taste, smell, or consistency). On the other hand, dairy products (UHT milk, pasteurized fresh milk, and rice milk dessert) are products for which the health risk is perceived by consumers in an insightful way—as shown in Table 7, the most significant risk for consumers is the risk of a product's decreased health safety and risk of a change in the product's appearance.

An important element of the analysis was also the issue of interdependence (strength of the relationship) between demographic and economic features differentiating the examined consumer community in Poland and indications regarding perceived risk in the event of expired food. Since the mentioned demographic and economic features mainly have a qualitative character and the answers are represented on the ordinal scale, the Spearman's rank coefficient was used to measure the strength of the relationship [55]. The analysis of the strength of the relationship covered all demographic and social features characterizing the research unit included in the study. In the case of farm size, material status, and place of residence in relation to UHT milk (decrease in the product's health safety), it showed a causal relationship, statistically significant at the significance level of 0.05, but at a very low level of 0.07 (Table 8). In the case of the other analyzed products, statistically significant relationships appeared incidentally, but with low values. Therefore, it is difficult to talk about the existence of a clear correlation between these features and the perceived risk of expiring food.

Table 8. Spearman coefficient values for selected demographic and economic features and perceived risk in relation to expired UHT milk.

Risk	Statistics	Demographic and Economic Variables		
		Education	Material Status of Family	Place of Residence
decreased health safety	correlation coefficient	0.070 *	0.062 *	0.063 *
	relevance (two-tailed)	0.023	0.043	0.042

* Correlation is significant at $p < 0.05$ (two-tailed). Source: own research

As the rank factor did not, in principle, indicate the existence of significant correlations, an analysis of variance (ANOVA) was also used to investigate the significance of the impact of the same demographic and economic factors on the perceived risk assessment in expired food. The analysis results obtained were different from the results for the Spearman coefficient, but also not very satisfactory. The generalized test of differences between the average indicated only the material status and the number of children on the farm as factors affecting the perceived risk in the case of UHT milk (decrease in the product's health safety). Additionally—on the basis of post-hoc tests (in this case, the Student–Newman–Keuls test), it allowed for the formulation of conclusions regarding differences or similarities in the values of grades in the case of UHT milk (for each feature, there were two medium groups that differed significantly). Thus, only in the case of UHT milk, there are statistically significant correlations between the perceived health risk and the material status and number of children in the consumer's household. In view of the above, it was considered that it is not justified

to make dependencies of the perceived risk of expired products in relation to demographic and economic variables, due to the fact that significant correlations occurred in the case of only one of the tested products.

An interesting research issue is also the analysis of the relationship between food products, where consumers perceive the highest health risk, and rational or irrational behavior in relation to such products. As already mentioned, consumers perceive the highest risk in relation to expired pasteurized fresh milk ($\bar{x} = 4.24$), so it could be assumed that consumers will handle this product rationally, i.e., discard it after its shelf-life. Meanwhile, it turns out that as many as 51.0% of consumers surveyed in Poland declare that they will taste, donate, or consume expired “use by” milk. Similarly, in the case of expired fresh-cut fruit salad, the level of risk perceived by consumers as to reducing the health safety of the product is relatively high ($\bar{x} = 3.79$), and 50.4% of respondents declare irrational behavior in relation to this product. Similar relationships can be seen for the other product categories studied, except for rice. Rice (a shelf-stable product with a long shelf life) has a low perceived risk of reduced health safety ($\bar{x} = 2.19$) and a relatively small percentage of consumers will act unreasonably if it expires—25.5% will discard such a product. In view of the above, it can be assumed that consumers in Poland are aware of the health risk associated with the expired fresh food product, but declare irrational ways of dealing with such products. It should be expected that the vast majority of consumers in Poland—since they perceive health risk—will declare that they do not consume expired fresh products. Unfortunately, it turns out that Poles are highly inconsistent in this matter, which may be due to ignorance, economic premises (savings), or low awareness regarding the ways of dealing with expired food. Studies conducted in the UK showed that there is no strong relation between the understanding of shelf life dating and proper handling of food. The percentage of correct answers was larger when consumers were only asked about definitions, and decreased when it was necessary to indicate how to proceed in a specific situation [40]. Interesting remarks were made by Tonkin et al. [56], who noticed that the level of risk relevant to the food issue addressed by a label created important exceptions. Some kinds of information like allergy statements were identified by consumers as something industry would “take very seriously”, while nutrient content claims “they might play around with”. On the basis of obtained responses, we can suppose that shelf life information given as “use by” or “best before” date may be treated as the second case.

3.3. Indicators of Perceived Health Risk

The last research issue analyzed was a detailed identification of health risk determinants that consumers perceive when consuming an expired food product. The vast majority of Polish consumers (Table 5) declare that they do not consume food products whose shelf life has expired (which—as already mentioned—in the case of shelf-stable products is unfounded). Thus, one of the next research goals is to identify the health risk determinants of expired food in the event of its consumption. Three product categories were analyzed: milk, juice (with variants: shelf-stable and perishable), and coffee/tea. The results are presented in Table 9.

Table 9. Indicators of perceived health risk in the case of consumption of expired food products, (%).

The Expired Product Can Be	Product				
	UHT Milk	Pasteurized Juice	Coffee/Tea	Pasteurized Fresh Milk	One-Day Juice
unpalatable	42.5	44.1	43.0	33.4	37.4
unsafe for elders	4.8	4.9	2.7	5.3	5.2
unsafe for kids	8.1	6.7	5.5	7.8	6.4
unsafe for all consumers	38.6	33.3	10.3	49.8	43.1
I don't know	6.0	11.2	38.5	3.7	8.0

Source: own research.

The results presented in Table 9 indicate that the determinants of health risk perceived by consumers in Poland in the case of consumption of expired products depend largely on the product category and its shelf life (perishable and shelf-stable). Therefore, in the case of coffee or tea, i.e., products with a long shelf life, risk is perceived to the greatest extent with the fact that these products will be unpalatable after expiration (43% of indications). A small percentage of consumers in Poland believe that expired coffee/tea will be unsafe for the elderly (only 2.7% of indications), unsafe for children (5.5% of indications), and unsafe for all consumers (10.3% of indications). Interestingly, a fairly high percentage of consumers (38.5%) declare that they do not know the risk of consumption of expired coffee or tea. Therefore, in the case of coffee/tea, the vast majority of consumers are correctly aware that exceeding the shelf life will worsen the sensory qualities of these products and will not necessarily make them unsafe for consumers (definitely lower percentage of indications). In the case of milk (UHT milk and fresh pasteurized), a small percentage of consumers are unable to provide indicators of the risk associated with the consumption of expired products (6.0% and 3.7%, respectively). The surveyed consumers declare that in their opinion expired milk will be unpalatable, although a larger percentage of consumers declare the above in relation to UHT milk than to pasteurized fresh milk (42.5% and 33.4%, respectively). In turn, a larger percentage of consumers claim that consumption of expired pasteurized fresh milk will be more unsafe for all consumers than UHT milk (49.8% and 38.6%, respectively). Less than 10% of milk consumers surveyed consider that consumption beyond expiration is only associated with a health risk for the elderly or children. Similar results were obtained for the third product tested—fruit juice. In the event of possible consumption of expired pasteurized juice, a slightly larger percentage of consumers declare that it will be unpalatable (44.1% to 37.4% compared to one-day juice), while fresh juice will be more unsafe for all consumers (43.1% to 33.3% compared to pasteurized juice). A small percentage of the surveyed consumers of juice (oscillating between 5–7%) believe that consumption after the shelf life is associated as unsafe only for the elderly or children. The analyzed results reveal that consumers in Poland are aware that food products after their shelf life may become unpalatable—the above risk is perceived in each category of examined food products. With regard to milk and juice, consumers indicate that after their shelf life, these products can be unsafe for all consumers (percentage of responses from 33% to 50%). The above is rational, but only in relation to fresh food products, i.e., in this case, pasteurized fresh milk and fresh juice. This risk is unfounded for UHT milk and pasteurized juice. Therefore, this is another premise indicating the relatively low level of knowledge and awareness of consumers in Poland regarding the shelf life of food, their physicochemical properties, as well as the threats or lack thereof if shelf life is exceeded. The results of the study clearly show that Polish consumers are not fully aware of the differences between the properties of shelf-stable and perishable food products. It seems that this is one of the basic premises of irrational attitudes and behavior of consumers in relation to expired food. Unfortunately, the above has significant negative consequences: as already mentioned, it results in health risks for consumers (in the case of consumption of expired perishable foods), food waste behavior (in the absence of consumption of expired shelf-stable foods), as well as the generation of food waste.

4. Conclusions and Recommendations

The results of the survey on consumer attitudes and behavior in Poland regarding expired foods and health risk associated with these products allow us to draw many interesting conclusions. The conclusions relate to both the issue of identifying differences in dealing with expired perishable and shelf-stable products, labeling food with the minimum durability date, and above all, health risks in relation to expired fresh and shelf-stable food and the distinguishing indicators of this risk.

Referring to the results in the area of identifying differences between perishable and shelf-stable food, including the rules for handling this food after its expiration, it can be concluded that consumers in Poland cannot clearly identify differences between perishable and shelf-stable products in a given category, in particular, they do not understand the difference in the way these products are date labeled and thus the rules of expired foods handling. In other words, consumers in Poland are not aware that expired perishable food products cannot be consumed, while expired shelf-stable foods can be consumed and should not be thrown out and wasted. The effect of the above is the irrational behavior of consumers with expired products, which on the one hand leads to the health risks associated with the consumption of expired perishable foods, and on the other promotes food waste behavior and causes the problem of food waste generation. Identified attitudes of consumers in Poland toward expired perishable and shelf-stable food also point to the fact that consumers do not understand the concepts of “minimum durability” and “use by” date and are not aware of the consequences associated with these concepts (especially for expired products). It is presumed that not consuming expired shelf-stable food (which is—as has been mentioned—unjustified) results from the health risk perceived by consumers in Poland. The health risk is more perceived in the case of expired fresh food, although in the case of shelf-stable products it is also relatively high, therefore it is recognized that it is one of the main determinants of not consuming expired food and thus generating food waste. Consumers in Poland perceive the risk of expired food mainly as a change in the taste, smell, and consistency of the product, which—as can be assumed—is a barrier to the consumption of these products. The risk of consumption of an expired product in the opinion of consumers in Poland is mainly associated with the fact that the products will be unpalatable and—more importantly—may be hazardous to health. Unfortunately, such risk markers are seen in both perishable (which is positive) and shelf-stable (perception of health danger is unfounded and unauthorized) foods. On the other hand, the positive fact is that higher health risk is perceived in the case of expired perishable food, although the consumers’ declarations regarding the ways of handling such food, i.e., tasting, giving away, or consuming, seem worrying. Therefore, despite the perceived high health risk, consumers in Poland show a lack of consistency in attitudes and behavior toward expired food. This is another indication that the knowledge and awareness of Polish consumers in the field of food labeling and procedures for dealing with expired shelf-stable and perishable food is at a relatively low level.

The results are important for food business operators, as according to remarks of Yeung et al. [57], the industry could benefit from exploring how consumer perception of food safety risk varies in response to informing about risk. Food producers together with decision-makers should engage in communication activities whose goal would be to increase consumer awareness in Poland both in the interpretation of information on food labeling with the minimum durability dates as well as shelf-stable (processing, consumption, food-sharing) and expired perishable foods’ (utilization and the more preferred option of prevention) handling. It is also important to take steps to increase the trust of consumers in risk communications by the means of food labels. It is obvious that the most desirable approach would be to increase consumer awareness of food waste generation and food waste behavior, leading to a change in consumption habits that would result in food consumption within shelf-life. Nevertheless, it seems necessary to conduct social campaigns to make consumers aware in Poland of the great economic, social, and ethical problem of food waste and what actions should be taken by consumers to implement the sustainable consumption models in households.

The study and its conclusions have limitations related to the adopted research procedure and the research method and technique used. It is worth emphasizing that the respondents’ answers, and thus

the research results, are only declarative in nature. Respondents' declarations regarding attitudes are not always identical with subsequent decisions relating to the handling of expired foods. The research does not exhaust the issues related to consumers' attitudes towards expired food and the perception and identification of determinants of health risk associated with the consumption of expired food. It would be interesting to continue research that will help more accurately identify the determinants of irrational consumer behavior concerning shelf-stable and perishable foods and extend the research to other food categories that are wasted in households.

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