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# Food upcycling focusing on private households: the potential of food upcycling in rural areas

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**Introduction:** Given the increasing importance of sustainability and the high levels of food waste, this descriptive, quantitative study explored food upcycling as a potential strategy to reduce waste, focusing on rural households in Germany.

**Methods:** A survey of 228 participants (response rate of 66%) examined the acceptance of food upcycling practices for fruits and vegetables in different age groups.

**Results:** While awareness of food waste is high, practical engagement with food upcycling remains limited. Notably, 51% of respondents was unfamiliar with the term “food upcycling,” although some of them may already be unknowingly apply this practice. Only 6% reported frequent upcycling of fruits and vegetables, while 59 % never do so.

**Discussion:** Generational trends suggest that older consumers (baby boomers and the post-war generation) are more likely to engage in food upcycling and show greater willingness to adopt and promote it. Younger generations (Gen Z and Gen Y), despite higher familiarity with the term, exhibit more neutral behavior and lower commitment. The results highlight a need for targeted initiatives to bridge the gap between knowledge and practice, especially in rural areas. Future research should include urban comparisons and a greater focus on inter-generational differences to encourage and support broader adoption of sustainable practices like food upcycling.

## KEYWORDS

food waste, Germany, rural households, consumer, generational trends, post-war generation

## 1 Introduction

The increasing importance of sustainability and the efficient utilization of resources is drawing rising attention from both science and practice to the prevention of food waste. Every year, around a third of the food produced for human consumption is lost or disposed of worldwide (Food and Agriculture Organization of the United Nations, 2015; Taufik et al., 2023). At EU level, this corresponds to 88 million tons per year (Vida et al., 2023). In Germany, the total amount of waste in 2022 was around 11 million tons (BMLEH, 2024a). Food loss in primary production, manufacturing, processing, distribution, and retail accounts for a total of 24% of food waste in Germany. A total of 76% of food is wasted in restaurants and catering services as well as in private households, with the majority (58%) being wasted in private households. Food waste in restaurants, communal catering, and catering services accounts for the second-highest proportion of food waste at 18% (BMLEH, 2024a).

According to Gustavsson et al. (2011), food losses are defined as the reduction in the amount of edible food for human consumption within the food value chain. These losses occur

in the various stages of the food value chain. Food losses that occur in the final stages of the supply chain are referred to as food waste. They are therefore the result of the behavior of retailers and consumers.

## 1.1 Differences between food waste in rural and urban areas

Although the study by Hübsch (2021) on wasted food in Germany compared regional differences, it did not assess the differences in food waste between rural and urban areas. A significant portion of Germany is characterized by rural areas, with more than half of the German population living in rural areas (BMLEH, 2024b). In Germany, rural areas can be defined as follows: A low population density, a high proportion of agricultural and forestry land, a high share of single-family homes, hardly any population in the vicinity of the settlements and a location far from the nearest center (Küpper, 2016).

In literature, a division of the private sector into rural and urban consumers was previously made in the study by Peronti et al. (2024), who found that rural regions waste less food than urban regions. Secondi et al. (2015) also found that consumers from rural regions waste less food than urban consumers. Similarly, Chereji et al. (2023) discovered that urban consumers are more likely to eat out (which may generate more waste), whereas rural consumers tend to dine at home more frequently. Supermarkets are the preferred shopping destination for both rural and urban populations. However, shopping exclusively at supermarkets leads to higher food waste (Boulet et al., 2021). Urban consumers also throw away a higher proportion of inedible food instead of using it as animal feed, for example. At the same time, however, the study found that the difference in the amount of food waste per week between rural and urban areas was not statistically significant (Chereji et al., 2023).

In contrast, a case study from Germany by Jürgens (2023) found that the urban sample was found to be less inclined to waste food than the rural sample, which can be attributed to the urban sample's open-mindedness towards environmental issues.

Furthermore, the study by Di Talia et al. (2019) examined the different types of consumers in the rural regions of Campania (Italy) and identified three different types of consumers:

- The majority can be recognized as unaware consumers, who neither see food waste as a problem nor attribute any importance to it in the household.
- Conversely, slightly less than one-quarter of consumers fall into the category of being unaware yet not wasteful. These individuals already pay attention to food waste within their own households but require additional sensitization through educational strategies.
- The third group of conscious consumers is characterized by a high level of concern about the issue of food waste, meaning that these consumers already demonstrate positive food handling behavior.

## 1.2 Generational differences regarding food waste

Factors such as age, gender, place of residence, and education influence consumer behavior, which in turn is the main driver of food waste (Bilska et al., 2020; Filimonau et al., 2022). A study by Karunasena

et al. (2021) on generational differences in food waste in Australia showed that younger generations tend to waste more food caused by the fact that they have less knowledge in the management, purchase and storage of food as well as the use of leftovers. Looking at food waste in Germany by generation, a similar picture emerges: the proportion of those who have never thrown away food in the past month is higher in the older generations (post-war generation and baby boomers) than in younger generations (X and Y). At the same time, the proportion of those who throw away food at least once a week is higher in the younger generations X and Y (Eyerund and Neligan, 2017).

This relation is also attributed to food waste reducing behaviors like the knowledge of food planning and utilization, which are higher among older generations as a result of (post-)war experiences (Eyerund and Neligan, 2017; Grasso et al., 2019). In addition, personal norms have a significant influence on reducing food waste (Filimonau et al., 2023). These norms, which are evident in older generations, for example, in the form of respect and gratitude for food, are formed at a young age (Crossley-Baxter, 2020; Filimonau et al., 2023; Olejnik et al., 2022).

## 1.3 Food upcycling as strategy against food waste

The current situation of food waste in Germany underscores the necessity of exploring innovative strategies to mitigate this issue. One measure to reduce food waste is the upcycling of food (Miroso and Bremer, 2023). The term “upcycling” refers to a process by which materials are transformed so that they have a higher quality and improved functionality. Food upcycling involves taking products that would otherwise be wasted and subjecting them to a process that enhances their value. This process transforms them into food products suitable for human consumption (Aschemann-Witzel et al., 2023).

According to the Upcycled Food Association, “upcycled food is a way that anyone can prevent food waste via the products they buy” (Upcycled Food Association, 2025). These upcycled foods therefore represent a food waste prevention solution for both food companies and consumers (Punia Bangar et al., 2024; Rakesh and Mahendran, 2024). For a better understanding at consumer level, Moshtaghian et al. (2021) have created a simplified definition of upcycled food in addition to the definition of researchers. According to this definition, upcycled foods are “environmentally friendly foods containing safe ingredients that otherwise would not have gone to human consumption such as damaged food produce, by-products and scraps from food preparation” (Moshtaghian et al., 2021).

The prevention of food waste can be promoted through consumer behavior. This includes buying upcycled food and practicing food upcycling in their daily lives. However, this requires increased awareness and knowledge of the possibilities and benefits of food upcycling, particularly about avoiding food waste and mitigating climate change (Aschemann-Witzel et al., 2023). The success or failure of the food upcycling trend ultimately depends on consumer acceptance (Miroso and Bremer, 2023).

## 1.4 Research objectives

In this study, the practice of food upcycling in private households is proposed as a viable innovative approach to mitigate food waste. To

this end, the knowledge about the acceptance of food upcycling among consumers in private households, especially in rural areas in Germany, is deepened and expanded to advance research on the development of the practice of food upcycling. The research aims to contribute to understanding the potential of food upcycling as a strategy to reduce food waste, identifying some trends in consumer behavior. This study is important as its findings can help to focus efforts and define target groups for future strategies, such as environmental education, aimed at preventing food waste.

Precisely, the study investigated the acceptance of the practice of food upcycling of fruits and vegetables by consumers in private households in different age groups. The consideration of different age groups allows the examination of correlations between these groups and the acceptance of food upcycling. Fruits and vegetables were chosen, as they make up the highest proportion of wasted food in private households in Germany (Hübsch, 2021).

## 2 Materials and methods

### 2.1 Acceptance in rural areas

This study aims to examine consumer acceptance of food upcycling practices among private households in various age groups in rural areas, as such a division into urban and rural consumers in Germany is considered insufficient in the literature to date. Since wastage of fruits and vegetables accounts for the highest proportion of total wastage (Hübsch, 2021), a focus is placed on the food upcycling of fruits and vegetables.

The survey was divided into four sections: first, the relevance of food waste as well as its frequency and type were recorded. Then, the topic of “food upcycling” was introduced, and the participants’ knowledge, previous experiences, methods used, and food scraps used were surveyed. The participants then evaluated their experiences and indicated whether they would like to engage in food upcycling in the future. In addition, potential factors influencing motivation and personal assessments of selected statements were surveyed. Finally, sociodemographic data such as age, gender, household structure, and place of residence were collected. The questionnaire consisted therefore of the following four sections:

1. Determine the respondents’ level of knowledge on the topics of food waste and food upcycling.
2. Determine the acceptance and willingness of respondents to take food upcycling measures.
3. Identify respondents’ attitudes towards the practical implementation of food upcycling.
4. Collect socio-demographic data.

The acceptance of food upcycling in private households was investigated based on Davis’ technology acceptance model (TAM), which is characterized by its simplicity, its focus on individual decision-making processes, and empirical support. An adaptation of TAM is necessary to capture the acceptance of food upcycling. The questions were based on the two main components of the model: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). PU could refer to consumers’ perceptions of the extent to which food upcycling is a helpful method for saving money and protecting the environment.

PEOU can be examined by analyzing the availability of instructions and recipes. In addition to PU and PEOU, the model also considers *Attitudes Toward the Behavior (AT)* and *Behavioral Intention (BI)*. AT was measured using questions that assessed consumer willingness. The measurement of BI was carried out using questions that assess the likelihood that consumers will actually practice food upcycling. The investigation of these factors allowed for the interpretation of attitude acceptance, from which behavioral acceptance can be derived (Watanabe et al., 2023; Zaineldeen et al., 2020).

The target group of this survey comprised consumers from private households of various age groups living in the rural district of Diepholz (Germany). The district of Diepholz is a structurally typical rural region in Lower Saxony (Germany) with a mix of small towns, villages, and agricultural areas. The region also has characteristics such as a comparatively low population density, which is typical of many rural areas in Germany. When selecting respondents, efforts were made to ensure different age groups and household types are represented, thereby achieving a balanced distribution. The online survey was distributed via social media due to its ease of access. The link to the survey was posted on popular social networks at regular intervals of 2 to 3 days. The data was primarily collected via an online survey conducted via the LimeSurvey platform. This platform allows users to create and publish online surveys without programming knowledge. In addition, participants who declined to take part in the online survey were offered the option of a face-to-face interview using a printed questionnaire. Data collection was therefore carried out using both an online questionnaire and a printed version, using the identical questions. The primary mode of data collection was the online survey.

Prior to online publication, a pretest was conducted with three persons in order to identify potential ambiguities regarding the questions and to incorporate any suggestions for improvement. The test subjects had no difficulty completing the questions, so no further modifications were necessary in this regard. The online survey was distributed via social media due to its ease of access. The link to the survey was posted on popular social networks at regular intervals of 2 to 3 days. The data collection period ran from 10 June 2024 to 8 July 2024, for a total of 4 weeks. Participants were given the opportunity to take part in the survey and submit their responses within this month. A total of 228 responses were received, with five questionnaires being printed out. However, 55 online surveys were abandoned or only partially completed. Furthermore, 22 questionnaires were not included in the evaluation because the participants came from urban areas. As a result, the responses from 151 questionnaires could be used for the evaluation.

### 2.2 Statistical analysis of the processed data

The processed data was analyzed using the software tool SPSS 29.0.0.0 (Statistical Package for the Social Sciences). The data analysis included the recording of frequency distributions to illustrate the distribution of answers to the individual questions, thus following a descriptive statistic. In addition, a correlation analysis was carried out, which contains the correlation coefficient (Spearman correlation), indicating the direction of the correlation. The Spearman test was

selected as the data is not normally distributed. A group comparison test was implemented using the Kruskal–Wallis test as well.

The first step was to identify the variables that are relevant for the investigation of the acceptance of food upcycling. This was followed by a correlation of the variables mentioned with the different age groups. The correlations between the results were based on the following four metric items:

1. Knowledge about the responsible use of food.
2. Availability of resources that promote knowledge about food upcycling.
3. Food upcycling as a way to reduce household costs.
4. Attitude towards further training through local workshops or courses.

In addition, the chi-square test was carried out to check whether there is a statistical correlation between the household structure (e.g., generations) and the acceptance or willingness to implement food upcycling. The Kruskal–Wallis test was carried out to examine these and other variables with regard to the different generations. The generations were defined as follows (Statista, 2025):

Generation Z: 1996–2009.

Generation Y: 1981–1995.

Generation X: 1966–1980.

Baby boomer generation: 1956–1965.

Post-war generation: 1948–1955.

## 3 Results

### 3.1 Presentation of the survey results

The sample of this study comprises a total of 151 participants who completed the questionnaire and whose place of residence is limited to the defined rural area (Diepholz). If the basis (N) for individual questions differs from the total sample, this is stated separately. If not stated, the total sample is used as the basis. The demographic characteristics of the participants can be summarized as follows (Table 1).

The results of the survey on consumer perceptions of food upcycling suggest that preventing food waste is highly relevant for the majority of respondents. A total of 52% of respondents ( $n = 79$ ) state that preventing food waste is important to them. For 39% ( $n = 59$ ) of respondents, preventing food waste is a very important concern. In contrast, 7% ( $n = 10$ ) of respondents have a neutral opinion. For 2% ( $n = 3$ ) of respondents, preventing food waste is a less important to unimportant priority.

Regarding the weekly disposal of food, 40% ( $n = 60$ ) state they throw food away regularly, while 52% ( $n = 78$ ) say they rarely throw food away. Within the group of respondents, 7% ( $n = 10$ ) state that they dispose of food several times a week; 1% ( $n = 1$ ) state that they dispose of food daily. In contrast, just over 1% of respondents say that they never throw food away ( $n = 1$ ).

The most frequently discarded types of food are fruits and vegetables ( $n = 149$ ), with 56% mentioning this category ( $n = 84$ ). In second place using multiple-choices is the category “prepared food” named by 37% ( $n = 55$ ), followed by the category “bread and baked goods” with 35% ( $n = 52$ ). In the “other” category, the food groups “eggs” and “jam” are also mentioned. This is followed by a focus on

TABLE 1 Composition of the sample of people surveyed.

Variable	Item	%
Generation	Z	30
	Y	23
	X	23
	Baby boomer	15
	Post-war generation	8
Gender	Male	29
	Female	69
	Other	1
Education level	Academic degree	16
	High school graduate	29
	Secondary school leaving certificate	56
Size of household	1-person household	21
	2-person household	43
	3-person household	36
Salary (euros per month)	<1.000 €	4
	1.000 €–1.999 €	17
	2.000 €–2.999 €	26
	3.000 €–3.999 €	21
	4.000 €–4.999 €	19
	>5.000 €	13

the “fruits and vegetables” category. Regarding the next question, 7% of respondents state that they never dispose of fruits and vegetables ( $n = 11$ ); 64% say that they rarely throw away fruits and vegetables ( $n = 96$ ). Only 26% state that they dispose of fruits and vegetables on a weekly basis ( $n = 39$ ). Within the group of respondents, 3% mention that they dispose of fruits and vegetables several times a week ( $n = 5$ ).

In view of the concept of food upcycling, 48% of respondents say that they have already heard of it ( $n = 73$ ). In contrast, 51% of respondents have not yet heard the term “food upcycling” ( $n = 77$ ); 1% of respondents do not answer this question ( $n = 1$ ). Those who say they have heard of the term are asked how they have heard of it before. The most frequently mentioned sources are the internet ( $n = 40$ ) and television ( $n = 36$ ). Furthermore, friends and family ( $n = 17$ ) as well as magazines and books ( $n = 9$ ) are named as sources of information. With regard to knowledge on the topic of upcycling food, the following distribution can be noted (Table 2).

Only a small proportion of respondents rate their own knowledge as very high. Furthermore, 76% state that they have already gained practical experience with the food upcycling method ( $n = 114$ ). However, 36% practice this only rarely ( $n = 54$ ). Regarding the frequency of food upcycling, 13% of respondents state that they do this monthly ( $n = 20$ ) and 19% even do it weekly ( $n = 28$ ), while 8% practice food upcycling several times a week ( $n = 12$ ) and 1% even do it daily ( $n = 1$ ). With regard to using leftover fruits and vegetables for food upcycling, the distribution is as followed (Table 3).

In response to the multiple-choice question, which fruits and vegetables would be most likely to be used for food upcycling ( $n = 120$ ), 48% state that they are most likely to imagine using herbs



**TABLE 2** Distribution of the survey results with regard to knowledge on the topic of upcycling food ( $n = 151$ ).

Knowledge of the topic food upcycling	%	$n$
High knowledge	5	7
Medium knowledge	22	33
Low knowledge	54	81
No knowledge	19	29

**TABLE 3** Distribution of the survey results about the use of leftover fruits and vegetables for food upcycling ( $n = 151$ ).

Using leftover fruits and vegetables for food upcycling	%	$n$
Frequent use	5	8
Occasional use	10	15
Rare use	27	40
No use	58	88

for food upcycling ( $n = 58$ ); 35% mention onion vegetables ( $n = 42$ ) and 33% leafy vegetables ( $n = 40$ ), followed by root vegetables with 27.5% ( $n = 33$ ), fruit vegetables like watermelons with 19% ( $n = 23$ ) and fruits with 17.5% ( $n = 21$ ).

The aim is also to investigate which food upcycling practices have already been used in practice. The analysis shows that the upcycling of fruits and vegetables into soups and broth is the most well-known practice, with 43% ( $n = 65$ ). However, 34% of the respondents state that they have not yet tried any of the examples of upcycling fruits and vegetables mentioned ( $n = 52$ ). The production of smoothies and baking with vegetables are mentioned by 26% ( $n = 39$ ) and 19% ( $n = 29$ ), respectively. Regarding making jam from leftover fruits, 13% state that they have already gained relevant experience ( $n = 20$ ), while 10% had already gained experience in producing snacks from fruit peel ( $n = 15$ ). Various other ways of upcycling fruits and vegetables such as puree, casseroles, vegetable cutlets, pesto, and the preparation of sauces are additionally mentioned.

## 3.2 Perceived usefulness and perceives ease of use

About the motivation for using food upcycling, it is found that for 70% of respondents the possibility of cost savings is an important factor ( $n = 105$ ), while for 76% environmental awareness is the main motivation for using food upcycling ( $n = 115$ ). For 41%, the creative challenge that food upcycling offers is an important motivating factor ( $n = 62$ ), while the health-promoting aspects of food upcycling convince 28% ( $n = 43$ ); 8% attribute the use of food upcycling to a community initiative ( $n = 12$ ).

Multiple answers are possible with regard to the perceived user-friendliness of food upcycling; 28% cite the time required as a barrier ( $n = 43$ ), while insufficient knowledge makes implementation more difficult for 76% ( $n = 115$ ). At the same time, 69% of respondents state that they lack ideas and recipes ( $n = 104$ ). With regard to the safety and hygiene of food upcycling, 23% express concerns ( $n = 35$ ), while a further 23% have concerns about taste ( $n = 36$ ). With regard to the

feasibility of food upcycling, 54% of respondents rate it as neither easy nor difficult ( $n = 82$ ); 25% state that implementing the practice of food upcycling is associated with difficulties ( $n = 37$ ). In contrast, only 17% say that it is easy for them to implement ( $n = 26$ ); 1% find it very easy to implement ( $n = 2$ ), while almost 3% still find it very difficult ( $n = 4$ ).

## 3.3 Attitudes toward the behavior and behavioral intention

Overall, it can be stated that 36% rate their experiences with the practice of food upcycling as positive to very positive ( $n = 54$ ); 63% classify their experiences in the “neutral” category ( $n = 94$ ); 1% report very negative experiences with the practice of food upcycling ( $n = 2$ ). The evaluation of the experience with food upcycling, the willingness to utilize food waste through food upcycling, as well as the future use, recommendation and attendance of workshops on the topic of food upcycling show the following results (Figures 1, 2).

Half of the respondents ( $n = 75$ ) therefore indicate a medium willingness to use it. At the same time, 35% of respondents expressed a high to very high willingness ( $n = 53$ ), while 15% of respondents indicate a low to very low willingness ( $n = 22$ ). With regard to the future use of food upcycling, however, the majority of respondents state that they would probably do so, while half of respondents consider participation in workshops to be unlikely. With regard to recommending food upcycling in the future, 47% are undecided, while 46% would probably consider recommending it ( $n = 151$ ).

## 3.4 Statistical analysis of the survey results

This study examines the extent to which the acceptance of the practice of food upcycling differs depending on the respective generation. Since the results are not statistically significant, they are only used to illustrate trends. However, these results should be viewed with caution. With regard to the first item (knowledge to practice food upcycling), the Spearman correlation coefficient shows a positive sign (0.097), which indicates a positive correlation between the item and increasing age. However, the correlation must be classified as weak. The correlation is also not significant (significance value of 0.237). This result also extends to the other three items. A weak positive Spearman correlation coefficient can be determined for each item, the significance value of which is also not significant. The results can be seen in Table 4.

The data shown in Figure 3 is determined using the chi-square test. The analysis shows that Generation Z has a medium willingness to practice food upcycling with a share of 43%; 37% of respondents even indicate a high to very high will. At the same time, Generation Z also has the highest proportion of all generations with the lowest score, with a total of 20%. In addition, 4% of respondents indicate a very low score, while no information is provided in the “very low” category in any of the other generations. When looking at Generation Y, the medium level is selected most frequently with a share of 44%. It should also be noted that 38% of respondents have a high to very high willingness. The middle age group (Generation X) has the lowest percentage of low willingness at 8%. In contrast to the younger generations, the average value is slightly higher at 56%. The proportion of those with a high to very high level of willingness is 36%. Similar to Generation X, the baby

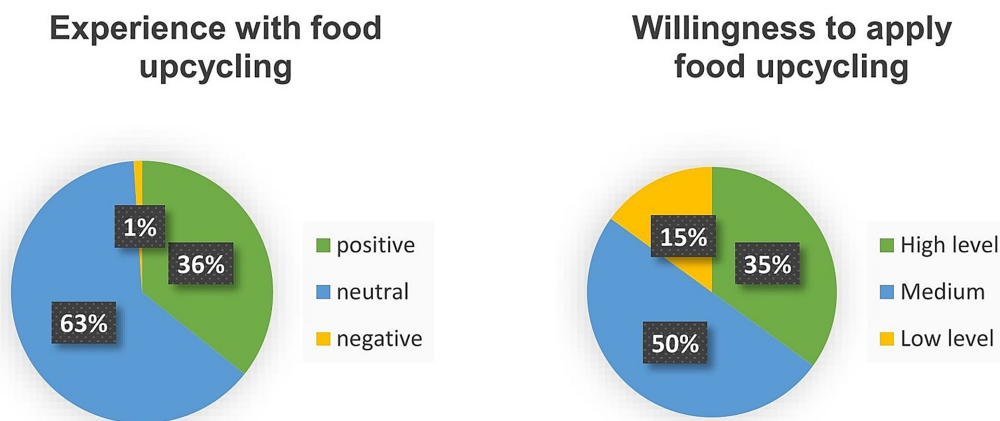


FIGURE 1

Survey results regarding the experience with food upcycling and the willingness to utilize food waste through food upcycling ( $n = 151$ ).

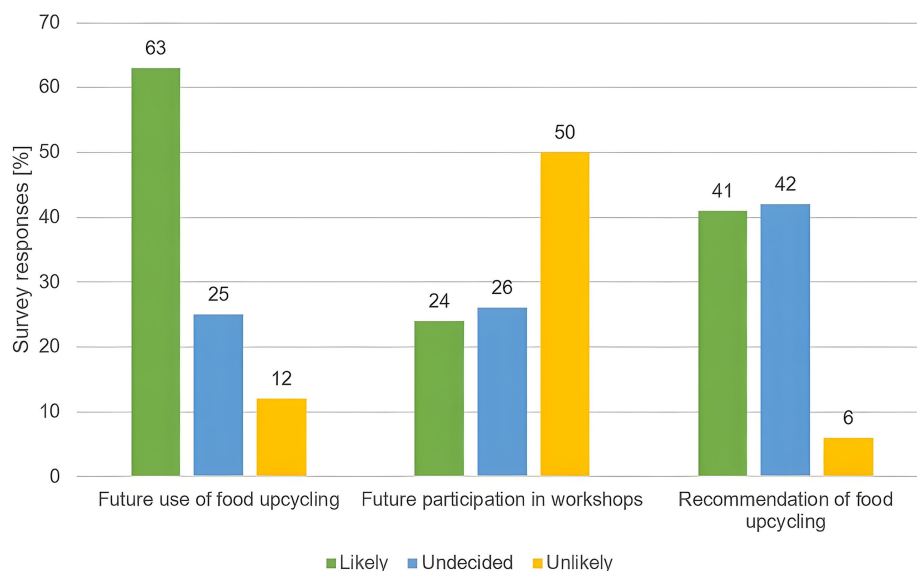


FIGURE 2

Survey results regarding the future use and recommendation of food upcycling as well as the future participation in workshops ( $n = 151$ ).

boomer generation shows the highest value in the middle at 57%. However, the low willingness value of 13% is slightly higher and the high value of 30% is lower than in the other generations. The post-war generation also shows no significant deviation. At 58%, their average willingness is the highest of all generations; 17% have a low and 25% a high willingness (Figure 3).

Although there are not statistically significant differences between generations (all  $p$ -values  $> 0.05$ ), some trends emerged. Older generations, particularly baby boomers and the post-war generation, are more likely to practice food upcycling ( $p = 0.289$ ), whereas younger generations (Generation Z and Generation Y) are more familiar with the term ( $p = 0.710$ ). Generation X and baby boomers report the most positive experiences with food upcycling, compared to more neutral ratings from younger generations and the post-war generation ( $p = 0.091$ ).

Generation X appears to be the most willing to engage in food upcycling, although this difference is not significant ( $p = 0.934$ ). Similarly, Generation X and the post-war generation evaluate everyday implementation of food upcycling most positively ( $p = 0.166$ ). Baby boomers and the post-war generation also show the highest likelihood of trying food upcycling ( $p = 0.118$ ), while younger groups are more neutral.

In terms of consumer behavior, baby boomers and Generation X express the greatest willingness to purchase ( $p = 0.126$ ) and recommend ( $p = 0.080$ ) food upcycled products. Generation Y consistently shows the lowest values in both categories (see Table 5). However, due to the lack of statistical significance across all Kruskal–Wallis tests, these trends should be interpreted with caution and do not support firm conclusions about generational differences.

TABLE 4 Results of the correlation analysis regarding the acceptance of food upcycling depending on the age.

Item		Correlation	Significance value ( <i>p</i> )
1	I have enough knowledge to make good use of food.	Spearman correlation	0.097
		Two-sided significance value	0.237
		<i>N</i>	151
2	There are enough resources such as books etc. to help me with food upcycling.	Spearman correlation	0.022
		Two-sided significance value	0.790
		<i>N</i>	150
3	Food upcycling helps me to reduce my household costs.	Spearman correlation	0.076
		Two-sided significance value	0.360
		<i>N</i>	149
4	I would feel better informed by local workshops or courses on food upcycling.	Spearman correlation	0.118
		Two-sided significance value	0.149
		<i>N</i>	150

## 4 Discussion

This study focuses on the acceptance of food upcycling practices for fruits and vegetables in rural private households. The survey was conducted with a total of 151 participants living in a defined rural area in Germany. The sample shows a certain socio-demographic heterogeneity, as all relevant age groups, education levels, income levels and different household sizes are represented. However, it should be noted that some variables show an uneven distribution: for example, younger people and women are represented at an above-average rate. It is therefore not representative of the German population.

While the importance of avoiding food waste is widely acknowledged, food upcycling is not yet commonly practiced. Around half of the participants are unfamiliar with the term, although some may be engaging in the practice without recognizing it as such. Furthermore, a quarter state that they have never practiced food upcycling before, with most of them not knowing the term food upcycling and therefore possibly unknowingly practicing food upcycling. This unfamiliarity could be related to the definition of food upcycling from a researcher's perspective, which may make it difficult for the general public to understand the meaning of food upcycling and thus requires a simpler definition (Moshtaghian et al., 2021).

In view of the perceived user-friendliness of food upcycling, the time required, insufficient knowledge, and the lack of ideas and recipes represent the biggest barriers. These results are in line with the literature, in which consumer acceptance and specifically awareness and knowledge of the benefits of food upcycling must be further increased at consumer level (Aschemann-Witzel et al., 2023; Miroso and Bremer, 2023). The acceptance is reflected in the results regarding the ease of implementation of food upcycling: Only 20% of respondents find food upcycling easy to implement, underscoring the need for more accessible guidance and resource. Raising awareness of the benefits of food upcycling could be successful, as the majority cite environmental awareness as a motivation for food upcycling. This motivation for environmental awareness and therefore a sustainable consumption can also have a positive impact on innovation within the food industry (Saari et al., 2021). For example, food packaging and designs are being developed that respond to changes in people's lifestyles and the increased

demand for high-quality, ready-to-eat foods with extended shelf life (Versino et al., 2023).

Furthermore, the results do not indicate whether rural consumers waste more or less food compared to urban consumers, as was the case in the studies mentioned before (Chereji et al., 2023; Jürgens, 2023; Peronti et al., 2024; Secondi et al., 2015). In addition, the results do not allow a clear comparison with the study by Di Talia et al. (2019) whether the majority of rural consumers are unaware consumers or not.

### 4.1 Observed trends

No clear correlation between age and willingness to practice food upcycling can be established. However, differences between generations are apparent in their experiences and attitudes. While younger generations (Gen Z and Gen Y) are more familiar with the concept, older generations (Gen X, Baby Boomers, post-war generation) tend to report more positive experiences and a higher willingness to implement food upcycling in daily life. Notably, Generation X appears to have the highest overall willingness, while Generation Y seems to be least likely to purchase or recommend upcycled food products.

Although not statistically significant, the data suggest that older generations—particularly baby boomers and the post-war generation—are more inclined to practicing, trying, and recommending food upcycling, while younger generations show greater familiarity but less behavioral commitment. These trends are in shape with the literature, where it was found that younger generations are more likely to waste food than older generations, which in turn can be attributed to their knowledge of how to handle food (Bilska et al., 2020; Eyerund and Neligan, 2017; Karunasena et al., 2021).

It is important to consider that the generational sample sizes were imbalanced, with Generation Z being overrepresented. This uneven distribution may partially explain the broader variability observed within Generation Z and limits the generalizability of the results. Furthermore, socio-cultural factors likely contribute to the divergent tendencies observed within and between generations. Future studies with more balanced sample sizes and deeper qualitative insights could help clarify the influence of age-related factors on food upcycling behavior.

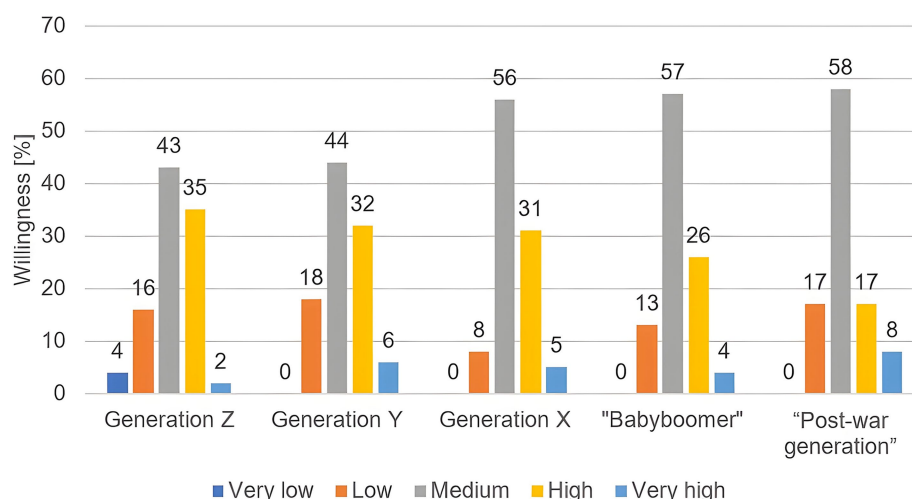


FIGURE 3

Comparison of willingness to practice food upcycling as a percentage across different generations ( $n = 151$ ).

TABLE 5 Generational differences with regard to various questions about food upcycling.

Topic	Highest mean	Lowest mean	Tendency	Significance value ( $p$ )
Heard of it?	Gen Y / Boomers (1.59)	Gen X (1.44)	Younger people are more familiar with the topic	0.710
Have practiced it?	Boomers (1.09)	Gen Y (1.35)	Older people practice more often	0.289
Willingness to recommend	Boomers (3.70)	Gen Y (3.00)	Boomers most positive	0.080
Willingness to buy	Boomers (3.57)	Gen Y (2.94)	Boomer ready to buy	0.126
Likelihood to try	Boomers (3.91)	Gen Z (3.37)	Older people show greater willingness	0.118
Implementation in daily life	Post-War (3.25)	Gen Y (2.76)	Gen X and Post-War more positive	0.166
Willingness to practice upcycling	Gen X (3.33)	Gen Z (3.15)	All similar, slight tendency for Gen X	0.934
Experience with upcycling	Gen X (3.53)	Gen Y (3.24)	Gen X and Boomers very positive	0.091

In summary, the results of the survey on food waste and food upcycling reveal a multi-layered picture of public perception and practice in relation to these essential topics. The broad recognition of the relevance of preventing food waste reflects a growing awareness of the ecological and economic consequences of unused food. However, the fact that 51% of respondents are not familiar with the term “food upcycling” indicates a clear lack of information and education in this area, so that the knowledge of food upcycling needs to be further expanded (Aschemann-Witzel et al., 2023). It can be concluded from this that the concept of food upcycling, although it has great potential, is not yet sufficiently anchored in the public in rural areas. Awareness of food upcycling in rural households is low in all age groups. There is still great potential for improvement in the areas of education and practical application to enhance consumer acceptance (Miroso and Bremer, 2023). Although there is a common concern about food waste, actual food upcycling practices are minimal.

Further research is needed to develop targeted educational initiatives for different age groups and to improve awareness and participation in food upcycling practices. In addition, focus must also be placed on factors such as digital literacy, food literacy (Lingireddy et al., 2023; Lisciani et al., 2024), and access to upcycling tools in order to optimally implement generation-specific measures.

## 5 Limitations

The results are based on a small number of participants, namely 151 people from a specific rural area. This may limit the generalizability of the results to other geographical regions or urban populations. Since the majority of respondents come from the district of Diepholz, the sample is homogeneous, meaning that possible differences in the acceptance of food upcycling practices in other demographic groups cannot be captured. The results presented are based on self-reported data from



participants, which carries the risk of bias. Respondents' answers may be distorted by the influence of social desirability, which affects the accuracy of the results. This study is primarily based on quantitative data, which means that qualitative aspects such as personal experiences and deeper insights into the motivations of the participants may not have been adequately captured. The data was collected at a single point in time, so changes in the attitudes and behaviors of respondents over time were not captured. As a result, no conclusions can be drawn about long-term trends and changes in the acceptance of food upcycling.

When interpreting the present results, it should be noted that they are influenced by the limitations mentioned above. Further research is needed to gain a more comprehensive understanding of the acceptance of food upcycling and to develop targeted measures to improve knowledge and application on this basis.

## 6 Outlook

As part of future research, it would be advisable to expand the sample to compare urban and rural regions. This could help to increase the generalizability of the results and identify potential differences in the acceptance of the practice of food upcycling. In this context, investigating the impact of educational and awareness campaigns on consumer behavior would also seem to be a sensible approach. Future research could focus on how educational programs and workshops can be designed to promote food upcycling. This could help to develop target group-specific strategies.

Although the observed generational differences in attitudes toward food upcycling were not statistically significant, the identified trends offer valuable starting points for future research. Further studies should aim for a more balanced sample in terms of age to validate these tendencies and explore underlying motivations. They could help to uncover socio-cultural, psychological, and economic factors influencing food upcycling behavior in age groups. Understanding these motivations is essential for creating effective communication strategies and interventions that are tailored to different generations, with the aim of promoting a wider adoption of sustainable food practices.

This study reveals that there is still a significant need for action to establish the concept of food upcycling among the public as a promising approach to reducing food waste. Targeted initiatives in the areas of education, politics and research can enhance the acceptance and practice of food upcycling, which will contribute to the sustainable and efficient use of food in the long term. Such measures could include, for example, age-specific awareness campaigns on the concept and application of food upcycling, as well as local co-creation workshops in which older generations can pass on their knowledge to younger generations. This could raise awareness of the concept of food upcycling and promote its implementation at the same time. Bringing seniors and children together could also be effective in this context, as it could help combat food waste in the future. In this way, younger generations could learn directly from older generations about their attitudes toward food waste and food in general, and gain inspiration for their own behavior.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

Ethical approval was not required for the studies involving humans because ethical approval was not required for this study as it involved an anonymous, voluntary survey that did not collect any sensitive personal data. The data collected does not allow for the identification of individual respondents, ensuring the anonymity and privacy of all participants. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

HS: Writing – original draft, Writing – review & editing. TS: Formal analysis, Methodology, Data curation, Writing – original draft. US: Conceptualization, Project administration, Writing – review & editing. SB: Conceptualization, Project administration, Validation, Supervision, Resources, Writing – review & editing, Investigation, Funding acquisition.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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