Foodtech as Part of the Circular Economy

Adrián Csordás
Lecturer, Faculty of Economics and Business, csordas.adrian19@gmail.com
University of Debrecen, 4032 Debrecen, Hungary

Abstract

Increasing food prices, intensifying competition, and even the need for sustainable operations lead players in the food sector to innovative strategies. Food Loss and Waste (FLW) is a major issue, the solution for which could significantly contribute not only to the achievement of Sustainable Development Goals (SDGs) but through novel approaches to the competitiveness and financial success of said actors. FLW studies are often related to production, while the retailers have not been broadly researched. Food upcycling has been emerging as an innovative solution, to transfer food loss into marketable food products. The current study analyzes the surplus-based upcycled food products' consumer acceptance and the competitive advantages that could be realized by the exploitation of this innovative approach. Following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines, some of the essential product features could be observed based on academic publications. The upcycled food is not well-known. Individuals who are environmentally conscious most support this type of product. However, the low level of processing was seen as a desirable feature for everyone. Due to the low level of processing, technophobia should not hamper, but rather support the spread and use of surplus-based products. Similar to conventional food, taste, sensory appeal, and price are those characteristics that can influence consumers' decision-making. Without a significant increase in marketing expenditures, innovative retailers can influence potential customer engagement through comprehensive and educational advertising. Offline presentations and trials are consistently more persuasive in involving customers, but the significance of online information sharing is equally important. These results imply that innovative businesses, by selling upcycled food, could realize competitive advantages from multiple sources while contributing to the SDGs.

Keywords: innovation; competitiveness; consumer; technology acceptance; technophobia; upcycling; food; retail; marketing; Sustainable Development Goals

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Introduction

The food sector is a dynamic and competitive industry, where retailers play a crucial role in shaping consumer choices and influencing the overall food system. These actors face a multitude of challenges and opportunities in navigating the evolving landscape of food production, consumption, and waste. Retailers must constantly differentiate themselves to attract and retain customers. Pricing is one of the decisive factors where they can compete. Due to this reason, food companies strive to find ways to lower their costs and pass those savings on to consumers. The other relevant area of competition is product assortment, where product offering has to fit the needs of the customers, but the economic aspects of the operation have to play a crucial role, too. The innovative retailers who can collectively consider and solve these issues should gain competitive advantages. All these challenges are embodied in the food waste generated by retailers. It provides an unexploited potential for the utilization of surplus. According to the Food and Agriculture Organization of the United Nations (FAO) (2011), approximately one-third of all food produced is lost or wasted globally. The distribution of it along the value chain varies considerably, but a relevant share of FLW is created at the retail level (Luo et al., 2022; Goodman-Smith et al., 2020). Particularly inadequate storage, incorrect forecasting, and overstocking practices contribute to the high loss of retailers (Herzberg et al., 2022; Riesenegger, Hübner, 2022; de Moraes et al., 2020). To mitigate these, the products close to their expiration date are often proffered with high discounts (Wu, Honhon, 2023; Tsalis et al., 2021). However, after this time the unmarketable products do not generate significant income, since these are often donated, composted, or sold to companies that recycle or upcycle them (Lowrey et al., 2023; Nenciu et al., 2022; Huang et al., 2021). The innovative players in production have discovered the market value of the byproducts. Upcycling involves transforming food loss into new and valuable products, diverting it from landfills, and reducing environmental impact (Punia Bangar et al., 2024; Mirosa, Bremer, 2023). This creative approach not only reduces food loss but also generates new revenue streams for businesses (May, Guenther, 2020) while contributing to environmental and social responsibility (Horoś, Ruppenthal, 2021; Jeswani et al., 2021).

Food upcycling encompasses a wide range of innovative solutions, which are mostly based on byproducts. Although the difference is significant between products made from byproducts and surplus food, these are rarely emphasized. Surplus food refers to food that is produced (or harvested) over what is required or demanded (Papargyropoulou et al., 2014). Meanwhile, a byproduct is a secondary product or substance that is produced during the manufacture or processing of another primary product (Rațu et al., 2023). The first was made for human consumption, but the second could be used for the same purpose only after processing (Damiani et al., 2021; Alao et al., 2017). The definition of upcycled food also often confuses the "raw material" used in the process (Thorsen et al., 2022). Beyond the theoretical issues, the differences in the management of creating edible products from these various raw materials are much more significant. While in one case a predictable amount of a given raw material is available, in another neither the product nor its amount is foreseeable. This phenomenon could make it complicated for innovative retailers to plan. However, it could be worth addressing this, since lately consumers face higher food prices worldwide (due to the consequences of inflation caused by the pandemic and war) which lead many of them to economize (Abay et al., 2023; Fan et al., 2023), and simultaneously one must consider the growing attention to and importance of eco-friendliness, which could foster demand for upcycled food (Chanda et al., 2023; Kim, Lee, 2023; Sharma et al., 2023). The current work aims to study the niche of surplus-based upcycled food products through the consumers' acceptance. Based on the provided comprehensive overview, this work highlights the potential benefits of this innovative approach's early adoption in the retail.

Material and Methods

A systematic literature review offers a structured approach to evaluating the available evidence related to a specific research question. This method encompasses the identification, evaluation, and analysis of relevant studies filtered by specific search criteria published in high-quality journals (Mishra, Mishra, 2023). To conduct comprehensive research the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Protocols (PRISMA) guidelines were followed, which were originally used for healthcare-related studies (Page et al., 2021). To achieve an extensive base the academic databases of Scopus, Web of Science, and Science Direct were used. Since the current work aimed to identify and synthesize the existing evidence on the acceptance of upcycled food, the used keywords were the following: acceptance, food, upcycling, and upcycled. The application of "and", and "or" operators provided a more specific search query. The records of the databases had to contain these terms in the title, abstract, or keywords. Only scientific articles written in English were evaluated, which have been recorded until December 26, 2023. A total of 682 relevant articles were identified. These works were managed by Rayyan, which is an online free-to-use platform to facilitate systematic literature reviews.[1] The in-

[1] https://www.rayyan.ai/, accessed 18.01.2024.

cluded works had to be based on primary data, and the definition of upcycled food applied in the given study was strictly reviewed. Given that the term "upcycled food" means different products in many cases (Spratt et al., 2021). The definitions used by the identified studies in this research were analyzed one by one. The number of articles that examined only the acceptance of food not produced using byproducts was rather low. Therefore, those studies whose definition did not exclusively focus on surplus in their definition were also analyzed. Unfortunately, surplus food is often considered as food waste (FAO, 2015), and due to this theoretical issue, this expression could not be added to the search criteria. To extend the number of the studied works, the references of the publications and even materials outside the academic sphere (grey literature) were checked. However, there was no suitable material to be added. This phenomenon may also support the under-representation of the given topic. Figure 1 presents the structure of the applied method.

After the selected articles were uploaded to Rayyan, the duplicates and irrelevant studies were identified. After this round, 552 articles remained as the basis of the systematic literature review. The initial screening was based on the abstracts which resulted in the exclusion of 174 articles. In the next section, the remaining 378 studies were analyzed to identify the various fields within the domain of upcycled food consumer acceptance. The popularity of upcycling in general has been rising as a significant method that supports the realization of various SDGs. Due to this issue, a wide range of less relevant studies could be found within the current database as well. As seen in Figure 2 a high share of works studied "plastic" in 2023. The relevance of this topic is probably due to the significant increase in research on which food (food waste) can be used to replace plastic food packaging with degradable or edible covers (Bhargava et al., 2020; Dilkes-Hoffman et al., 2018). The distribution of the topics not related to the current research was as follows; battery: 17, building: 77, electronic waste: 21, fashion: 34, plastic: 73, theory: 84, soil: 6, and wastewater: 21. After a thorough examination of available research only five relevant academic publications were left.

The "building" related articles also presented a high share. However, this approach of upcycling does not truly offer a sustainable solution to food waste. Since the use of construction materials regularly does not return to nature as organic components (Zhang et al., 2022; Barbu et al., 2021). The share of works focused on "wastewater" was also substantial. This field could have a high impact in the near future on the food industry through the increased agricultural productivity (Lee et al., 2022; Roman, Brennan, 2021).

Results

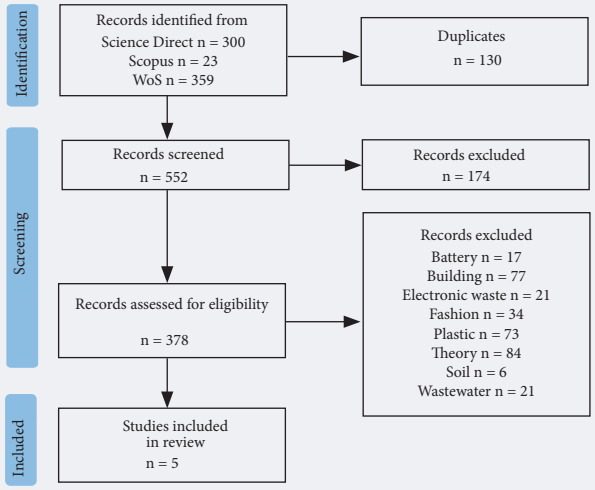
Related Reviews

An analysis of the review articles was carried out to gain insight into the existing body of knowledge. To achieve this, the same PRISMA method was used that provided the basis for the study, but this time only the relevant articles were involved. From the fifty-three reviews, only four could be considered relevant for the current study. Their main findings are presented in Table 1. The published studies revealed major differences between the used definitions. The various approaches differed regarding the source of the upcycled food. The broad approach defines the raw material as an ingredient that otherwise would not be used for human consumption (Moshtaghian et al., 2021). A more specific approach points out that these materials are typically discarded near the source, and are often called co-streams or byproducts (Bhatt et al., 2020). While only the most widely used approach involves surplus as a possible source of upcycled food (Thorsen et al., 2022). These substantial variances in the definitions became clear during the analysis of the research articles.

Academic Papers

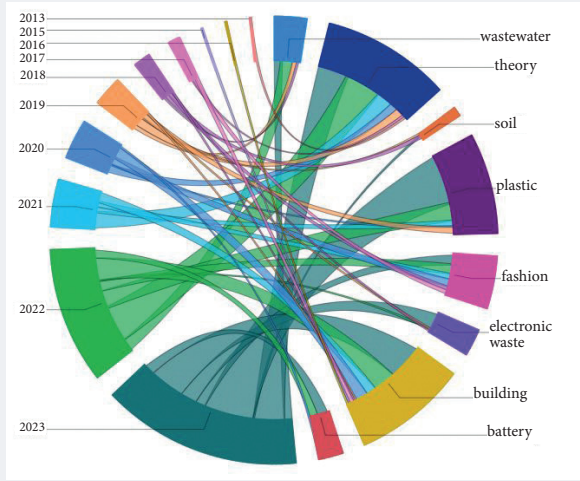
The study of Jamaludin et al., (2022) delves into the issue of food waste in Malaysia. The data was collected in an urban area of Kuala Lumpur between October and November 2021, where 147 participants answered a semi-structured questionnaire. The authors also conducted a pilot test, to verify the clarity and validity of the questions. The respondents had to choose between two models based on their preferences. The first option suggested that the produced food would be consumed by the households and the potential leftovers would be used as landfills, so increasing the amount of methane and carbon dioxide gases, which is disadvantageous for climate change. In the other case, the food will be consumed, and the potential leftovers will be used to provide higher-quality products by reprocessing. The overwhelming part of the surveyed chose the second – circular economy – model. The ten percent of the respondents who preferred the first option were men with low income and education levels. Questions were asked related to the taste of the upcycled products as well. All in all, less than twenty percent found that the upcycled food had a suboptimal or bad taste. This high openness paired with a willingness to pay since seven out of ten respondents would be ready to pay a given amount of money weekly for a driver to collect the food waste from their homes. Nearly six out of ten would be ready to pay even more for it, in addition, the less open people would be ready to pay a lower amount for this service too.

Figure 1. **Process of the Systematic Literature Review**



Source: author.

Figure 2. **The topics and their publication year excluded from the current database**



Source: author.

Hellali and Korai, (2023) studied the acceptance of upcycled food through the innovation behind these products. The data source was provided by Dynata's consumer panel. It created 1014 participants' answers, which accurately represented the demographics of Quebec. Before the run of data collection pilot test was done, and even CERUL ethical approval was received. The authors created three questionnaires through SurveyMonkey, which were mostly based on a 5-point Likert scale. The surveys presented upcycled food from various points of innovation. The first level was the incremental innovation. This approach focuses on meeting particular consumer requirements or enhancing existing product features. In the given study, beer made from wasted bread embodied this stage. The second level was so-called disruptive innovation, which brings new methods, technologies, or business models that significantly change how a product or service is perceived, delivered, or used. This can be exemplified by vegan mayonnaise made from aquafaba (chickpea water). The most significant changes created for the market and consumer were surveyed through radical innovation. This stage can be characterized by transformations that profoundly influence the product, give rise to completely new and pioneering concepts, and surpass conventional boundaries by introducing revolutionary ideas. An example of this could be 3D-printed snacks made from dehydrated dough. The surveyed were randomly appointed to one of the questionnaires, where each survey included three examples to promote understanding. Confirmatory factor analysis was applied to validate the reliability, convergence, and discrimination properties of the latent variables (i.e., Attitude, Behavioral Intention, Ecological Consciousness, Food Neophobia, Perceived Usefulness, and Risk Aversion). Except for "Risk Aversion," all items related to the latent variables' factor loadings were greater than 0.5, but it was not removed. As this finding contributed to the scale's validity, it ensured further evidence of the model's convergent validity. The created model's ability to represent the data was supported by various fit measures like RMSEA, CFI, or TLI. The statistical tests revealed a clear connection between favorable attitudes toward upcycled foods and the willingness to consume them. Through these measures, the authors also stated, that the belief that food products from the circular economy are beneficial positively affects consumer attitudes toward upcycled food. Environmental awareness has a positive effect on the perception of the usefulness of food technologies that incorporate waste into edible products. Food neophobia, risk aversion, and the degree of innovation applied by these technologies have a negative influence on perceived usefulness. The higher innovation in the food product is combined with the lower perceived usefulness of the innovation. This is explained by the sensory appeal and emotional response of disgust associated with upcycled food technology. Regarding gender, women were more likely to adopt upcycling technologies than men. However, age did not have a statistically significant effect on the likelihood of adopting these technologies in the study.

The research of Moshtaghian et al. (2023) aimed to analyze consumer preferences for the nutritional, environmental, and food safety aspects of upcycled food. The data for the study was collected by questionnaire. The authors focused on sociodemographic data, attitudes, and factors motivating up-

Table 1. **Studies Reviewing the Academic Literature on the Acceptance of Upcycled Food**

Issues Reviewed (Source)	Key Findings
Stages of consumer behavior in the transition to circular food systems	The transition of the consumers could be divided into tree stages; Linear: It can indirectly foster circularity by promoting secondary environmental or social advantages. Transitioning: This is characterized by the coexistence of traditional patterns and emerging circular practices. Circular: It is a lifestyle choice driven by consumer engagement.
The carbon footprint labels' effect on consumers (Rondoni, Grasso, 2021)	Women who are more environmentally conscious and have higher levels of education and income are more likely to support carbon footprint labels.
Which factors affect the acceptance of byproduct-based food? (Aschemann-Witzel, Stangherlin, 2021)	Product attributes, situational factors, and personal characteristics influence the acceptance of byproduct-based food. Promoting environmental awareness and highlighting the environmental benefits can further enhance it.
Challenges for upcycled food (Moshtaghian et al., 2021)	Strive to define the meaning of upcycled food, its position within food waste management strategies, and its consumers.

Source: author.

cycled food choices. The questions concentrated on concerns related to the environmental impact of food waste, previous experiences with upcycled food, intention for its consumption, relevance of its value-added feature in addition to preferences for conventional food over upcycled food. The questions were grouped into the following three sections: nutritional, environmental, and food safety characteristics. A 5-point Likert scale was mostly used for data collection. Not only was a definition provided in the survey (those food products that are made from ingredients that would not be consumed or would be wasted) but some examples were given as well. The answers were recorded through the SUNET platform on the University of Boras website. The English and Swedish questionnaires were filled out by 681 Swedish residents aged 18 or older, residing in Sweden between September 2021 and December 2021. The demographical analysis showed that women were the majority in all age groups. Additionally, the share of elderly individuals living independently in small households without children was higher than that of other age groups. The statistical tests revealed that the respondents between 18–39 years have somewhat higher concerns related to the environmental impact of food waste compared to the other age groups. All the studied clusters were open to the consumption of upcycle food, and approximately half of the surveyed people had already eaten it. However, the other half of the participants were uncertain whether they had ever consumed it. In all three age groups (18–39, 40–64, 65+), one out of ten respondents preferred conventional foods over upcycled food, and the same share considered the value-added feature of these products relevant. The nutritional characteristics of the upcycled product were the less important for all the groups. The nutritious and the minimally processed features were the most relevant. None of the clusters considered low energy and low-fat content as significant nutritional characteristics of upcycled food. The younger participants had fewer problems with processed/minimally processed products than middle-aged and elderly participants. This group also considered the nutritious features less relevant, nor did they focus on the vitamin and mineral content of the upcycled products as the oldest participants did. All the participants found the contribution of upcycled products to a lower level of food waste the most relevant. In second place, the youngest participants ranked green production. Meanwhile the middle-aged group positioned green packaging in the second place. None of the surveyed groups were particularly interested in the location of production. Nevertheless, local production was more relevant for the oldest respondents than the younger ones. The younger respondents worried less compared to other groups about green packaging. The authors analyzed the food safety-related characteristics of upcycled products as well. All respondents named the lack of contaminants and harmful substances of the utmost importance. The oldest and middle-aged paid more attention to the lack of GMOs, hormones, additives, and chemicals than the youngest group. Regarding the sociodemographic attributes, the first Generalized Linear Model – adjusted for gender – showed up positive connection between the age and the importance score of all nutritional features. The second Generalized Linear Model– adjusted for education, employment status, and income – did not reveal the same linkage in the case of fiber content, high-protein, and nutritious features. Related to the environmental characteristics, none of the models showed a significant relationship between the age and the importance of green production in addition to packaging. The first model revealed a positive relation between age and local production, but the second model did not. Even though there was no connection between the relevance of food waste reduction and age in the case of the first model, in the second model a negative association was found. Regarding the nutritional characteristics, all food safety characteristics' scores showed a positive relationship with the age in the first model, while the absence of poison and contamination did not reflect that in the second model.

The study of Goodman-Smith et al. (2023) analyzed how consumers in New Zealand respond to upcycled craft beer and how could it be effectively promoted. For data collection, the researchers together with the Citizen Collective developed a survey, which was tested (pilot) with customers. Using a non-random sampling method and an exploratory research approach, the finalized questionnaires were used in-store in February 2021 and online in March 2021. During the in-store data collection (which had ethics approval from the University of Otago Ethics Committee) a dedicated corner was created for this purpose, where the customers were informed about the product's origins and the manufacturing process. They learned it was made from surplus bread and had a chance to try it. After this, the was survey completed, which focused on their preferences for craft beer, their knowledge and perceptions related to upcycled food, their opinions on upcycled craft beer versus conventional craft beer, and factors that would influence their future purchases of upcycled food. Through this method, sixty-five answers were collected. The online survey was run on the platform "Yabble" according to the code of ethics for the Research Association of New Zealand. The craft beer consumers of PAK'nSAVE and New World panels were called upon to participate. In that way, three hundred answers were collected. The analysis of the answers was based on the comparison of the two samples. Regardless of where the respondents were involved in the study, taste, price, and country of origin were named as the most important aspect in selecting craft beer. The offline respondents paid more attention to company ethics, sustainability, and taste than the online ones. The z-test revealed that a higher share of in-store participants had prior knowledge of upcycled foods compared to the online ones. The three most significant benefits of upcycled food in both of the samples were sustainability in addition to the reduction of food waste and a lower carbon footprint. However, statistically, more offline consumers found the upcycled beer sustainable, as it decreases one's carbon footprint while increasing social status. In contrast, the people surveyed online were more likely to pair upcycled beer with nutritional benefits and higher earnings for producers than the in-store customers. A higher share of respondents who were surveyed offline expressed concerns related to the taste of upcycled food compared to those who answered the survey online. Based on a statistical test, a higher proportion of offline participants expressed concerns about the cost and quality of upcycled food. Meanwhile a higher share of online participants believed there were no negative aspects of upcycled food. In both of the groups only a small minority worried about food safety issues related to these products. Eight out of ten offline participants found the upcycled beer a little more or a lot more appealing than conventional beers. However, only five out of ten online customers thought the same. The statistical test proved a significant difference between the two groups. Nearly a two times higher share of online respondents found the upcycled beer less appealing than conventional beer, compared to the offline participants. No offline participants found the upcycled beer less appealing than conventional beer. According to the offline respondents, labeling could help the most for spreading word about the product. In contrast, the price was identified as the most significant factor for promotion by the online respondents. These people also identified third-party endorsement, a dedicated upcycled area, and price as crucial promotional tools.

The work of Moshtaghian et al. (2024) explored the driving forces behind consumer preferences for upcycled food and studied the relationship between the motivations and hesitancy surrounding upcycled food consumption. For data collection a questionnaire to uncover factors that could influence upcycled food choices, furthermore, sociodemographic questions were posed as well. The respondents answered mostly on a 5-point Likert scale and were informed about the definition of upcycled food. The current work defined it as products made from ingredients that would have ordinarily been discarded or wasted. These products are crafted from imperfect or damaged goods, food scraps, and byproducts from the food preparation process. The online survey was accessible between September 1 and December 1, 2021. During this period 682 Swedish respondents filled it out. Almost eight out of ten participants showed a willingness to consume upcycled food. The participants were classified (inclined or hesitant groups) based on their answers. In both of the groups, the average age of participants was 48 years, but a few more women could be found in the first group. The inclined group also had a higher percentage of full-time employed individuals and higher household incomes. The hesitant group meanwhile had a higher proportion of postgraduate-educated participants living alone. The following seven factors were identified by the explanatory factor analyses that influence the consumption of upcycled food; natural content, ethical concerns, healthiness, familiarity, sensory appeal, price, and impression. The hesitant respondents placed the highest importance on good taste, followed by chemical-free certification and natural ingredients. In contrast, the more open participants emphasized the contribution to food waste reduction, animal welfare, and chemical-free certifications. The groups did not differ significantly in their mean importance scores for items related to natural content. However, a significant difference was measured in the mean importance scores for items re-

lated to familiarity, sensory appeal, and impression. Related to the ethical concerns, there was a significant difference in the average importance ratings of most food choice factors between the studied types of respondents. A statistically significant difference was found in the mean importance ratings of low fat, low energy, and high protein content regarding the healthiness aspects among the various consumers. Both groups' consumers looked at ethical concerns as the most crucial factor when choosing upcycled food. Natural content and sensory appeal followed in importance. However, impression did not play a relevant role at all in any of the groups. The comparative analysis highlighted that, except for natural content, the average importance scores of all other factors significantly differed between the hesitant and inclined consumers. Those participants who were ready to consume upcycled food more frequently raised ethical concerns related to food waste reduction. Those respondents who considered ethical concerns a significant factor in their decision were 60% less likely to hesitate to consume upcycled food. However, the participants who prioritized healthiness and sensory appeal in their decision were significantly more likely to be hesitant, compared to those who did not prefer these features. In addition, those who named the appearance as a major feature were 2.4 times more likely to be hesitant, than those who did not focus on it.

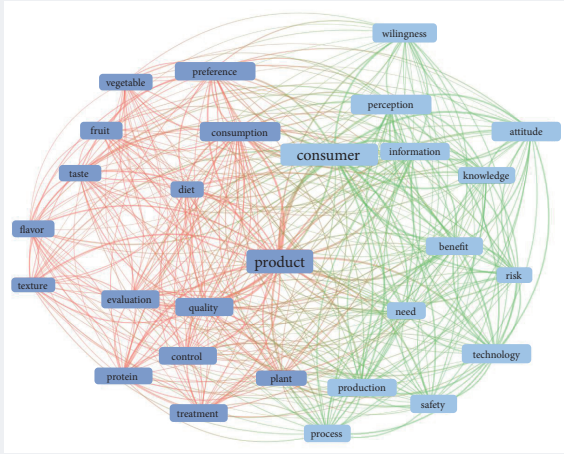
Discussion

The presented scientific articles studied the same phenomenon from various perspectives, which made it challenging to summarize the diverse variables and their effect on the acceptance of upcycled food products. The analyzed variables also aligned with the focus of the given study, but some common tendencies even could be seen. The consumers' knowledge regarding upcycling products is not so vast. According to the reviewed works, people who are into eco-friendly consumption seem to be open to this food. Regarding the nutrient content, the members of older generations tend to have more expectations than the younger ones. However, this feature should be less relevant, as a higher level of processing is needed to produce a value-added product (which is one of the attributes of byproduct-based food). In contrast, the low level of processing appeared to be a desired feature of the upcycled products. The taste, price, and level of processing seem to be general issues, which strongly can influence the decision-making of consumers. Considering that the acceptance of various food products was broadly studied, based on the last fifty years of scientific publications recorded by the Web of Science, several major attributes could be underlined related to the current study. Figure 3, created from over 11,000 studies' abstracts, divides the relevant features into two significantly different clusters.

The red words are product-related terms that could be evaluated when (similar) goods are compared. The green words are connected to consumers' attitudes, which could influence whether the red factors are relevant at all. When considering consumer attitudes, high demand for information is one of the decisive factors. The other key aspect within the same cluster is linked to production. Regarding the upcycled food products, informing the respondents about upcycled food (by for example, providing a definition, an example, or trial) was crucial in the majority of the studies, as this approach is emerging and not part of general public knowledge. The lack of information could be handled by directed advertising and in-store presentations. The in-person format with trials tends to be more convincing in engaging customers, but the role of online information sharing is also crucial. Reaching the widest possible audience can be costly, but compared to regular marketing expenditures, the advertising of upcycled products should not be a significant cost (Lehn, Schmidt, 2022). However, in the second case regarding production, technophobia is much more difficult to overcome. Food technophobia is a phenomenon that describes consumers' rejection or resistance to novel food innovations (Wendt, Weinrich, 2023). Retailers have to take it seriously because it is one of the most significant limitations of a product range's expansion (Siddiqui et al., 2022). Considering the customer fears, minimal processing (e.g., drying, grinding, cooking) and a flood of information could open up new avenues for surplus-based upcycled products. Well-positioned items could not only mitigate the financial loss in the short term, but could provide various benefits from multiple sources in the long term as presented in Figure 4.

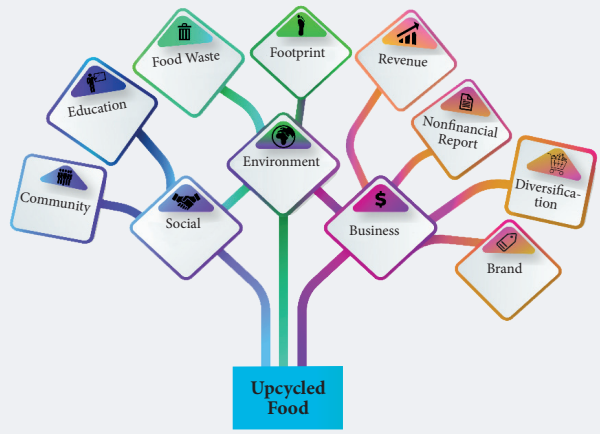
From a business perspective, the demonstration of a firm commitment to sustainability can appeal to environmentally conscious consumers and reflect creativity and an innovative mindset (Ishaq, Di Maria, 2020; Zameer et al., 2020; Loučanová et al., 2021). These associations could be incorporated into the retailer's brand. Although the supply of surplus food is unpredictable, this still could be beneficial. Through the various unsold products, everyday unique sustainable food options could be proffered, which improves companies' product diversification (Araujo et al., 2021; Ojha et al., 2020). Upcycling could also reduce financial losses, while increasing revenue through the higher sales (Paraskevopoulou et al., 2022; May, Guenther, 2020). In addition, the nonfinancial report could be improved with proven good practices, which could garner interest from green investors (Jaouhari et al., 2023; Ng, 2021). From an environmental perspective, by up-

Figure 3. **Information and Production, the Most Relevant Factors for Consumer Acceptance**



Source: author.

Figure 4. **Benefits of Upcycling's Early Adoption**



Source: author.

cycling, the amount of food waste could be significantly reduced (Tchonkouang et al., 2023). This also mitigates the emission of greenhouse gases that are produced during the decomposition of food waste (Jain, Gualandris, 2023). Upcycling also has social benefits. The sustainable lifestyle and values could bring people together and encourage consumers to adopt these practices at home. By promoting upcycling, children can also develop skills in cooking and nutrition (Coppola et al., 2021; Rondeau et al., 2020).

Conclusions

A constantly changing environment, new consumer demands, and the highly competitive nature of the market are some of the difficulties faced by retailers. Innovation is one of the opportunities that could help businesses in the food sector succeed. The enormous amount of Food Loss and Waste (FLW) generated by the retailers provides a hidden opportunity for the realization of a competitive advantage. However, according to the reviewed studies, until now this issue has only been studied at the production level. Upcycling is an innovative method to handle emergent challenges andsuch products are currently not well-known. Despite the lack of consumer knowledge, technophobia has not appeared in the reviewed articles, which propose a generally low level of upcycled food rejection. The decisive product features for upcycled food are similar to those of conventional products, which suppose the existence of a niche. The sales of these upcycled products could create a new sustainable alternative food category for retailers. However, this innovative solution needs extensive marketing campaigns to spread public knowledge about these products. Through in-store trials, consumer engagement could be quickly improved and the benefits of such innovations could be realized even in the short term. These advantages would furthermore improve contributions to the Sustainable Development Goals (SDGs). By reducing Food Loss and Waste, more food would be available, while resources such as land, water, and energy would be conserved. The lower level of FLW could help to protect forests and other natural habitats, in addition to mitigating climate change. Considering the growing eco-friendliness and price sensitivity on the consumer side, the positive associations with sustainable operating retailers could be built into the pioneers' brands. Furthermore, through the contribution of social values, the innovative retailers may be preferred by families as well. However, due to the hardly predictable nature of consumer demand and surplus, a permanent lack of upcycled products could disappoint potential clients. The retailers also have to the physical and human resource needs, by constantly developing new food products and recipes, and align those new products with the local regulations. Despite these difficulties, for smaller (e.g., family-owned) retailers, upcycling is certainly a great opportunity to reduce losses and build their brand. For larger (national/international) chains, the standardization of upcycling could cause difficulties. These challenges should be analyzed in future studies.

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