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Review paper

## **Circular Economy Based Food Products a Sustainable Solution for Food Waste and Mitigating the Environmental Issues in Consumer's Perspective**

Qamar U Zaman\*, Luca Rossetto, Mara Thiene

Department of Land Environment Agriculture and Forestry, University of Padova, Italy

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### **Abstract**

**Background and Aim:** Food waste is a huge global problem which poses plenty of environmental, economy related and food security related issues. Circular economy-based food production and consumption can mitigate this problem, however, the consumer preferences and behaviors towards circular economy food products is required. This review paper aims to give an overview of literature about circular economy food products and consumers preferences for circular economy-based food products.

**Methods:** We used key words; “circular economy”, “food products”, “upcycled foods”, “consumers” on google scholar, Scopus and web of science to find the most relevant research papers. The Inclusion and exclusion criteria were followed strictly and only relevant research papers included in this review paper. The finalized research papers were investigated in terms of title, abstract, methodology and result. The studies in literature were discussed and summarized in a proper way.

**Results:** This review summarizes research on circular economy-based food products, including recycling, reprocessing, reusing, upgrading, and adding value. Studies indicate that consumers generally prefer these products if they ensure environmental preservation, are healthful, and offer nutritional value. The review also identifies factors influencing consumer preferences for circular economy-based foods.

**Conclusion:** Adopting the circular economy food products is a sustainable solution, however their acceptance and consumption is required. This review paper identified and discussed the circular economy-based food products and consumer's preferences for these food products.

**Keywords:** *Food waste, Circular economy, Upcycled foods, Consumer's preferences*

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\***Corresponding author:** Qamar U Zaman, Department of Land Environment Agriculture and Forestry, University of Padova, Italy.

**E-mail address:** xxx.qamaruzaman@studenti.unipd.it

## **Introduction**

Every year, approximately one third of food is waste throughout the food production and consumption process. Food loss and waste (FLW) is an important and crucial topic due to its high socioeconomic impact and its relationship to food waste management food security and climate change related challenges. The FLW leads to huge losses of valuable resources and contributed to the environmental degradation FLW is also a moral issue because almost 12 percent of the population in the world is suffering from hunger [1]. Despite all the efforts taken to minimize FLW, it remains excessively high and requiring issue. Nearly half of all root crops, vegetables and fruits across the globe get wasted [2]. There are several studies in which the main sources of food waste are reported and they propose solutions. Recently, significant research has emerged concerning food loss and waste in various food supply chain stages: farm, postharvest, processing, distribution, and storage [3]. Food wastage occurs at each stage within the food supply chain. To effectively mitigate this issue the initial step involves recognizing the main source and then adopting the mitigating strategies [4]. The concept of a circular economy emerged in the 90s and consists of a production and consumption involving sharing, reusing and recycling existing materials and products, thus extending their life cycle [5]. Nowadays, a considerable part of the world's economy is defined as circular, how the main goal is to move toward a circular, sustainable and green food systems therefore, the main factors which affect the environment in terms of food production and consumption need to be considered [6].

Production of circular economy-based food products and food by-products have beneficial effects not only on the environment but also considered as a solution for food security and malnutrition. The ingredients and the components of these types of food products come from the transformation of other by products into a sustainable value-added food product with high functional value [7]. These foods are also termed as value-added surplus products made from the surplus ingredients which are gone the waste. However, a question remains: will consumers be willing to embrace products made from ingredients destined for the trash bin? [8]. Upcycled foods utilize ingredients that are typically discarded despite being usable. Although these products aid in reducing food waste, however, there remains a lack of knowledge regarding the optimal marketing strategy for their promotion [9]. Consequently, the food marketers need to promote these products as not only healthy and convenient but also boasting extended shelf life, distinguishing them from conventional and less innovative foods [10].

Consumer behavior continually evolves due to the introduction of ever-changing innovative foods that consistently meet people's expectations [11]. Sustainable consumption involves analyzing product choices and behaviors to address environmental concerns. The success of a sustainable and environmentally friendly food system relies on understanding the consumer's role. Individual consumer actions play a vital role in minimizing the adverse impacts of climate change [12]. It is crucial to understand customer intentions and behaviors when purchasing food by-products or products derived from leftover foods or components. Consumer insights play a significant role in bolstering the development of circular systems through their buying decisions. Therefore, evaluating consumer perceptions of foods produced from other left-over foods is essential. This assessment helps in understanding related consumer habits and how their purchasing intentions can either support or hinder the circular economy an environment [13]. In this context, the acceptance of the upcycled food products by the consumers, with ingredients previously wasted in the supply chain is fundamental for the final absorption of all products in

the market. Hence, one of the main challenges in this evaluation is trying to explore consumer preferences for such products [14]. In addition to that there are various food technologies that can increase the value of consumable food waste through upcycling and value addition in production. Nevertheless, implementing these technologies comes with costs for businesses, and consumers may not be willing to bear these expenses. This situation often leads to consumer trust issues [15]. However, the consumption behavior and intentions of consumers towards these green, sustainable and circular foods needs also governmental policies, consumers' environmental value, and convenient channels [16].

Keeping in view the introduction and background this review paper is intended to identify different studies on circular economy-based food products and to analyze the consumer's preferences and behaviors towards these products so that the consumption of environment friendly and sustainable food products made by upcycled ingredients can be promoted.

## **Methods**

The review of literature was conducted by using some specific key words which were “consumer”, “circular economy”, “foods”, “upcycled foods”. The data was searched from three main data bases; google scholar, Scopus and web of science. The inclusion and exclusion criteria was defined according to the key words. In the first phase of selection of research papers for review; the title of papers was read and assessed according to the key words. According to inclusion criteria only research papers published since 2010 were collected. According to the exclusion criteria; reports, review articles, papers published before 2010, conference abstracts and presentations were excluded from the study. All the papers were gone through extensive analysis after reading their titles the abstracts were read and then their methodologies and results were evaluated. Many articles were excluded during the abstract reading and evaluation of methodologies. Only those research papers were finally included in the review in which specifically upcycled foods, circular economy foods, consumers preferences and waste to value foods were discussed. The main purpose of this careful and rigorous searching was done to ensure that the layout of this review paper may be up to the mark and to meet the main objective of this this review paper.

## **Literature of Review**

In 2004 Floros, described in his study that food processing and preservation is very deep in history and is dated back to very old and ancient civilizations. For example, the three most important foods in Ancient Greece—bread, olive oil, and wine—were all products of complicated processing that transformed perishable, unpalatable, or hardly edible raw materials into safe, flavorful, nutritious, stable, and enjoyable foods [17].

In 2020 Donner highlighted circular business models for valorizing agricultural waste and by-products. The study emphasized the cascading use of biomass to generate high-value products as a crucial aspect of a circular economy. Analyzing 39 cases, the study illustrated how agricultural waste and by-products could be translated into valuable products through various circular business models, including upcycling entrepreneurship, agricultural cooperatives, and agro parks [18].

In 2020 Sousa reported such food by-products: cereals to obtain fibers, hemicelluloses, beta-glucans and prebiotic oligosaccharides, Root crops to obtain polyphenols and organic acids. Oil crops to obtain phytosterol and polyphenols, fruit and vegetables to obtain pectin and carotenoids, meat to obtain proteins, peptides or amino acids, fish and crustaceans for protein

chitin and chitosan. Milk by-products, mainly whey, peptides, and lactose. The production of upcycled foods in the form of powders, flours or dehydrated snacks also helps to increase both the convenience of the products and their shelf life, thus transforming the food market to more productive and sustainable [19].

In 2023 Cela et al, conducted a consumer analysis of upcycled food products focusing on cheese, beer, and biscuits in Italy. They collected data from 80 individuals and employed principal component analysis (PCA) and analysis of variance (ANOVA). They focused on assessing consumers' purchase intentions regarding these products based on parameters such as personal benefit, health value, eco-friendliness, societal benefits, origin, quality, taste, and traditional values. It was found that eco-friendliness, and benefit for my self was high for these upcycled foods [20].

In 2020 Sehnem analyzed how the maturity stages of wine relate to consumer acceptance behavior within a circular economy model involving twenty-eight wine producers. The study revealed a link between the implementation of circular economy principles and underlying business models [21].

In 2005 Yam notably highlighted the direct influence of packaging evolution, transitioning from conventional packaging to intelligent packaging, on consumer preferences [22].

In 2020 Coderoni and Perito assessed the factors influencing consumers' purchasing intentions for value-added foods. Their research delved into how socio-demographic and psychological characteristics affect consumers' inclination to purchase food by-products enriched with ingredients typically wasted in the supply chain. The findings indicated that over half of the interviewees expressed willingness to buy food based on environmental sustainability, emphasizing the importance of product origin and nutritional values [14].

In 2021 Bhatt et al, conducted a consumer analysis of upcycled chicken nuggets in the USA. These chicken nuggets were made from ingredients typically discarded to reduce food waste. The research emphasized that the commercial success of upcycled foods depends on consumer acceptance. The findings indicated that consumers value the benefits of upcycled foods while expressing concerns about their quality. The upcycled logo and perceived quality were the main factors of determining the consumer's preferences [22].

In another study by Goodman Smith in 2021 in New Zealand by surveying consumer perceptions of muffin snacks made with peels of bananas. This study utilized a descriptive statistics approach to analyze consumer perceptions of these food items. More than half of the consumers were willing to buy the snacks made with other by products keeping mind that it will positively affect the environment [23].

In 2021 Ali et al. conducted a consumer analysis focusing on Waste-to-Value products, demonstrating the circular economy's processes by converting excess materials into new foods with enhanced nutritional properties. The study aimed to evaluate various factors influencing consumers' perceptions and purchase intentions for sustainable Waste-to-Value foods within the context of the circular economy. Factors such as demographic factors, origin, and nutritional value. The study findings indicated that younger consumers demonstrated higher intentions towards waste-to-value foods [13].

Sijtsema (2019) demonstrated various factors influencing consumer perceptions of the circular economy and sustainable consumption through four focus group discussions; perceptions, attitudes, motives, and barriers involving 24 participants in the Netherlands. It was revealed that most consumers lacked a clear understanding of the term circular economy in foods. Additionally, participants showed diverse views regarding the advantages and disadvantages,

which were linked to product functionalities, production system, economic aspects, and emotional concerns such as risk apprehension linking to practical cases; and applying multidimensional CE-related behavior in everyday life and involving consumers in its innovation [5].

Cadena et al. (2012) conducted sensory evaluation of vanilla ice cream with upcycled ingredients and with reduced fat and sugar to determine drivers of liking. Descriptive sensory profiles (n = 11) and consumer test (n = 117) of 6 samples of vanilla ice cream (3 traditional and 3 with reduced fat and sugar) were conducted. The attributes were brightness, level of sweetness aftertaste, creaminess (appearance and texture), aeration, powdered milk aroma and flavor, and white chocolate aroma and flavor. It was found that most of the consumers chose the reduced fat [24].

A study conducted in Pakistan by Ghazanfar et al, did consumer analysis in Pakistan regarding the willingness to pay for value-added products such as chicken nuggets, granola bars, ice cream, and muffins. Their study encompassed 300 consumers, focusing on consumer intentions, familiarity with the products, shopping frequency, and food categories. Using an online questionnaire, they collected data and employed the multiple linear regression model for analysis. It was deduced that the virtue products either conventional or upcycled were more accepted by the consumers [25].

## **Discussion**

The literature reviewed suggests that there are several factors which affect the consumer's preferences and behaviors toward circular economy-based food business models [26]. In addition to that age and lifestyle of consumers is a very important factor determining the preferences for upcycled foods [27]. These studies also looked into the effect of information provided to the consumer and transparency of information. In addition to that the willingness to pay and willingness to accept has also been explored in these studies, these willingness and acceptability are very important to know about the upcycled foods or circular economy-based foods. In this way the food manufacturers can be able to know about the intentions likes and dislikes of the consumers about these foods. Moreover, it was concluded from the literature review that the upcycled food products features like nutritional characteristics and environmental information affect the consumer preferences for these types of products [28], [29].

These studies were conducted in various countries like Italy, USA, China, Pakistan and many countries in Europe. But most of the studies have been conducted in Europe that can be due to the fact that European Union is collectively willing to address the environmental issues by promoting the circular economy-based food production and consumption at a large scale. These studies show that there is dire need to understand how consumers perceive about these types of new food products. Most of the studies included demographic factors, ages, genders, education economic status and the geographical area. In addition to that several other factors like the concept of sustainability and circular economy in agri-food businesses was discussed [17], food packaging innovation from conventional to innovative food packaging with respect to the consumers perception was explored [22]. Apart from that the beneficial factors which bring benefit to the consumer themselves and the society, nutritional benefits and self believes were also demonstrated [22].

## **Conclusion**

By reviewing all the papers identified during this review paper it can be easily concluded that the

production of circular economy-based food products is a promising solution for the prevention of food waste and also to enhance the food security. However, there is a dire need of consumer analysis and knowing the consumer preferences towards these types of food product which are made from other upcycled ingredients or by products.

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### **Conflict of Interests**

The authors declare that there are no competing interests and all the authors are willing on common ground to publish this article without any conflict or distraction.

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