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FROM FOOD WASTE TO FOOD SUPPLEMENTS: SUSTAINABLE TRANSFORMATION FOR ECONOMIC SECURITY

Abstract. *In this study, we explore the potential for cooperation between hospitality and food supplement manufacturers. The concept aligns with sustainable development principles, addressing both social and environmental concerns. Specifically, it focuses on the collection and upcycling of food waste into food supplements. The paper identifies alternative SWOT strategies to evaluate the feasibility of this idea in the entrepreneurial sector. One key solution to food waste is food upcycling, a growing trend where unused food scraps are transformed into new products. Emerging innovative methods, like advanced food drying technologies, offer effective ways to combat food waste by converting scraps into nutritious products without excessive heat. The study highlights several critical aspects of food upcycling, including: economic efficiency through resource conservation, reduced dependency on external food sources, and enhanced food security. The process also fosters technological development, attracting investments and generating new job opportunities, which strengthens economic stability. Furthermore, upcycling reduces waste and conserves natural resources, positively impacting environmental and economic sustainability. By turning food waste into valuable supplements, this approach contributes to sustainable development goals, such as combating hunger and improving access to nutritious food, thus promoting both social and economic security at the national level.*

Keywords: *sustainable development, food waste, food supplements, food security, economic security*

1. Introduction

Food waste is a major issue with widespread implications, negatively affecting society, the environment, and the economy on a global scale. Among the 17 Sustainable Development Goals (SDGs) outlined in the UN 2030 Agenda, signed in 2015, SDG 12 — Responsible Consumption and Production and its associated targets have emerged as a significant challenge due to the ongoing rise in global industrial food waste [1].

The SDGs provide a unique opportunity to transform the concept of sustainability into actionable plans, emphasizing the urgency needed to achieve specific goals that will guide the world toward a more sustainable and resilient future. The primary aim of SDG 12 is to cut global food waste and food loss in half by 2030. Reducing food waste also supports progress toward other SDGs, including Climate Action (SDG 13), Zero Hunger (SDG 2), Sustainable Water Management (SDG 6), and Life on Land (SDG 15).

According to the "Food Waste Index Report" from the United Nations Environment Programme [2], a staggering 931 million tons of food waste were

generated worldwide in 2021 across every stage of the food supply chain: production, distribution, retail, markets, and domestic consumption. This report plays a critical role in advancing SDG 12, with new estimates published annually.

Food waste was also a key topic during the side events at the 26th UN Climate Change Conference (COP26) in November 2021, held at the Scottish Event Campus (SEC) in Glasgow.

The food industry is a major contributor to global greenhouse gas emissions, responsible for approximately one-third of all emissions, according to the United Nations [3]. Reducing food waste is key to helping lower these emissions. In regions that rely on local agriculture, food waste often occurs during production. In wealthier areas with a global food supply network, the problem tends to stem more from consumer waste and inefficient food usage

The annual increase in food waste is one of the most significant problems also in the hospitality industry. Every year, around 1.3 billion tonnes of food waste is produced by hotels and restaurants around the world. This is not only a waste of food itself, but also a loss of other resources such as land, water, energy needed to produce all this food. Financial losses are no exception. In the European Union, an impressive 20% of food produced — around 173 kg per person — is thrown away, with the hospitality industry accounting for 12% of food waste in Europe [4]. Given the existing problem, the European Union has declared food waste reduction as a key sustainable development goal in its 2030 agenda. This initiative calls for collective efforts from governments, institutional organizations, businesses and households. By implementing a food waste reduction strategy, both businesses and households can save a lot of money. Not to mention the reduction of their impact on the environment. The financial savings from reducing food waste can be significant. In fact, by solving the problem of food waste, both businesses and individuals can contribute to creating a more sustainable food system, while receiving economic benefits.

One of the directions for solving the problem of food waste is food upcycling — this is a new food trend, according to which previously unused food residues are processed into one or another type of completely new product. Innovative methods, such as advanced food drying techniques, are emerging as effective solutions to combat food waste. Companies are creating technologies that transform food scraps into nutritious flavors and supplements without the need for excessive heat. The focus of food upcycling in this context is on the following aspects:

Economic efficiency of resources. The transition from food waste to food supplements contributes to the reduction of resource losses and savings. This is important for ensuring sustainable economic development, which is the basis of the country's economic security. Creating supplements from waste can help increase production efficiency and reduce costs.

Ensuring food security. The use of food waste to create supplements allows reducing dependence on external food suppliers, reducing the risks associated with global food crises, shortages and food price inflation. This contributes to market stability and ensuring access to nutrients.

Innovation and technological development. The development of technologies for processing food waste into supplements contributes to economic growth and the development of new industries. This process increases the competitiveness of the economy, attracting investment and creating new jobs, which has a positive impact on economic security.

Impact on environmental and economic sustainability. Reducing waste by upcycling it into useful products conserves natural resources and reduces waste disposal costs. This can help ensure environmental sustainability, which in turn affects long-term economic security.

Support for sustainable development and social responsibility. Using food waste to create supplements also contributes to the achievement of sustainable development goals, in particular in combating hunger and improving access to nutritious foods for all. This is directly linked to social and economic security at the national level.

In this study, we propose the idea of cooperation and interaction between hospitality enterprises — hotels and hotel chains, restaurants, cafes, etc. — and food supplements manufacturers. In fact, this is a reflection of the idea of sustainable development, focused on social and environmental issues and aimed at collecting food waste and its further upcycling to create food supplements. This study identifies alternative SWOT strategies [5] in order to determine the feasibility of using such an idea in entrepreneurship. For example, fruit and vegetable by-products can be used as nutraceuticals due to the content of substances beneficial to health [6]. The term "nutraceuticals," which is a hybrid of the words "nutrition" and "pharmaceutical," refers to nontoxic extract supplements with scientifically proven health benefits for both treatment and prevention [7]. Probiotics, prebiotics, antioxidants, polyunsaturated fatty acids, etc. are the most common food components used as nutraceuticals [8]. In turn, a Chinese food supplement manufacturer has patented an innovative process for producing dietary supplements containing lycopene from tomato by-products [9]. The company has registered a patent for an extraction method that offers the health benefits of the antioxidant through a technology that removes pesticides and improves the quality of lycopene. All this confirms that this new approach to food upcycling, based on circular thinking, can provide the right solutions to new technical, economic, and environmental challenges.

The topic of efficiently utilizing food products and reducing food waste in the hospitality industry remains a significant area of research, as demonstrated by numerous global studies [10–19]. A key focus has traditionally been on the environmental benefits of minimizing food waste in the restaurant sector [Beretta & Hellweg, 2019]. Many researchers explore food

waste in the context of sustainable development, particularly considering regional factors [20; 21]. Understanding the quantity, patterns, and causes of food waste is essential for developing strategies to reduce it [22]. From an economic side, McKinsey's research indicates that tackling food waste can reduce retail and manufacturing costs by 3 to 10%, unlocking up to US$80 billion in new market potential [23]. U.S. food waste costs approximately $162 billion annually [24]. One proposed solution is selling suboptimal food that would otherwise be wasted [25]. The global nature of this issue is also reflected in studies focused on strategies to combat food loss and waste [26]. On the other hand, the issue of food additives is also addressed by a number of scientific publications, the vast majority of which focus more on the role of dietary supplements and their impact on human health [27–29]. Díaz, Camara, and Fernandez-Ruiz note that food supplements and functional foods are considered foods that contribute to optimal nutritional well-being, health status, and quality of life by reducing the risk of disease and promoting the proper functioning of human organs and systems [30]. Other studies [31] focus on the sources, models, and human studies that support the health claims of these supplements, followed by sections describing side effects and potential causes for concern.

Overall, food waste in the hospitality sector is a significant and complex issue that requires multifaceted solutions. Existing research highlights the importance of understanding the root causes of food waste and implementing targeted strategies to combat it. However, the idea of food upcycling to address the issue of recycling waste into food supplements is new and not widely used in current scientific literature.

2. Materials and Methods

Justifying the need to define alternative SWOT strategies as a tool for determining the feasibility of food upcycling for the purpose of obtaining food supplements, we should note the following. SWOT analysis as an analysis of the weaknesses and strengths of a specific project or business idea, its threats and opportunities involve creating an appropriate matrix for analyzing the life conditions of the idea and its potential.

The definition of alternative SWOT strategies as a tool for determining the feasibility of food upcycling for the purpose of obtaining food supplements was carried out in the context of sustainable transformation. In order to obtain comparative results, a unified system of criteria for assessing the strengths and weaknesses, opportunities and threats of a specific idea was used. A scoring method based on assessments was used to evaluate all of the specified criteria. The assessment was carried out on a 5-point scale, where:

5 points — the maximum significant force of the factor.

4 points — significant influence of the factor

3 points — noticeable influence of the factor

2 points — moderate influence of the factor

1 point — insignificant influence of the factor

The overall assessment of the influence of each group of factors is determined by the sum of the points. The corresponding SWOT map is given below.

In order to determine in which field of interaction of the SWOT matrix influence factors the most optimal strategies are located, which must be followed, it is advisable to find out which combination of factors has the greatest impact on the development process of the object for which the SWOT analysis matrix is being built. For this purpose, the assessment of the strength of the interaction of factors is found as the product of the sum of the scores of the corresponding factors according to formulas (1) — (4) [32].

$$X_{SO} = \sum X_S \times \sum X_O \quad (1)$$

X_{SO} — cumulative score assessment of the feasibility of implementing a strategy combining strengths and opportunities;

$\sum X_S$ — overall assessment of the strength of the strengths, determined by the sum of the points;

$\sum X_O$ — overall assessment of the strength of the capabilities, determined by the sum of the points.

Table 1

SWOT map

Opportunities	Point	Threats	Point
– Factor 1 – Factor 2 – Factor 3 – Factor 4 – Factor 5…		– Factor 1 – Factor 2 – Factor 3 – Factor 4 – Factor 5…	
Total points		**Total points**	
Strengths	**Point**	**Weakness**	**Point**
– Factor 1 – Factor 2 – Factor 3 – Factor 4 – Factor 5…		– Factor 1 – Factor 2 – Factor 3 – Factor 4 – Factor 5…	
Total points		**Total points**	

Source: created by authors based on [5]

$$X_{ST} = \sum X_S \times \sum X_T \quad (2)$$

X_{ST} — cumulative score assessment of the feasibility of implementing a strategy combining strengths and threats;

$\sum X_T$ — overall assessment of the strength of threats, determined by the sum of the points.

$$X_{WO} = \sum X_W \times \sum X_O \quad (3)$$

X_{WO} — cumulative score assessment of the feasibility of implementing the strategy of combining weaknesses and opportunities;

$\sum X_W$ — overall assessment of the strength of the weaknesses, determined by the sum of the points.

$$X_{WT} = \sum X_W \times \sum X_T \quad (4)$$

X_{WT} — cumulative score assessment of the feasibility of implementing a strategy combining weaknesses and threats.

As a result, we will have a generalizing SWOT matrix for choosing the optimal strategy for the behavior of the object of analysis in the market.

In the analysis matrix, the interaction of factors occurs, resulting in the following areas: S&O — the area of interaction of strengths and opportunities; W&O — the area of interaction of weaknesses and opportunities; S&T — the area of interaction of strengths and threats; W&T — the area of interaction of weaknesses and threats. In accordance with the pair interactions that are in these areas, a further economic business model is built based on a map of alternative strategy vectors. Accordingly, the strategy vector is determined by the area of the rectangles that characterize the corresponding area of interaction of factors of strengths and weaknesses, opportunities and threats. The choice of the optimal strategy of behavior should be carried out in accordance with the maximization of the area of the rectangle of the interaction of factors [33].

$$\begin{cases} S_{S\&O} = X_{SO} = \sum X_S \times \sum X_O \to \max \\ S_{W\&O} = X_{WO} = \sum X_W \times \sum X_O \to \max \\ S_{S\&T} = X_{ST} = \sum X_S \times \sum X_T \to \max \\ S_{W\&T} = X_{WT} = \sum X_W \times \sum X_T \to \max \end{cases}$$

The optimal strategy will be to combine those factors, the product of the score estimates and, accordingly, the area of the interaction rectangle, which is maximum.

3. Results and Discussion

According to the Upcycled Food Association, upcycling food is “the process of transforming by-products, surplus food, and food waste into new, high-quality products for human consumption”. In 2020, a group of specialists from Harvard Law School, Drexel University, the World Wildlife Fund, Natural Resources Defense Council, ReFED, and other organizations officially established the definition of ‘upcycled food’ for applications in policy, research, and beyond: “Upcycled foods use ingredients that otherwise would not have gone to human consumption, are procured and produced using verifiable supply chains, and have a positive impact on the environment” [34].

Food waste can be classified into consumer waste, production waste and post-consumer waste [35]. Production or industrial food waste is usually organic residues defined as unavoidable food waste generated during sorting and cleaning processes, and is mainly represented by plant-based waste such as fruit and vegetable peels or pomace; grains and cereal bran; and animal waste that has no economic value for the producing company, therefore, it is intended to be processed according to the linear model [36]. Except for this waste, if it is intended for reuse by the same company or other organizations, it cannot be considered as waste, but becomes a by-product with a market value.

As world community work toward a more sustainable future, upcycling presents an effective and meaningful solution to cut waste, reduce CO^2 emissions, and minimize land use.

Reducing waste: by repurposing food by-products, it can significantly reduce the amount of waste that ends up in landfills, which helps lower methane emissions. The Food and Agriculture Organization states that food waste is responsible for approximately 8% of global greenhouse gas emissions [37].

Lowering CO^2 emissions: upcycling typically uses less energy than creating new materials from scratch. For instance, repurposing spent grain into flour instead of growing new crops conserves energy and resources, lowering the overall carbon footprint.

More food, less land: upcycling enables us to maximize the use of existing resources, allowing for the production of more food without the need for additional agricultural land. This is essential for protecting natural habitats and preserving biodiversity.

Everyday examples of food upcycling:

1. From brew to bread. Spent grain, a byproduct of beer brewing, is rich in nutrients and can be upcycled into high-fiber, protein-packed flour. This flour can be used to bake bread, cookies, or even pasta, transforming what would have been discarded into delicious and nutritious foods.

2. Turning fruit scraps into snacks. Some companies upcycle leftover fruit pulp into snacks, dried chips, or smoothie bases, utilizing the remaining fiber and flavor to create tasty and healthy products.

3. Coffee grounds in baking. Leftover coffee grounds are increasingly used in baked goods like brownies and cookies. Not only do they add a rich, earthy flavor, but this practice also helps reduce the waste generated by coffee shops and households.

In general, the process of transforming food waste and leftovers into food supplements is a growing trend in sustainability and the circular economy. It involves recycling food waste (such as peels, stems, seeds, or leftovers) into valuable ingredients that can be used in health-oriented products. This approach not only reduces food waste, but also creates new sources of

nutrients and functional ingredients. The main pathways for this transformation are:

1. Source of food waste.

Fruits and vegetables: the peels, cores, and other parts of fruits and vegetables that are often thrown away can be rich in vitamins, fiber, and antioxidants. For example, citrus peels contain flavonoids that are beneficial for health.

Grains and seeds: the leftover parts of grains, such as spent grains from brewing or rice husks, can be processed into flours or protein-rich powders.

Coffee grounds and tea leaves: these byproducts may contain antioxidants and nutrients that can be extracted and used in supplements or skin care products.

2. Processing methods.

Drying: innovative drying techniques, e.g. freeze-drying or air-drying, are often used to preserve nutrients in food waste without losing as flavor as quality. This method reduces the moisture content, making it easier to process leftovers into powders or concentrates.

Fermentation: companies use fermentation to improve the nutritional profile of food waste, e.g. fermented fruits or vegetables. This not only improves the nutrient content, but can also add probiotics and other beneficial compounds.

Cold pressing: some products, such as fruit pulp or vegetable waste, can be cold pressed to extract juices or oils, which are then concentrated into food supplements.

3. Creating food supplements.

Powders and protein supplements: once food waste is processed into powders or concentrated forms, it can be used in food supplements, e.g. protein powders, vitamin-rich shakes, or smoothie boosters. For example, spent grains can be dried and ground into flour that is used in baking or mixed into protein shakes.

Functional products: using processed food waste or leftovers, manufacturers can create functional products that provide additional health benefits. For example, powders from vegetable waste can be added to energy bars or smoothies, increasing the fiber and antioxidant content.

Nutrient-rich extracts: leftovers such as fruit peels or seeds can be processed into extracts rich in vitamins (such as vitamin C from citrus peels) or omega-3 fatty acids from seeds. These extracts can then be incorporated into dietary supplements or used to fortify other foods.

4. Health benefits.

Fiber and antioxidants: a lot of food waste byproducts are rich in fiber, which is important for digestion and maintaining gut health. They also often contain antioxidants that help fight inflammation and oxidative stress, which could be the subject of a specific type of food supplement.

Vitamins and minerals: leftovers from fruits and vegetables can be rich in essential vitamins like A, C, and E, which support a healthy immune system, skin, and overall well-being.

5. Sustainable development.

Recycling food waste and leftovers into supplements not only reduces the environmental impact of landfills, but also closes the loop in the food production system, aligning with the principles of a circular economy. By turning waste into valuable products, companies are helping to conserve resources and reduce the need for new raw materials. There are some samples of companies with sustainable approach in business:

– Toast Brewing: this company brews beer from leftover bread and also recycles the grains into protein-rich products [38].
– Upcycled Food Association: this non-profit organization helps promote the use of food waste as an ingredient in food products, including supplements [39].

Table 2

SWOT map of food upcycling

Opportunities	Point	Threats	Point
– reducing food waste	5	– safety and quality issues	5
– using useful food properties	4	– non-compliance with food standards	5
– production of functional supplements	4	– loss of nutritional value	3
– increasing economic efficiency for business and countries	3	– psychological barrier of consumers	4
		– supply instability	2
– improving food technology	5	– environmental risks	2
– social responsibility	4		
Total points	**25**	**Total points**	**21**
Strengths	**Point**	**Weakness**	**Point**
– economic benefit	4	– lack of legal basis on this issue	5
– reducing production costs	2	– negative perception by consumers	5
– innovations development in the food industry	5	– social and cultural barriers	
		– high costs for technology and equipment	4
– improving food security	3	– difficulties in scaling production	4
– stimulating the development of a “circular” economy	5	– heterogeneity and instability of raw materials	3
– increasing awareness of healthy eating	3		4
Total points	**22**	**Total points**	**25**

Source: created by authors

– Upcycled Foods, Inc. (ReGrained): this company takes grains from breweries and recycles them into nutrient-rich bars and flours [40].

In general, converting food waste into food additives is an innovative and effective way to address both food waste and nutrition issues. It's a win-win for everyone in terms of sustainability, reducing waste, and providing valuable nutrients to consumers.

The above gives grounds to assert the unconditional feasibility of converting food waste into food supplements.

Accordingly, we will identify alternative SWOT strategies as a tool for determining the feasibility of processing food waste to obtain food supplements.

The overall assessment of the strength of each group of factors, calculated by summing the individual points, is as follows: the strength of strengths is 22 points, weaknesses total 25 points, the strength of opportunities also amounts to 25 points, and threats account for 21 points. Based on these evaluations, we can construct a comprehensive general SWOT matrix that will guide the selection of the optimal strategy for implementing food upcycling within this context. The general SWOT matrix is presented below.

Based on the results of the calculations, the highest value is observed in the intersection of weaknesses and opportunities, where the cumulative score reaches 625 points. This indicates a significant alignment between the identified weaknesses and the potential opportunities available. To visually represent these findings, the graph below illustrates the chosen vector for the alternative SWOT strategy, providing a clear depiction of the strategic direction based on the analysis.

As it mentioned above the food upcycling process needs a strategy that mitigates the weaknesses of food upcycling while leveraging its opportunities. The structured approach to build such a strategy includes policy and regulatory development addressing the lack of legal basis. The possible way could be collaboration with policymakers, industry experts, and international organizations to establish clear regulations for food upcycling. Opportunities help align legal frameworks with global sustainability trends and use the argument of economic efficiency to advocate for incentives and subsidies.

Consumer education could be reached with awareness campaigns addressing the negative perception by consumers, social and cultural barriers. It includes developing targeted campaigns to change consumer perception about upcycled food products. Opportunities help to emphasize health benefits (functional supplements, improved food technology) and to partner with influencers, chefs, and sustainability advocates to reshape social norms.

Cost reduction through innovations (addressing: high costs for technology and equipment).

Action: Invest in R&D to develop cost-effective upcycling technologies and alternative processing methods.

How Opportunities Help:

- Improved food technology can optimize processes and lower costs.
- Economic efficiency for businesses will attract investors and grants.

Scalable business models (addressing: difficulties in scaling production).

Action: Foster partnerships between startups, food manufacturers, and hospitality businesses to create scalable production chains.

How Opportunities Help:

- Reducing food waste provides a continuous supply of raw materials.
- Economic benefits will attract investors and facilitate expansion.

Stable supply chain management (addressing: heterogeneity and instability of raw materials).

Action: Develop a digital platform for food waste collection and classification, ensuring a steady and quality supply of raw materials.

How Opportunities Help:

- Social responsibility can motivate businesses to join such networks.
- Technology improvements will enhance tracking and quality control.

As we can see, successful implementation of food processing depends on a comprehensive strategy that addresses both threats and opportunities. By focusing on key areas such as policy and regulation development, consumer education, technological innovation, scalable business models and supply chain management, the food processing industry can overcome existing barriers and realize its full potential. Collaboration with policymakers, experts and influencers, as well as investment in research and development, will help create an environment conducive to growth. Seizing opportunities such as global sustainability trends, technological advances and cost efficiencies will not

Table 3

General SWOT matrix of food upcycling

		Opportunities	**Threats**
		$\sum X_O$ = 25 points	$\sum X_T$ = 21 points
Strengths	$\sum X_S$ = 22 points	S&O X_{SO} = 22*25 = 550	S&T X_{ST} = 22*21 = 462
Weakness	$\sum X_W$ = 25 points	W&O X_{WO} = 25*25 = 625	W&T X_{WT} = 25*21 = 525

Source: created by authors

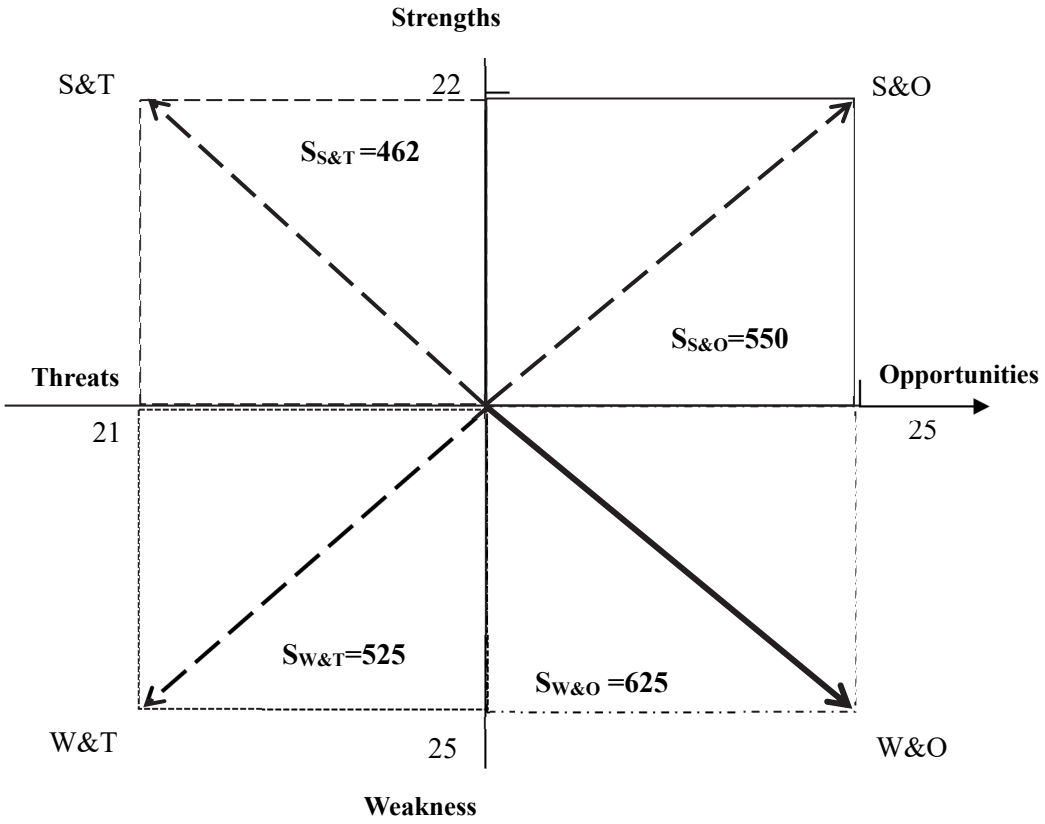

Figure 1. Vector of the alternative SWOT strategy
Source: created by authors

only strengthen the industry but also facilitate its widespread adoption. Ultimately, with a strategic and well-coordinated approach, food processing can become a key component of sustainable food systems.

4. Conclusions

Addressing food waste is a critical global issue with far-reaching consequences for society, the economy and the environment. Food waste can be described as a significant portion of resources that could otherwise contribute to a more sustainable food system. With global food waste levels reaching staggering levels every year, and sectors such as the hospitality industry contributing significantly to this waste, it is clear that innovative solutions are urgently needed. In this context, food recycling has emerged as an important and promising approach to reducing waste while simultaneously creating valuable products that can contribute to human health.

Food upcycling involves the recycling of food waste, surplus food and food scraps into new, high-quality products for human consumption. It aligns with the principles of the circular economy, transforming waste into valuable resources and closing the loop in the food production system. Examples of beer grounds, fruit pulp, coffee grounds and other food residues confirm the growing recognition of the nutritional potential of these often-discarded leftovers. Food upcycling can provide nutrient-rich ingredients for food supplements, functional foods and even improve the production of everyday food products such as snacks, flours and beverages.

The potential for upcycling leftovers is enormous, not only in terms of solving the problem of food waste, but also in terms of the opportunities it offers for economic and sustainable development. By upcycling food waste into nutraceuticals — food products that promote health — companies are simultaneously addressing two pressing issues: food waste and nutrient deficiencies. Using food waste as ingredients in supplements and functional foods could make a significant contribution to the health and wellness industry, creating a valuable market for these upcycled materials. As research into food upcycling continues to grow, new technologies and processing methods, such as drying, fermentation, and cold pressing, will play an important role in unlocking the full potential of food waste.

However, the successful implementation of food upcycling depends on careful consideration of both the opportunities and the challenges. The SWOT analysis conducted in this study highlighted the need for a strategic approach to address the weaknesses of the current food processing industry while capitalizing on its opportunities. Key areas identified for improvement include regulatory development, consumer education, technological innovation, scalable business models, and supply chain management. Collaboration with policymakers, industry experts, and international organizations is essential to create a clear legal framework for food upcycling that aligns with the global sustainable development goals. By creating policies that encourage and support the adoption of upcycling

practices, governments can encourage businesses to invest in innovative technologies and processes.

Equally important is the need for consumer education. Food upcycling is still a relatively new concept, and many consumers remain unaware of the benefits or the nutritional value of upcycled products. Targeted awareness campaigns, which address negative perceptions and social barriers, are crucial to changing consumer attitudes and encouraging the adoption of upcycled foods. Emphasizing the health benefits of upcycled products — such as the presence of antioxidants, fiber, and essential vitamins — can help reshape consumer perceptions and promote the idea of upcycling as a sustainable and healthy alternative.

Technological innovation is another key factor that can drive growth in the food processing industry. High technology and equipment costs have been identified as significant barriers to scaling up production. However, investing in research and development to create cost-effective processing technologies and alternative processing methods will reduce production costs and make processing more financially viable. As technology advances, businesses will be better equipped to optimize processes, improve product quality, and reduce costs, creating a more sustainable food system.

In addition to technological advances, promoting scalable business models is essential to the long-term success of food processing. By forming partnerships between startups, food manufacturers, and hospitality businesses, the food industry can create robust value chains that support the upcycle process. Reducing food waste will ensure a continuous supply of raw materials, and the resulting economic benefits will attract additional investment and expansion opportunities. A scalable approach will be critical to meeting the growing demand for processed foods while maintaining a stable and reliable supply chain.

Finally, sustainable supply chain management is vital to ensure the stability and quality of raw materials used in upcycling food production. Developing digital platforms to collect and classify food waste will help businesses track and manage their raw material supply, ensuring that it meets the required processing standards. Technological advances in this area will also improve supply chain efficiency and transparency, further enhancing the reliability of upcycling. Ultimately, the success of upcycling as a sustainable solution depends on a coordinated, multi-faceted strategy that addresses both the challenges and opportunities present in the current food system. By focusing on policy development, consumer education, technological innovation, scalable business models, and supply chain management, upcycling can play a key role in creating a more sustainable, resource-efficient food system. As the global community works to achieve the SDGs, upcycling can reduce food waste, reduce greenhouse gas emissions, conserve natural resources, and provide consumers with valuable nutrients. With the right strategies, food upcycling can become an integral part of a sustainable future food.

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ВІД ХАРЧОВИХ ВІДХОДІВ ДО ХАРЧОВИХ ДОБАВОК: СТАЛА ТРАНСФОРМАЦІЯ ДЛЯ ЕКОНОМІЧНОЇ БЕЗПЕКИ

Анотація. *У цій науковій праці ми досліджуємо потенціал співпраці між готельним бізнесом та виробниками харчових добавок. Концепція відповідає принципам сталого розвитку, враховуючи як соціальні, так і екологічні проблеми. Зокрема, вона зосереджена на зборі та подальшій переробці харчових відходів у харчові добавки. У статті визначено альтернативні SWOT-стратегії для оцінки доцільності цієї ідеї в підприємницькому секторі. Одним з ключових рішень проблеми харчових відходів є переробка харчових продуктів, що набирає обертів, коли невикористані харчові відходи перетворюються на нові продукти. Новітні інноваційні методи, такі як передові технології сушіння харчових продуктів, пропонують ефективні способи боротьби з харчовими відходами шляхом перетворення відходів на поживні продукти без надмірного нагрівання. У дослідженні висвітлено кілька критичних аспектів переробки харчових продуктів, зокрема: економічну ефективність завдяки збереженню ресурсів, зменшення залежності від зовнішніх джерел їжі та підвищення продовольчої безпеки. Цей процес також сприяє технологічному розвитку, залученню інвестицій та створенню нових робочих місць, що зміцнює економічну стабільність. Крім того, переробка зменшує кількість відходів та зберігає природні ресурси, позитивно впливаючи на екологічну та економічну стійкість. Перетворюючи харчові відходи на цінні добавки, цей підхід сприяє досягненню цілей сталого розвитку, таких як боротьба з голодом та покращення доступу до поживної їжі, тим самим сприяючи як соціальній, так і економічній безпеці на національному рівні.*

Ключові слова*: сталий розвиток, харчові відходи, харчові добавки, продовольча безпека, економічна безпека.*