НАУЧНИ ТРУДОВЕ НА
УНИВЕРСИТЕТ ПО ХРАНИТЕЛНИ
ТЕХНОЛОГИИ - ПЛОВДИВ
2019 г.
ТОМ 66, КНИЖКА 1

SCIENTIFIC WORKS OF
UNIVERSITY OF FOOD
TECHNOLOGIES
2019
VOLUME 66 ISSUE 1

Research Article

Food processing and preservation - An added economic and ecological value to European countries

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Abstract

The largest manufacturing sector in Europe remains the food, and beverage industry providing employment and contributing highly to the gross domestic products of European nations. With the continual demand for EU food and beverages overseas, growth in the sector doubled compared with its status ten years ago. Going by this steady development of the industry, it is imperative that innovative technologies improve service deliverables for a continual increase in returns. According to the EU Commission, there is annual food wastage of eighty-eight million tonnes. This food wastage is approximately a loss of 143 billion euros and an eight percent increase in greenhouse gas emissions. How can these losses be prevented and converted to a value-added product? The correct application of food processing and preservation techniques would save the European nations 143 billion euros. This paper investigates the various sources of food wastage in European countries and discusses how food preservation and processing technique can reduce these food losses. The study identifies, addresses, and proffer solutions to the economic and environmental issues associated with food wastage. The systematic review shows that economic and ecological effects from food wastage result from the reduced application of processing and preservation of techniques, most notably by farmers, food manufacturers, and food processors in the food chain. The study infers that new EU food policies are required to achieve substantial improvements in preventing wastage in the food chain. Also, stakeholders must embrace best practices in processing and preservation of food to avoid food wastage.

Keywords: *Food wastage, Food Preservation and Processing, Food policies, Economic and ecological issues.*

Abbreviations:

EU - European Union;
PUFA - polyunsaturated fatty acids;
SCF - supercritical fluids;
SFE - supercritical fluid extraction;
GDP - Gross Domestic Product

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Article history:
Received: 30 September 2019
Reviewed: 31 October 2019
Accepted: 28 November 2019
Available on-line: 16 March 2020

Introduction

Food wastage impacts the economic and environmental sustainability of a country negatively. Stakeholders in the food chain are mostly responsible for the alarming increase in food wastage. The consumers, for instance, play a significant role in food wastage, especially those who can afford to waste food. The producers, retailers, and distributors all have contributory parts to play. Hence, the proposed preservation and processing techniques must be adopted by all impacted by food wastage. According to the EU Commission, there is annual food wastage of eighty-eight million tonnes. This food wastage is approximately a loss of 143 billion euros and an eight percent increase in greenhouse gas emissions. According to Ghosh et al. (2016), these scraps of food if adequately preserved, could have been eaten instead of becoming a waste pile. Also, in the United States, 30% of food produced eventually becomes a waste pile (Ghosh et al., 2016). The authors also reported that 120 cubic kilometres of irrigation water are used annually for food production. Thus, a 30 percent loss of this food produce results in a waste of 40 billion litres of water (Ghosh et al., 2016). The economic and environmental loss associated with food wastage is enormous; there is the loss of resources (water, human efforts, time, money invested). There is also the loss of the worlds' capacity to provide food for other developing countries in need.

Consequently, food wastage is also a humanitarian issue. Quantifying the economic loss, Ghosh et al. (2016) showed that only 43 percent of the world's annual cereals produced is consumed. While more than half of the produced seeds, 57 percent, is estimated to be lost in the food chain and a small percentage used as animal feed (Ghosh et al., 2016). Likewise, the annual consumption of fruits and vegetables is estimated at 43 percent, while the remaining 57 percent constitutes a waste pile (Ghosh et al., 2016). Ultimately, developed countries spend about 222 million tons of food yearly, an amount that is almost equivalent to the net food production (230 million MT) in sub-Saharan Africa (Ghosh et al., 2016).

Also, environmental degradation and global warming associated with food wastage are estimated to be between 2000 to 3600 kg CO2-eq. t-1 (Tonini et al., 2018). The degradation of food waste produces methane which is a stronger greenhouse gas compared to carbon dioxide (Tonini et al., 2018). Therefore, with the evaluated evidence of the economic, environmental and humanitarian impacts of food wastage, it is significant to study the phenomenon of food wastage, as well as preservation and processing techniques that will reduce these identified losses in the food supply chain. This review shall identify, address, and proffer solutions to the economic and environmental issues associated with food wastage.

Materials and Methods

In this study, academic journals evaluating, and discussing food waste source, the economic and environmental impacts were sought. The economic and environmental impacts of food wastage have been extensively studied in the past. It is still being considered due to the changing contributory factors and policies. This systematic review holds enormous opportunities in identifying areas for further research and study (Briner and Denyer, 2012).

Based on the objectives of this study, several keywords and phrases were applied to search for peer-reviewed journals in databases like; “Food waste management,” “economic impacts of food wastage,” “environmental impacts of food wastage,” “food preservation techniques” and Food storage or processing technique. Additionally, some grey literatures were also included to inform this study because most of the literature contains valuable policies in their recommendation sections. A total of 100 research studies were collected from different journal databases such as Elsevier, Jstor, and Journal on Waste Management, Journal of Environmental Management, and Science Direct. Studies without significant correlation with recent statistics, twenty research studies were eventually selected to inform this study. This number of valuable research works was augmented to 30 using the snowballing tool.

Results and Discussion

Food processing and preservation techniques

Food processing includes all techniques applied to process food from one form to another product to increase shelf-life and prevent spoilage. Biological, Chemical and Physical processing are the major classifications of food preservation and processing methods. Chemat et al. (2017) described some green food processing and preservation techniques which are sustainable and have economic value. Also, it was reported by Chemat and Vorobiev (2019) in their book - Green Food Processing Techniques how these green food techniques enhance nutritional quality and food, and its shelf life.

The authors also demonstrated how the techniques are environmentally friendly and economical. Green food techniques are capable of recovering bioactive compounds from food waste or by-products. These bioactive compounds have activities against diseases such as cancer and heart conditions (Atef and Mahdi Ojagh, 2017). Atef and Mahdi Ojagh (2017) showed how bioactive compounds contribute in improving the quality of life.

Supercritical fluid extraction (SFE)

Supercritical Fluid Extraction is a separation technique that uses supercritical fluids like carbon-dioxide to remove a desired component from a matrix, usually in a solid form. The application of Supercritical Fluid Extraction technique has been in the retrieving of valuable essential oils and antioxidants from natural plant materials (Chemat and Vorobiev, 2019). However, it has found new applications in the food industry (Chemat and Vorobiev, 2019).

Fruits and vegetables processing in developed countries usually generate a huge pile of waste, such as seeds, peels and kernels (Chemat and Vorobiev, 2019). Fruit and vegetable processing represent 6.7 percent of the overall value of the European Union food sector output (De Cicco, 2016). These fruits and vegetables are usually processed into other food products like, canned vegetables, dried fruits, jams and marmalades. In the processing of these food crops, high amounts of waste are produced (Oreopoulou and Tzia, 2007). A recently published report by the European Commission showed that 29 percent of fruits and vegetables purchased by households are wasted. The study evaluated six European countries; Germany, Spain, Denmark, Finland, United Kingdom and the Netherlands and identified 21.1 kg of unavoidable wastes and 14.2 kg of avoidable wastes. Table 1.0 and 2.0 shows the amount of avoidable waste generated in the processing and consumption of fruits and vegetables in European countries.

In the processing of olives for olive oil, two types of by-products are produced in the process; crude olive cake/olive husk and olive mill wastewater. Also, the processing of seafood by companies generates wastes which have high Polyunsaturated Fatty Acids (PUFA) contents and capable of being used to prepare PUFA concentrates. The extraction of these bioactive compounds and essential oils and nutrients follows the pre-treatment of the solid matter such as drying and size reduction. Aside from the use of supercritical fluids (SCF) in retrieving significant molecules from food waste, SCF also have usefulness in the preservation of food. Perrut (2012) reported that SCF is effective in the preservation of food and pest control by sterilization. To achieve adequate inactivation of microorganisms that cause food spoilage, Chemat et al. (2017) mentioned that the carbon dioxide pressure (CO_2) should be between 80 and 120bars and below 70^{o}C. The application of Supercritical Fluid (SCF) in the treatment of food waste has also been explored. Darani and Mozafari (2011) reported how SCF is being used in the treatment of lignocellulose materials, which are the major constituents of food wastes. Supercritical fluid treatment on food wastes makes possible to continued utilization of lignocellulose material in the food waste. The treated lignocellulose material can then be used for chemicals, pulp and energy (Darani and Mozafari, 2011). The table below highlights food processing techniques using supercritical fluids.

Table 1. Estimations of avoidable vegetable waste by country based upon literature values

Country	Source	Reference year	Avoidable waste	Amount purchased
			[kg/p/y]	[kg/p/y]
Germany	Kranert et al. (2012)	2010	9.6	75.2*
Spain	Zapata (2017)	2016		
Denmark	Edjabou et al. (2016)	2011	11.6	56.8***
Netherlands	van Westerhoven and Steenhuisen (2013)	2013	10.3	55.3***
Finland	Silvennoinen et al. (2014)	2010	4.4	53.4***

Table 2. Estimations of avoidable fruits waste by country based upon literature values

Country	Source	Reference year	Avoidable waste	Amount purchased
			[kg/p/y]	[kg/p/y]
Germany	Kranert et al. (2012)	2010	6.9	57.3
Denmark	Edjabou et al. (2016)	2011	5	47.9
Netherland	Van Westerhoven and Steenhuisen (2013)	2013	5.6	38.5
Finland	Silvennoinen et al. (2014)	2010	3	44.8

Ultrasound food preservation technique

Ultrasound food preservation technique eliminates the associated losses when conventional heat is applied to inactivate microorganisms, enzymes, and spores (Chemat et al., 2017). Considering that microorganisms and enzymes are the major food causative agents, techniques that eliminate or inactivate their activity improve food shelf-live. Conventional thermal heating is effective but results in an associated reduction in the quality of food (Chemat et al., 2017). The application of ultrasound in combination with thermal heating effectively disrupts the cells of harmful microbial agent, and increases the rate of sterilization of foods (Chemat et al., 2017). The combined use of ultrasound with thermal heating was found to have a synergistic effect other than an added effect. Hence, most microorganisms and enzymes that are heat resistant, the combined effect of heating and high power ultrasound (Chemat et al., 2017).

Ultrasound application in the processing and preservation of food results in higher product yields, improved taste, texture, flavour and colour. Additionally, ultrasounds have shorter processing times, low maintenance and operating costs (Chemat et al., 2017). The table below shows the application of ultrasound in the preservation and processing of food.

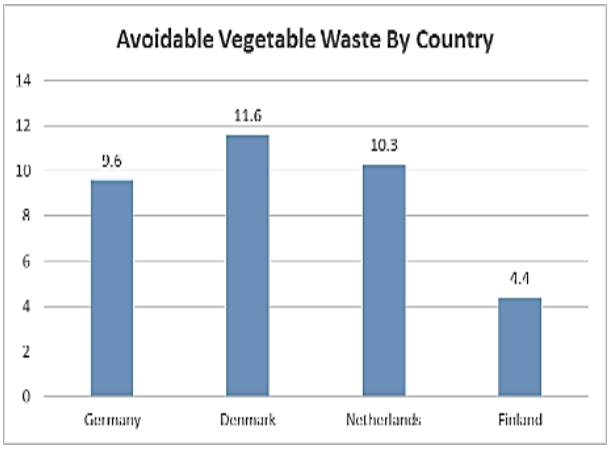

Figure 1. Avoidable vegetable waste by country

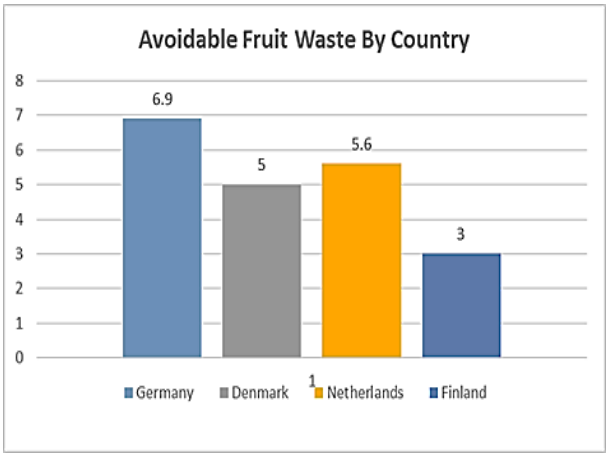

Figure 2. Avoidable fruit waste by country

Economic and environmental impact of food wastage

Food wastes are generally classified into avoidable food waste and unavoidable food waste, with the former being food waste that was once edible, and due to inadequate preservation of poor handling is no longer edible. The research study by Tonini et al. (2018) examined the environmental effects of food waste from four food chain levels in the United Kingdom: food processing, wholesale and retail, food service and households. The food impacts on the following environmental concerns were evaluated as well; global warming, terrestrial acidification, photochemical ozone formation, particulate matter, aquatic eutrophication, human toxicity, ecotoxicity, fossil resource depletion, and water depletion (Tonini et al., 2018). According to the research study, food waste from homes contributes the largest environmental impacts in the society, it accounts for 11Mt CO_2-eq annually, which represents 3.4% of the annual total carbon footprint of the United Kingdom in 2015 (Tonini et al., 2018). Unlike most studies on the environmental impact of food waste, the work by Tonini et al., (2018) gathered the impact on land use change, which directly raised the carbon footprint recorded in the report. Land use change refers to the impact of human activities on the natural landscape (Kanti and Rashid, 2017). Following with a recent study evaluating the economic impact of food waste; it was also observed that household consumption produced the largest food waste (Campoy-Muñoz et al., 2017).

The findings of this research study by Campoy-Muñoz et al. (2017) is also in line with the work of Tonini et al. (2018) who identified household consumption as the highest producers of avoidable food waste. Campoy-Muñoz et al. (2017) assessed the impact of food waste on the economy by modelling impacts on production, Gross Domestic Product (GDP), and employment. The economic impact on Germany, Spain and Poland were assessed. And it was discovered that the monetary value of food waste in Germany amounts to €29 968 million. Spain also saves €12 742 million followed by Poland €6.868 million (Campoy-Muñoz et al., 2017). This also indirectly connotes that Germany produces more food waste compared to other European countries (Campoy-Muñoz et al., 2017).

Another study evaluated the environmental impacts of different types of meats. It also assessed impacts from dairy products and cereal – based meals (Notarnicola et al., 2017). The analysis results showed that beef has the highest environmental impact compared with pork and poultry meat. Also, dairy and cereal based meal exhibited the least environment burden (Notarnicola et al. 2017). All the studies evaluated highlight that human food consumption presents the highest food wastage in Europe, followed by food processing in the

industries. This doesn't eliminate other players in the food chain from food wastage, but reveals areas were more efforts must be put in place to curb food wastage in European countries.

Food policies

According to the Swedish Institute for Food and Biotechnology (SIK), food wastage is caused and facilitated by poor food behaviours (Vittuari, n.d.).There are different intervention strategies put forth to reduce and totally eliminate food wastage. This study focuses on the significance of governmental policies against food wastage. Policy is a principle of action, proposed by a government to influence and determine coherent actions for a common long-term purpose (Vittuari, n.d.).
The policies for reducing food waste are generally classified into four major categories, for the purpose of this study; farm food policy, household food policy, supply chain food policy, and spoilt food policy.

Farm food policy

Farm food policy is targeted at reducing food wastage from the farms. It happens that not all farm produce specifically meet the quality of the buyer or retailer, such that the low quality crops are rejected and wasted to the loss of the farmer. A Whole Crop Purchase policy will prevent against low quality crops rejection. When this policy is followed, the low crop produce can be used to prepare other types of food as the circumstance demands. This policy can be enacted in the form of a contract between the farmer and the customers (Food waste: A response to the policy challenge, 2017).

Household food waste policy

Several interventions have been put in place to reduce household food wastage, as the major source of wastage in the society. Some intervention mechanisms include the "Love Food, Hate Waste" campaign, the familiarization with individual portion size and continued education of the effects of food waste in the society (Food waste: A response to the policy challenge, 2017). All these interventions methods have contributed to reducing household food waste till date (Food waste: A response to the policy challenge, 2017). This research study has, however, identified a policy in the form of an incentive program that will discourage food wastage in homes. The incentive on household food sustainability targets food waste reduction in homes. Here, points are awarded to households with a reduced amount of food waste; there will be a minimum satisfactory food waste level that families must achieve to gain points. These points on the other hand can be used to pay bills like rent and electricity (Food waste: A response to the policy challenge, 2017).

Food wastage is a global challenge that represents a waste of energy and resources, with adverse impacts on both the economy and the environment. Several processing and preservation techniques abound that can be utilized to reduce food wastage in all parts of the food chain. Likewise, policies are also the right way of enforcing the reduction of food wastage in societies. This study highlighted some processing and preservation techniques as well as policy recommendations that will reduce food wastage in the farm and households.

Conclusions

This paper investigated the various sources of food wastage in European countries and discussed how food preservation and processing technique can reduce these food losses. The systematic review showed that economic and ecological effects from food wastage result from the reduced application of processing and preservation of techniques, most notably by farmers, food manufacturers, and food processors in the food chain. The study inferred that new EU food policies are required to achieve substantial improvements in preventing wastage in the food chain. Also, stakeholders must embrace best practices in processing and preservation of food to avoid food wastage.

Some green preservation and processing techniques were discussed for possible application in a large scale. Ultrasound, Supercritical fluids and autoclaving are some processing and preservation techniques to reduce food spoilage. It was also discovered from research studies that households generate the highest quantity of food waste in the

food chain. Although food wastes/spoilage were recorded in order categories, several intervention techniques have been put in place to fight against food wastage. However, to effectively eliminate food wastage, more than one intervention techniques must be applied or considered together. This research work took the approach of policy formulation especially as it has to do with behavioural management for reducing food wastage. Food policies were suggested in the food chain first is to reduce food waste generated in the farm, and then those generated in the households. The study strongly believes the effectiveness of food policies in reducing or completely eliminating food reduction

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