17th International Conference on Environmental Science and Technology

Athens, Greece, 1 to 4 September 2021

The Circular Economy Shift for Business Models: Creating value from waste in the Peach Canning industry

PARASKEVOPOULOU C.[1], VLACHOS D.[1]

[1]Laboratory of Statistics and Quantitative Analysis Methods, Logistics and Supply Chain Management, Department of Mechanical Engineering, Aristotle University of Thessaloniki, 541 24 Thessaloniki, Greece

*corresponding author: Paraskevopoulou Christina
e-mail: chripara@auth.gr

Abstract With the Circular Economy (CE) concept emerging, the reorganization of the supply chain (SC) and the reengineering of its processes is highlighted. In Greece, industrialized agriculture and more specifically the peach canning industry can be an important factor for the economy within and outside the country's borders, with the total yearly exports worth at around 400 million euros. However, an important source of waste is not utilized in the optimal way; the kernel is often mistaken as a useless by-product or at best as biomass. This paper focuses on the optimization of this supply chain achieved through CE applications, by separating the seed from the kernel's wooden exterior and utilizing it to create new products that will provide added value for the SC, while the wooden exterior serves as biomass feedstock. The resulting products studied include (i) the peach oil which can be consumed as is or in cosmetics and (ii) natural medicine. The above mentioned are investigated and valued, in order to shift the peach canning industry's business model, thus reinventing the sector. Finally, the new optimized SC framework is presented under the prism of CE, which can be applied for other processed stone fruits.

Keywords: Circular Economy, Sustainability, Peach Canning, peach kernel utilization, peach waste management

1. Introduction

The Circular Economy (CE) concept has been in the center of attention over the last few years, with academia, businesses and policymakers realizing its worth (Geissdoerfer et al. 2017). The concept focuses on turning traditional linear supply chains and turn them into circular ones, by valorizing their otherwise non-purposeful waste (Ellen MacArthur Foundation 2012). Sustainability, Green SC management, Waste Management and Closed Loop SCs are the predecessors that have established the academic and practical foundations for the reorganization of the SC and the reengineering of it processes to suit the CE Paradigm (Geissdoerfer et al. 2017).

In Greece, the peach canning industry as well as agriculture and industrialized agriculture as a whole, have an important role for the economy, both on a domestic and global level, as exports accumulated over 300 million US dollars in 2020 (United Nations Statistics Division 2019). However, the peach kernel which is extracted before the peach composting and canning, is in many cases thrown away, although, it has great potential for valorization through the separation of the wooden exterior and the seed that can be used by food, cosmetics and pharmaceutical industries (Ordoudi et al. 2018).

Although CE is the subject of discussion among academics, government officials and the business world, there is lack of applications in agriculture that does not mainly involve energy production and creates a new product and thus added value for the value chain. This paper aims at exploring these applications, evaluating their impact and presenting a new optimized SC by incorporating CE values and strategies.

2. The Peach Canning Supply Chain

2.1. The Peach Canning Supply Chain

The peach canning SC has been depicted by a number of authors along with its processes. In Figure 1 the 3 stages of the peach canning SC are presented from farm to fork, by combining the existing literature (Folinas et al. 2015; Nanaki and Koroneos 2018; Ordoudi et al. 2018). As of today, the SC is mostly linear with a few exceptions where the peach kernel is extracted, dried and then combusted to produce energy needed for the peach canning facilities by replacing crude oil. The 3 stages are:

1. Production, where the peaches are harvested.
2. Manufacturing, where the peaches are peeled, sorted in order to repurpose the inappropriate sized fruits to produce other products e.g., juice or pulp, and then canned and put in storage as peach compote facilities in Greece only work for 4 months each year complying with the seasonality of peach harvesting.
3. Marketing and Distribution, as the peach cans have mainly international clientele, with over 305 thousand tons of "prepared or preserved" peaches being exported from Greece in 2020 all around the world. To put this in perspective, the trade value of these exports represented around 9% of the total exports, while the same year the country exported around 165 thousand tons of virgin olive oil, a product the country is well known for worldwide according to COMTRADE (United Nations Statistics Division 2019).

The waste of the supply chain is accumulated from all stages. During the manufacturing process, the accumulated

waste consists of liquid waste as well as solid: inappropriate fruit, which are usually used to produce other products, peels, and kernels. These kernels have been researched on their energy production usability; however, the adding value potential lies within its use in other industries.

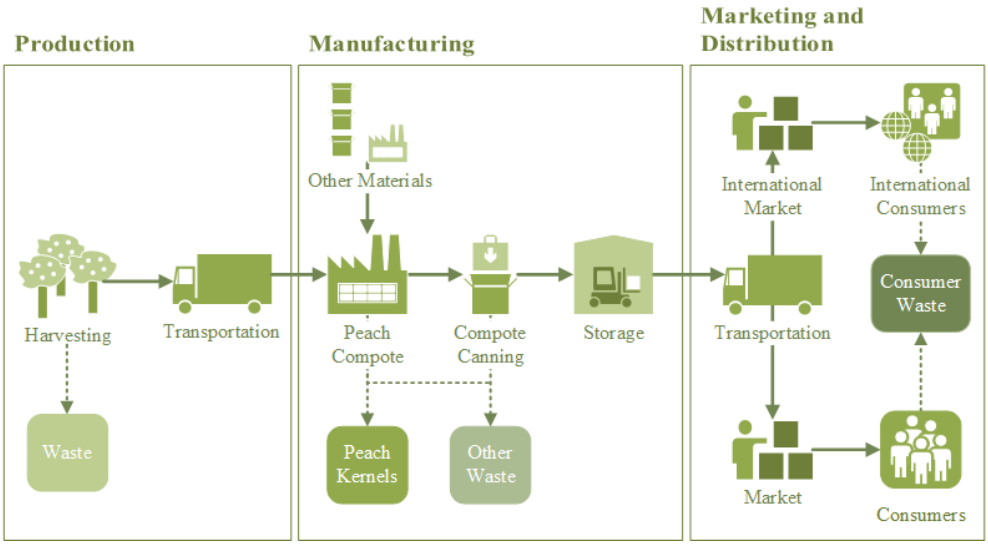

Figure 1. The Peach Canning Supply Chain

2.2. The peach stone in literature

Over the years, the scientific community have researched the potential of the peach kernel. The solutions can be divided into two main categories, the energetic valorization and the new product creation.

Regarding the thermochemical treatment of the peach kernel, the literature consists of uses (i) for combustion using the bubbling fluidized bed combustor (BFBC) method on its own or in a fuel mixture (Kaynak et al. 2005; Atimtay and Kaynak 2008) and (ii) as gasification feedstock (Arvelakis et al. 2005).

On the other hand, and with regard to the valorization through the production of value-adding products, in 1991 the composition of the oil of apricot, peach and cherry kernels was studied by Lazos who concluded that they can be used in cooking and cosmetics as they are rich in nutrients. Another potential use is by drying the seed to produce peach kernel flour, that can be used both for animal and human nutrition (Pelentir et al. 2011).

The analysis from four Greek peach cultivars concluded their kernel is a promising source for strong antioxidant activity compound that can be used as an active ingredient in cosmeceuticals and food supplements (Karadimou et al. 2017). Ordoudi et al. (2018) explored the potential uses of inedible parts of tree fruits. Regarding the case of peaches, the authors make reference to the potential uses for heat supply, the use for the production of perzipan, an alternative to the marzipan, but also mention the potential of utilization of their seed oil from the cosmetics industry.

The peach kernels have also been analyzed for their bioactive compounds as a source of polyphenols which have been linked health-promoting activity for hyperglycemia, obesity and Alzheimer's (Nowicka and Wojdyło 2019) disease and can be valorized from pharmaceuticals.

2.3. CE processes in the peach supply chain

Depending on the species, the peach pit represents 4-10% (Markidis et al. 2004; Ordoudi et al. 2018) total weight, while the seed inside its wooden exterior represents around 12% of the total kernel and contains 54.5% of oil (Rahma and El-Aal 1988). The peach kernel that is currently wasted from the industry - or in some cases burned for heat as is – will be separated to produce two by-products: the pit, i.e., the wooden exterior, and the endocarp (seed). The former will be thermochemically processed to produce energy that can be reused for the manufacturing process, thus providing a closed-loop SC solution. As explored in section 2.2, the endocarp can be used and sold as is for food production, can be dried to produce flour for human and animal consumption, can be used in pharmaceutical companies to provide health benefits to patients of various conditions or in cosmetics, to provide valuable skin benefits. The abovementioned solutions can provide added value for the peach canning value chain, with benefits relevant to all three pillars of sustainability.

3. Solutions and Impacts

In Figure 2, the CE perspective of the peach canning SC is presented. The proposed framework includes the energy recovery from biomass using the kernel's wooden exterior and the repurposing of the seed as is or by extracting oil as explained in section 2.3. Reduction of packaging waste, as well as the use of recyclable or biodegradable packaging could also lead to an eco-friendlier SC.

3.1. The economic value

The economic benefits that can be realized result from the energy cost reduction due to the utilization of biomass and the value adding products that provide new marketing opportunities. By using the biomass to produce energy, the

costs associated with energy can be reduced. although an initial investment for the biomass combustion plant is necessary and may affect the decisions of a company to incorporate such solutions.

On the other hand, the potential use in the food, pharmaceuticals and cosmetics industries can provide the SC with new opportunities. The research in section 2.3 has showed a number of applicable solutions that can be adopted and provide a CE perspective for the supply chain. However, although the initial investment would be less than the energy exploitation, the new SC may add new marketing and logistics costs. At the same time in "full circular firms", i.e. firms that are circular "internally and externally", the marketing tends not only to refer but to be focused on their circularity (Urbinati et al. 2017), thus in the case of the new SC, the products should highlight and promote their circularity.

3.2. The environmental value

CE has been linked with environmental benefits. Avoiding waste by exploiting the peach kernel is on its own an important step. However, given the carbon-neutrality of biomass (Skoulou and Zabaniotou 2007; Iakovou et al. 2010) and the fact that the peach canning facilities are usually close to the peach plantations, it can be deducted that the environmental footprint of the manufacturing process is reduced through the biomass combustion. Regarding the new products, the repurposing of the peach kernels is an important step towards a more circular SC. However, the waste produced during the marketing and distribution stage from the consumers should be prevented. This could happen through a careful product design and minimizing the packaging or where needed and allowed, using recycled or biodegradable packaging.

3.3 The social value

The social aspect of the new peach canning SC could be divided into two categories: the added revenue for all stakeholders and the human health benefits. As explore in section 3.3, by repurposing and recovering energy from the peach kernel, the SC has added value. This added value could be distributed among the SC stakeholders. The added income for them, and especially those in lower economic strata, could improve their and their families' quality of life. On the other hand, the health benefits can be subdivided in (i) the reduced environmental impact and its effects in human health, but also (ii) the potential use of these products from pharmaceutical companies with health benefits for patients with hyperglycemia, obesity and Alzheimer's (Nowicka and Wojdyło 2019).

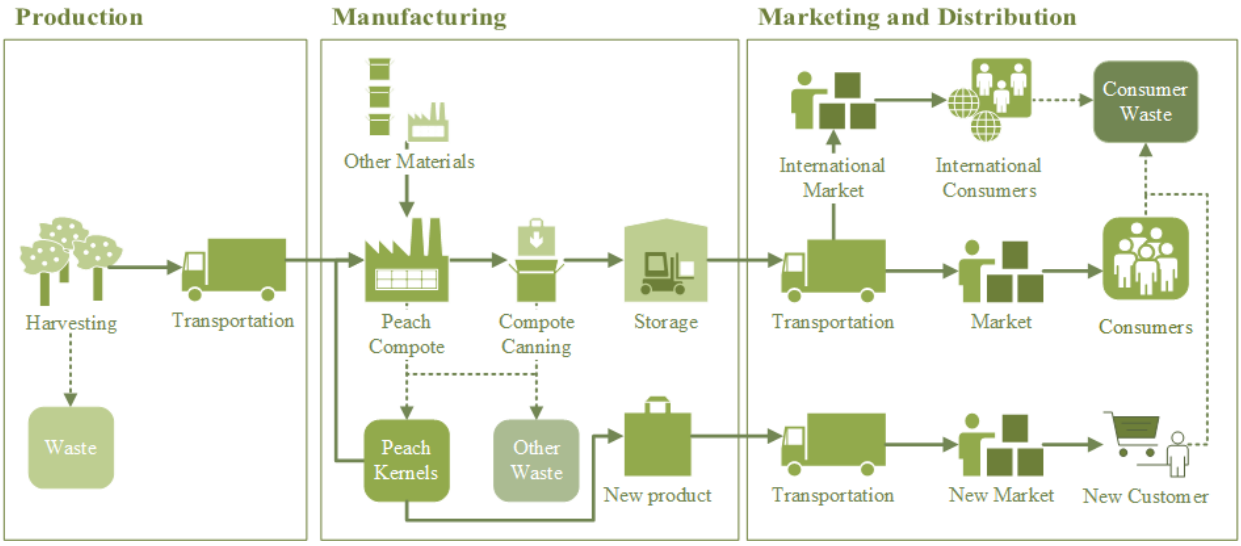

Figure 2. The CE perspective of the Peach Canning Supply Chain

4. Conclusion

CE has increased in popularity over the past decade, and has captured the interest of researchers, businesses, and governments to provide solutions to the planet's environmental problems and limited resources. At the same time, these solutions could provide an opportunity for new value-adding products with many benefits. In Greece, the peach canning industry is blooming and has been an important sector for the agricultural economy. However, the peach kernel which is extracted during the canning process is in many cases wasted. This paper aimed to introduce a CE perspective for the peach canning SC by valorizing this waste. The potential uses of the kernel were gathered, their value was discussed and finally a CE framework was presented that could be beneficial on an economical level through the added economic value for the SC, environmental through the energy exploitation, and social level through the potentially improved standard of living for the SC's stakeholders due to their increased income, and through the health benefits of some of the proposed solutions.

Acknowledgments

This paper is supported by the research project "«ENIRISST – Intelligent Research Infrastructure for Shipping, Supply Chain, Transport and Logistics") which is implemented under the Action "Reinforcement

of the Research and Innovation Infrastructure", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).

References

Arvelakis S, Gehrmann H, Beckmann M, Koukios EG (2005) Preliminary results on the ash behavior of peach stones during fluidized bed gasification: Evaluation of fractionation and leaching as pre-treatments. Biomass and Bioenergy 28:331–338. https://doi.org/10.1016/j.biombioe.2004.08.016

Atimtay AT, Kaynak B (2008) Co-combustion of peach and apricot stone with coal in a bubbling fluidized bed. Fuel Process Technol 89:183–197. https://doi.org/10.1016/j.fuproc.2007.09.007

Ellen MacArthur Foundation (2012) TOWARDS THE CIRCULAR ECONOMY: Economic and business rationale for an accelerated transition

Folinas DK, Aidonis D, Karayannakidis P (2015) Greening the canned peach production. J Agric Informatics 6:24–39. https://doi.org/10.17700/jai.2015.6.1.154

Geissdoerfer M, Savaget P, Bocken NMP, Hultink EJ (2017) The Circular Economy – A new sustainability paradigm? J Clean Prod 143:757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Iakovou E, Karagiannidis A, Vlachos D, et al (2010) Waste biomass-to-energy supply chain management: A critical synthesis. Waste Manag 30:1860–1870. https://doi.org/10.1016/j.wasman.2010.02.030

Karadimou CC, Koletti AE, Moschona A, et al (2017) P36 : PEACH KERNEL : A POTENTIAL SOURCE FOR COSMECEUTICALS. In: 3rd IMEKOFOODS. Thessaloniki, pp 317–320

Kaynak B, Topal H, Atimtay AT (2005) Peach and apricot stone combustion in a bubbling fluidized bed. Fuel Process Technol 86:1175–1193. https://doi.org/10.1016/j.fuproc.2004.12.007

Lazos ES (1991) Composition and oil characteristics of apricot, peach and cherry kernel. Grasas y Aceites 42:127–131. https://doi.org/10.3989/gya.1991.v42.i2.1260

Markidis M, Nikolaou A, Djouras N, Panoutsou C (2004) Agricultural Biomass in Greece: Current and Future Trends. In: OECD (ed) Biomass and Agriculture: Sustainability, Markets and Policies. OECD Publishing, Paris, pp 363–376

Nanaki EA, Koroneos CJ (2018) Sustainable peach compote production: A life cycle thinking approach. Sustain 10:1–15. https://doi.org/10.3390/su10114229

Nowicka P, Wojdyło A (2019) Content of bioactive compounds in the peach kernels and their antioxidant, anti-hyperglycemic, anti-aging properties. Eur Food Res Technol 245:1123–1136. https://doi.org/10.1007/s00217-018-3214-1

Ordoudi SA, Bakirtzi C, Tsimidou MZ (2018) The potential of tree fruit stone and seed wastes in Greece as sources of bioactive ingredients. Recycling 3:15–20. https://doi.org/10.3390/recycling3010009

Pelentir N, Block JM, Monteiro Fritz AR, et al (2011) Production and chemical characterization of peach (PRUNUS PERSICA) kernel flour. J Food Process Eng 34:1253–1265. https://doi.org/10.1111/j.1745-4530.2009.00519.x

Rahma EH, El-Aal MHA (1988) Chemical characterization of peach kernel oil and protein: Functional properties, in vitro digestibility and amino acids profile of the flour. Food Chem 28:31–43. https://doi.org/10.1016/0308-8146(88)90004-0

Skoulou V, Zabaniotou A (2007) Investigation of agricultural and animal wastes in Greece and their allocation to potential application for energy production. Renew Sustain Energy Rev 11:1698–1719. https://doi.org/10.1016/j.rser.2005.12.011

United Nations Statistics Division (2019) United Nations Commodity Trade Statistics Database. In: United Nations Stat. Div. New York, NY, USA. https://comtrade.un.org/data/. Accessed 25 May 2020

Urbinati A, Chiaroni D, Chiesa V (2017) Towards a new taxonomy of circular economy business models. J Clean Prod 168:487–498. https://doi.org/10.1016/j.jclepro.2017.09.047