

A Manufacturing Approach to Reducing Consumer Food Waste

Aicha JELLIL^a, Elliot WOOLLEY^{a,1}, Guillermo GARCIA-GARCIA^a and Shahin RAHIMIFARD^a

^a*Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough LE11 3TU, UK.*

Abstract. Globally, one third of food produced is wasted. In the UK, 47% of the food waste is post-consumer revealing a need to encourage more efficient consumption. This research asserts that manufacturers and retailers can play a crucial role in minimising consumer food waste (CFW) through consumer engagement and provision of smart solutions that ensure more efficient use of food products. Supporting manufacturers and retailers to minimise CFW can be achieved via two stages: a) understanding and evaluating CFW, and b) identifying improvements to manufacturing and retail activities that would reduce CFW. On-site waste audits have identified that the percentage of edible CFW from domestic environments (77%) is greater than that disposed of in public areas (14%) supporting the hypothesis that improving the full food provisioning process (e.g. packaging, storage, guidance) would be beneficial. This paper proposes a number of mechanisms to support manufacturing and retail in reducing CFW.

Keywords. Consumer food waste, food manufacturers, retailers.

1. Introduction

It is estimated that in developing countries about 40% of food waste is generated at post-harvest and processing stages, whereas 40% of food waste in the developed countries is created at the retail and consumer stages [1]. This research focuses on consumer food waste (CFW) generated in the UK, as a representative of developed countries, which is estimated to amount to 7 MT p.a. out of a total of 15 MT p.a. of food wasted in the UK [2]. This makes UK consumers the largest single contributor towards food waste (Figure 1). Moreover, 60% of CFW in the UK is estimated to be avoidable [3]. CFW has the highest level of environmental and economic impacts compared to waste generated at other stages of the supply chain and this is due to the significant amount of resources (water, labour, etc.) used to produce the final products.

Several factors contribute to CFW generation including consumer behaviour, retail environment (e.g. promotions, packaging) and other external factors (e.g. economic, governmental) [2]. These three main factors highly influence how consumers purchase, store, prepare and consume food which in turn influence consumer generation of waste. Therefore, CFW is not just an issue of individual behaviours [4] and manufacturing and retail have the power to influence the consumer choices and improve their business activities in order to reduce domestic food waste. This paper presents an overview of

¹ Corresponding Author. E.B.Woolley@lboro.ac.uk

the approaches suggested for businesses to minimise CFW, proposes a new approach for manufacturers and retailers to support efficient consumption and discusses findings from on-site food waste audits conducted at domestic properties as well as public areas.

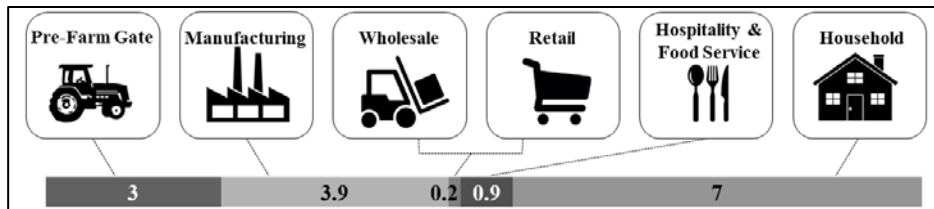


Figure 1. Food waste in the UK by stage (in million tonnes). Data from [5].

2. Consumer Food Waste Reduction

A review of the literature has identified several proposed (or implemented) solutions for manufacturers and retailers to support the reduction of CFW. These solutions can be categorised into strategic or functional. It was observed that only a minority of these solutions focuses on reducing CFW in terms of environmental impact. This deserves more attention as reducing the waste of a certain food product by a small quantity (e.g. beef) can have better environmental benefits than reducing a greater amount of waste generated from another product (e.g. potato).

For the solutions that can be implemented at a strategic level, several frameworks have been identified; some of these are detailed in Table 1. All of these frameworks stress the importance of deploying communication, technology and policy making in supporting consumers to minimise their food waste.

At a more functional level, some actions were taken to reduce CFW by extending food shelf-life, offering more variety for food portion size, providing storage guidance and clarifying food date labels. These actions are important since 80% of avoidable CFW is due to factors such as: “*Cooked, prepared or served too much*” (48%) and “*Not used in time*” (31%) [3]. Most of the offered solutions rely on improving food packaging as it constitutes a medium to communicate with consumers.

Resealable packaging and packaging that reduces cross-contamination (e.g. pre-cut packaged ingredients) are examples of solutions that extend food shelf life at home and provide more flexibility for portioning [6]. To keep food fresh for longer and to utilise it efficiently, packaging has been used to provide clear guidance on how to store food [2] and phone apps have been proposed to help consumers manage their food inventory [7]. Regarding date labelling, some actors called for the “abolishment of best-before labels for long-lasting products” [8] since some consumers use “this label as a ‘use by’ date, rather than a quality guideline” [9]. To overcome the confusion over food date labels, temperature sensitive colour changing smart labels, made of gold nanorods, have been suggested to enable a more precise indication of whether the food is spoiled or not [10].

The proposed solutions are effective ways for manufacturers and retailers to help solve issues stated as direct causes for food waste (e.g. products perishability); however, the majority of these approaches focus on short-term interactions with consumers. They regard provision of food as simple transactions instead of a medium to build stronger relationships between businesses and consumers. For instance, provision of guidance

on how to use a product does not take into consideration the environment in which that product will be prepared and used as well as its interaction with other food products.

Table 1. Frameworks for reducing consumer food waste.

Innovate, Influence Edit Framework [11]	4 E's Framework [12]	UNEP Guidance [13]	Working on Waste Framework [14]
Innovate: integrate sustainability into product design innovation	Exemplify: lead by example; achieve consistency in policies	Plan: a strategy to engage consumers	Use technology: to facilitate reduction of food waste
Influence: use communication to enable consumers to choose products more sustainably	Enable: remove barriers; provide facilities, alternatives; train; educate	Set targets: establish a baseline Develop: evidence-based guidance	Tailor messages: to the occasion, keep it simple in store
Edit: remove unsustainable products, product components and services from marketplace	Encourage: tax system; reward schemes; penalties Engage: communication; media campaigns	Act: to prevent food waste Evaluate: measure, monitor and report progress	Create value: by being specific with technical solutions and communication

3. A Manufacturing Approach for Addressing Consumer Food Waste

As discussed in the previous section, the majority of the solutions proposed to minimise CFW regard manufacturers/retailers–consumers relationship as transactional. Transactional exchanges (Figure 2) refer to those “anonymous transactions” where both the buyer and supplier seek to “win at the other’s expense” [15]. The idea is for manufacturers and retailers to move towards the right of the relationship spectrum (Figure 2) by adopting value-added exchanges where they should improve their understanding of consumer behaviour (needs, attitudes, habits, etc.) leading to the generation of food waste and then formulate adequate and targeted solutions that would remove the barriers to a more environmentally sustainable consumption.

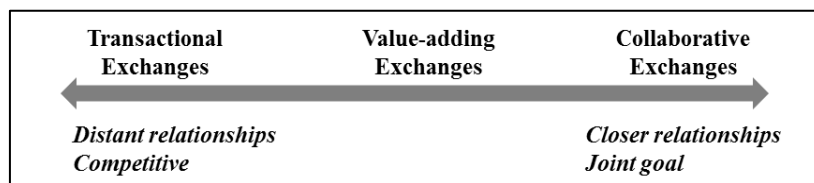


Figure 2. Buyer seller relationship spectrum. Adapted from [15].

In order for manufacturers and retailers to build strong relationships with their customers, they need to acquire three main capabilities: a) the mind-set of the organisation should be relationship-oriented so that its culture is focused on interacting with consumers before, during and after purchase; b) the organisation needs to continually deepen its knowledge of its customers; c) and the organisation process needs to be integrated and aligned with the customer’s process [15].

A possible approach to integrate manufacturers and consumers processes would be the servitization of food manufacturing. Servitization is “[when] the manufacturer [act]

as a service provider that sets out to improve the process of their customers through a business model rather than product-based innovation” [16]. It leads to the offering of a combination of goods and services, support, knowledge and/or self-service [17]. This concept has been mainly applied to products that do not cease to exist once they are used (e.g. washing machines); however, it can also be applied to consumable products [18] and therefore to the food sector. Thus, food manufacturing servitization would enable manufacturers and retailers to support consumers during the whole food provisioning process and in managing their domestic food related operations efficiently.

This research asserts that for manufacturers and retailers to support consumers in minimising CFW, they should first acquire a strong understanding of their customers and then change their internal activities to align them with the consumption process (demonstrated in Figure 3). This should enable the manufacturers and retailers to supply the right offering to the right consumer, resulting in a reduction of CFW.

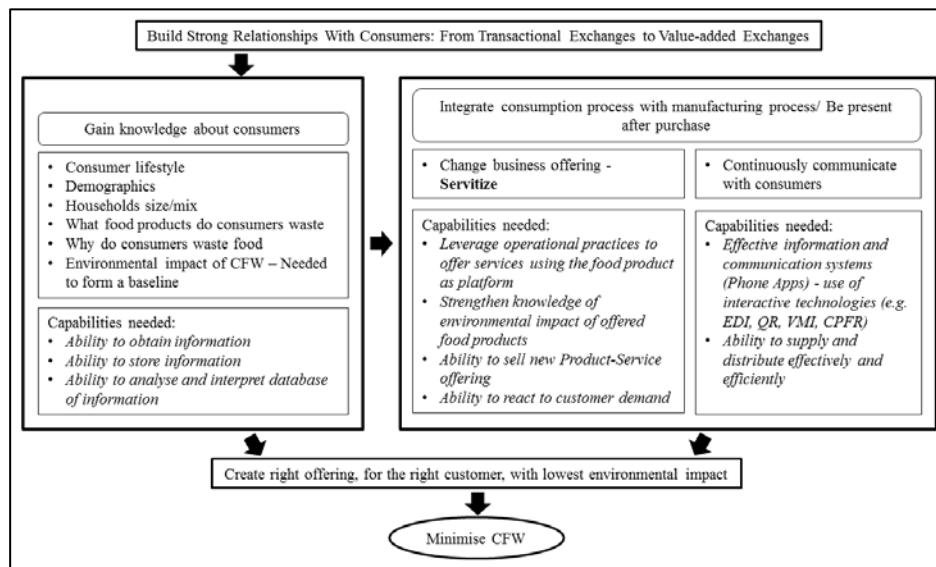


Figure 3. Proposed approach to minimise CFW in this work.

Servitization is advantageous to manufacturers as it enables them to gain a competitive edge by ‘locking in’ customers, setting up barriers to competitors and differentiating the market offer [17]; however, there exists some risk associated with implementing it. First, the early transition to servitization could be challenging depending on the market offering: manufacturers need to ensure that they have the capability to sell their product-service offering. The second risk concerns in the investment cost needed to make this strategic transition which includes: the initial capital needed to change the technical and organisational structure, and the additional transitional cost arising from producing the new offering such as costs of building new customer relationships [19]. The third risk is associated with the cost of production [19] as the manufacturing operations would be affected by the interaction with customers which would create uncertainties and increased variations.

4. Case Study

In order to better understand CFW and support the assertion that manufacturers and retailers play a crucial role in minimising CFW by collaborating with consumers, several food waste audits were conducted in public areas as well as domestic halls at Loughborough University. The university was chosen as it constitutes a good representation of an urban area. The investigations took place in three different living halls, the library and one of the university's major schools. A total of 74.35 kg of general waste was audited where six general waste bags were collected from each facility and food waste was categorised into edible/inedible, animal/plant based and packaged/unpackaged. These three food waste categories were selected from a nine-stage classification proposed by Garcia *et al.* [20]; the remaining six categories in the aforementioned classification were not considered relevant in this investigation.

The analysis of the data obtained from the audits revealed that the proportion of edible food waste is significantly greater in the living halls compared to the public areas as shown in Figure 4. This observed difference can be explained by suggesting that consumers generate more edible food waste in domestic environments (kitchens) where food preparation, food inventory management as well as food consumption occurs; conversely, in public areas, it is expected that edible food waste is mainly a result of consumption in the absence of preparation or stock management.

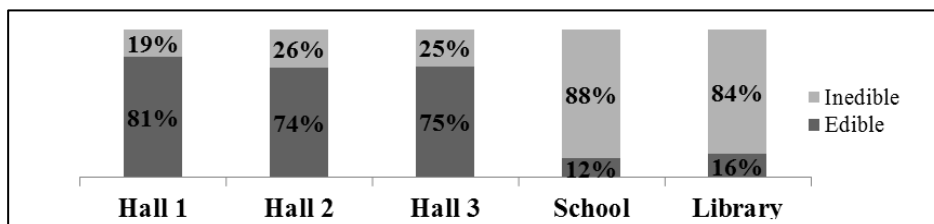


Figure 4. Food waste audits results for the edible/inedible category.

The investigation's result justifies the need for manufacturers and retailers to support consumers through their full food provisioning process in order to minimise CFW and this by adopting the aforementioned proposed approach (Figure 3) to: create innovative business offering which uses the product as a platform to provide services, knowledge and support that would enable consumers to be efficient in managing their food related operations; tailor their solutions so that products be customised depending on consumers' needs; and engage the consumers through continuous communication supported by effective information systems.

5. Concluding Discussion

This work has highlighted the importance of manufacturers and retailers to foster more efficient and responsible food consumption and presented an overview of the efforts that have been made to support businesses in reducing CFW. The review has identified that the majority of the existing solutions regard manufacturers/retailers–consumers relationships as transactional and thus fail to consider the highly complex domestic environment where food related operations take place.

A proposed solution to solve this complex issue is to strengthen manufacturing and consumption relationship and this by: a) acquiring a deep knowledge of consumers, b) changing business offering through the servitization of food manufacturing and c) effectively communicating with consumers to adapt to their needs by using strong information systems and technologies.

This approach is a result of preliminary findings from an ongoing research project and does not cover elements necessary to change the mind-set of the organisation from offering products to offering products and services. Changing the organisation mind-set is regarded to be an important component to create more collaborative manufacturers/retailers-customers relationships.

Acknowledgements

This research is funded by the Engineering and Physical Sciences Research Council (EPSRC) UK through the grant EP/K030957/1.

References

- [1] FAO, Save Food: Global Initiative on Food Loss and Waste Reduction, (2016), [online] Available at: <http://www.fao.org/save-food/resources/keyfindings/en/>, [Accessed 11/04/2016].
- [2] WRAP, From Concept to Consumer Preventing Food Waste in the Home – How can you and your business make an impact?, (2014).
- [3] WRAP, Household Food and Drink Waste in the United Kingdom 2012, (2013).
- [4] D. Evans, Blaming the consumer – once again: the social and material contexts of everyday food waste practices in some English households, *Critical Public Health*, **21** (2011), 429-440.
- [5] WRAP, Estimates of Food and Packaging Waste in the UK Grocery Retail and Hospitality Supply Chains, (2015).
- [6] C. K. Sand, Decreasing Consumer- Derived Food Waste. *Food Technology Magazine*, (2015).
- [7] E. Woolley, G. Garcia-Garcia, R. Tseng, S. Rahimifard, Manufacturing resilience via inventory management for domestic food waste, *CIRP*, **40** (2016), 372-377.
- [8] A. Adam, Drivers of Food Waste and Policy Responses to the Issue: The Role of Retailers in Food Supply Chains, (2015).
- [9] WRAP, Consumer Insight: Data Labels and Storage Guidance, (2011).
- [10] C. Zhang, A. Yin, R. Jiang, J. Rong, L. Dong, T. Zhao, L. Sun, J. Wang, X. Chen, C. Yan, Time-Temperature Indicator for Perishable Products Based on Kinetically Programmable Ag Overgrowth on Au Nanorods, *ACS Nano*, **7** (2013), 4561–4568.
- [11] WBCSD, Sustainable Consumption Facts and Trends from a Business Perspective, (2008).
- [12] DEFRA, Securing the Future – Delivering UK Sustainable Development Strategy, (2005).
- [13] UNEP, Prevention and Reduction of Food and Drink Waste in Businesses and Households - Guidance for governments, local authorities, businesses and other organisations, (2014).
- [14] IGD, Celebrating Food: The Opportunities Surrounding Household Food Waste, (2015).
- [15] G., Day, Managing Market Relationships, *JAMS*, **28** (2000), 24-30.
- [16] T. Baines, H. Lightfoot, *Made to serve: how manufacturers can compete through servitization and product-service systems*, Wiley, Chichester, 2013.
- [17] S. Vandermerwe, J. Rada, Servitization of Business: Adding Value by Adding Services, *European Management Journal* **6** (1988), 314-324.
- [18] A. Neely, Is Servitization for You?, (2012), [online] Available at: <http://andyneely.blogspot.com/2012/02/is-servitization-for-you.html>, [Accessed 25.04.2016].
- [19] A. Tukker, Eight types of product-service system: eight ways to sustainability? Experiences from SusProNet, *Business Strategy and the Environment*, **13** (2004), 246-260.
- [20] G. Garcia-Garcia, E. Woolley, S. Rahimifard, A framework for a more efficient approach to food waste management, *International Journal of Food Engineering*, **1** (2015), 65–72.