Waste Management xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Applying Value Stream Mapping to reduce food losses and wastes in supply chains: A systematic review

Hans De Steur [a,1], Joshua Wesana [a,b,*,1], Manoj K. Dora [c], Darian Pearce [a], Xavier Gellynck [a]

[a] Department of Agricultural Economics, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium
[b] School of Agricultural and Environmental Sciences, Mountains of the Moon University, Fort Portal, Uganda
[c] College of Business, Arts & Social Sciences, Brunel Business School, Brunel University, London, United Kingdom

ARTICLE INFO

Article history:
Received 25 March 2016
Revised 13 July 2016
Accepted 24 August 2016
Available online xxxx

Keywords:
Food supply chain
Food loss
Food waste
Lean manufacturing
Nutrient loss
Value Stream Mapping

ABSTRACT

The interest to reduce food losses and wastes has grown considerably in order to guarantee adequate food for the fast growing population. A systematic review was used to show the potential of Value Stream Mapping (VSM) not only to identify and reduce food losses and wastes, but also as a way to establish links with nutrient retention in supply chains. The review compiled literature from 24 studies that applied VSM in the agri-food industry. Primary production, processing, storage, food service and/or consumption were identified as susceptible hotspots for losses and wastes. Results further revealed discarding and nutrient loss, most especially at the processing level, as the main forms of loss/waste in food, which were adapted to four out of seven lean manufacturing wastes (i.e. defect, unnecessary inventory, overproduction and inappropriate processing). This paper presents the state of the art of applying lean manufacturing practices in the agri-food industry by identifying lead time as the most applicable performance indicator. VSM was also found to be compatible with other lean tools such as Just-In-Time and 5S which are continuous improvement strategies, as well as simulation modelling that enhances adoption. In order to ensure successful application of lean practices aimed at minimizing food or nutrient losses and wastes, multi-stakeholder collaboration along the entire food supply chain is indispensable.

Contents

* Corresponding author at: Department of Agricultural Economics, Ghent University, Coupure Links 653, 9000 Ghent, Belgium.
E-mail addresses: Joshua.Wesana@UGent.be, wesanaj@yahoo.com (J. Wesana).
[1] HDS and JW contributed equally to this work and shall be considered as co-first authors.

http://dx.doi.org/10.1016/j.wasman.2016.08.025
0956-053X/

1. Introduction

The year 2016 represents the start of the global challenge for reaching the UN Sustainable Development Goals (SDGs) (Kumar et al., 2016; Sachs, 2012). While there is no doubt that the Millennium Development Goals (MDGs) accelerated progress in fighting hunger and malnutrition between 2000 and 2015, the major threat to food security in the SDG-era is expected to be reinforced by population growth and adverse climatic changes (Hanjra et al., 2013; Wheeler and von Braun, 2013). And although increasing food production as such is often considered as a key solution, it comes at a high cost i.e. utilizing the already scarce resources such as clean water, land, protected areas and forests, that are necessary for a healthy environment and biodiversity (Godfray et al., 2010; Phalan et al., 2011). Since one-third of food produced is lost or wasted along the supply chain (Gustavsson et al., 2011), dedicated efforts ought to be directed toward the implementation of innovative measures from farm to fork, thereby not only ensuring the delivery of significant quantities of food, but also retaining the level of nutrients in those foods (Ruel et al., 2013). In this context, literature distinguishes "food losses", a decrease in edible food mass occurring during production, postharvest and processing from "food wastes", any raw or cooked food mass that is discarded at retail and consumption (Gustavsson et al., 2011; Kummu et al., 2012; Miller and Welch, 2013; Parfitt et al., 2010). Together, they are defined as "food supply chain losses", referring to each stage along the chain where a given proportion of food that is initially meant for consumption does not reach the intended consumer (Richter and Bokelmann, 2016; Willersinn et al., 2015).

From an economic point of view, initiatives that tackle food losses and wastes (FLW) are not only beneficial to those food producers aiming to sell more, but also to consumers who could save money as the available food becomes more affordable (Rutten, 2013), and enhance their energy and nutrient intake, when also quality losses in food would be addressed (Almdal et al., 2003; Barton et al., 2000; Edwards and Nash, 1999). A study by Rutten (2013) shows that reduction of FLW has potential to lower food prices particularly in favour of net food consumers but not net food producers. Similarly, FLW reduction efforts in developed countries might lower food prices in developing countries (Rutten et al., 2015), save resources that can be used to feed a hungry population and boost efficiency along their supply chains (Buzby and Hyman, 2012). Although such changes are said to potentially improve accessibility to nutritious foods among vulnerable households (Brinkman et al., 2010; Gustavsson et al., 2011), there is need to better address food and nutrient losses or wastes simultaneously in order to reach some of the SDGs. First of all, perishable products that are highly nutritious such as vegetables, fruits, dairy, meat and fish, are often more prone to loss and wastage along the supply chain than staple foods, like cereals (Yu and Nagurney, 2013). Post-harvest losses in such foods are singled out as a factor that affects availability and accessibility to poor individuals (Murthy et al., 2009). Second, through reducing weight or size of edible parts of plants or animals, an estimated 25% loss of available calories eventually are not consumed (Searchinger et al., 2013). When half of such FLW along the supply chain would be reduced, the nutritional requirements of about 63 million undernourished people from developing regions would be met (Munesue et al., 2015). In addition, food processing activities such as inappropriate peeling and cutting are known to not only lead to quantitative FLW, but also compromise the micronutrient quality (Artés et al., 2007; Francis et al., 2012). Vitamin C and A, for example, are easily lost in fresh cut fruits as compared to whole fruits due to the processing operations (Barrett et al., 2010; Gil et al., 2006). This approach of tackling both food and nutrient losses, can reinforce agriculture-nutrition linkages and ultimately contribute to food and nutrition security (Pangaribowo et al., 2013).

Lean manufacturing, a quality management approach initially developed to eliminate waste in the automobile sector, is defined as "a system that utilizes fewer inputs and creates the same outputs while contributing more value to customers" (Womack et al., 1990). It is viewed as a philosophy rather than just a collection of tools (Hines et al., 2004), and can be considered as a gateway to a systems thinking that requires collaboration of all value chain actors with a collective goal to boost customer satisfaction (Halloran et al., 2014). Identification and elimination of wastes (non-value adding activities) is key to the concept of lean manufacturing, and its application is currently not only limited to the automobile sector, but also has increasingly been applied in other sectors particularly the agri-food industry (Dora et al., 2014; Zokaei and Simons, 2006a). Nevertheless, its penetration into the agricultural sector has been slow and this is attributed to the perishability of a wide range of food products, complexity of the agri-food supply chain and dynamic consumer preferences (Dora et al., 2016). Regardless of the fact that not all lean tools can easily be adapted to a new processing industry, Value Stream Mapping (VSM), defined as "a tool that helps you to see and understand the flow of materials and information of a product as it makes its way through the value stream" (Rother and Shook, 1998), has found its way into the agri-food industry (Panwar et al., 2015). It involves identifying seven lean wastes (i.e. defects, overproduction, inappropriate processing, unnecessary inventory, unnecessary motion, transport & waiting (Hines and Rich (1997)) through the development of a current and, through the application of other lean tools, a future state value stream map (Dal Forno et al., 2014; Womack, 2006). Its success has for example been shown in its ability to improve the effectiveness of value chain analysis by enhancing consumer value at each stage (Zokaei and Simons, 2006b), boost food production and service (Ahmed et al., 2015), minimize wastes in convenience food manufacture (Darlington and Rahimifard, 2006) and improve efficiency of a food contract manufacturer (Lehtinen and Torkko, 2005). Although previous studies justify its use in various industries as a tool to curb waste, none to the best of our knowledge has explicitly explored its adaptability to FLW with a specific link to nutrient retention; yet the potential exists.

Based on a systematic review approach, this study is considered the first to aggregate and examine evidence on the application of VSM in the agri-food industry. Thereby, specific attention was devoted to the potential of VSM to be combined with other methods targeting the elimination of FLW, as well as its adaptability for identification and measuring nutrient losses. The next section of this article outlines the procedure that was used to search and select studies, from which relevant data was obtained. The third section gives an overview of studies characteristics, application of lean manufacturing mainly focusing on VSM and identification of losses and wastes. The fourth section is devoted to a discussion of important findings which is followed by a conclusion.

2. Methods

The structure of this systematic review followed applicable guidelines set in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement. In addition, the search for data, synthesis and conceptualization of data from relevant studies was based on Petticrew and Roberts (2008), complemented with qualitative content analysis process suggested by Hsieh and Shannon (2005).