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Adel Kader Review

Postharvest losses of fruit and vegetables during retail and in consumers' homes: Quantifications, causes, and means of prevention

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ABSTRACT

The issue of food loss and waste (FLW) reduction has recently achieved much public attention as part of worldwide efforts to combat global hunger and improve food security. Studies conducted by various international and national organizations led by the FAO indicated that about one third of all food produced on the planet and about a half of all fruit and vegetables (F&V) are lost and not consumed. FLW occurs during five key stages of the food supply chain: agricultural production, postharvest handling and storage, processing, distribution, and consumption. Large portions of FLW in developed countries occur during retail and consumption, and are largely related to logistic management operations and consumer behaviors. In light of the great importance of FLW reduction, the United Nations set up in September 2015 an ambitious goal to halve per capita global food waste by 2030, and this decision was adapted by the US Federal Government, the EU Parliament, and many other countries. This first Adel Kader review article is dedicated to the subject of F&V losses during retail and consumption, and contains the following chapters: 1) Introduction of the problem of global food losses; 2) Quantifications of F&V losses during retail and consumption in the UK, US and other countries; 3) Causes and consumer decisions related to F&V wastage; 4) Emerging new technologies for prevention of F&V losses, including advances in logistics and cold chain management, retail packaging and technological innovations; 5) Other means to reduce F&V losses, including consumer awareness campaigns, advertisement of home storage instructions and policy and legislative measures. Due to the great importance of reducing F&V losses, we encourage postharvest researchers to become more engaged with logistics and food supply-chain operations, and to conduct multidisciplinary research incorporating consumer behavior studies into postharvest research.

Preface

We are grateful for the honor of dedicating the first Adel Kader review article series to the subject of postharvest losses of fruit and vegetables (F&V), of which Professor Adel Kader was one of the world's pioneers and leading researchers. Professor Kader truly realized and emphasized the great importance of quantification and prevention of postharvest food losses, in order to secure adequate food supplies and combat global hunger (Kader, 2005). Professor Kader also served as an expert contributor to the landmark publication "Global Food Losses and Food Waste" (FAO, 2011), which opened our minds to the significant global problem of food losses and waste along the supply chain.

1. Introduction

The increase in global population, together with the increased purchasing power of the burgeoning middle-class populations in developing countries with emerging markets will result in a projected increase in food demand of 50–70% by mid-century (Godfray et al., 2010; Parfitt et al., 2010; Bond et al., 2013). In contrast to this background of rising global demand, it is estimated that nearly one billion people are chronically under-nourished and suffer from nutritional deficiencies (Bond et al., 2013; UNEP, 2014). Furthermore, future food security – the ability of the world to provide enough safe and nutritious food for its entire population, is deeply threatened by emerging environmental constraints, such as stringent climate change, land degradation, and water scarcity (Wheeler and Von Braun, 2013; Liu, 2014).

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The issue of food loss and waste (FLW) prevention has recently achieved high importance as part of worldwide efforts to combat global hunger and improve food security, as reducing food losses will increase food availability and security, and promote environmental sustainability (FAO, 2011; Shafiee-Jood and Cai, 2016). Accordingly, it was suggested that if the current rate of FLW were cut by half by 2050, the world would need to produce about 1314 trillion kilocalories (kcal) less food per year than it would in a "business-as-usual" global food requirements scenario. Thus, reducing FLW should be one of the leading global strategies for achieving sustainable food security (Lipinski et al., 2013). In light of the above-mentioned necessity to increase food availability, the Association of Public and Land-Grant Universities (APLU) has recently endorsed Universities in the United States, Canada, and Mexico to focus their future research on the key challenge of ensuring global food and nutrition security, including reduction of FLW (APLU, 2017). In addition, the UK Government has recently elevated "reducing waste" to one of the four key research priorities in its Agriculture and Food Security Strategy Framework (BBSRC, 2017). The global activities on FLW reduction are currently greatly inspired by the FAO's "SAVE FOOD: Global Initiative on Food Loss and Waste Reduction" program (FAO, 2015).

The term "FLW" refers to any decrease in edible food mass available for human consumption throughout the various segments of the supply chain (FAO, 2011; Okawa, 2015). Food losses occur during the early stages of the food supply chain including at production, postharvest storage, transportation, and processing, whereas food waste takes place towards the end of the food supply chain including retail and consumption (FAO, 2011, 2013) (Fig. 1). Food waste is largely related to improper behavior and decision making of suppliers, retailers, and consumers, which results in discarding of food that still contains adequate nutritional value and that could have been consumed (Parfitt et al., 2010; Lipinski et al., 2013; Okawa, 2015).

FLW can also be divided into qualitative and quantitative losses. Qualitative losses refer to food losses due to poor perceived quality in terms of color, size, shape, flavor, etc., that result in low consumer acceptability, whereas quantitative losses refer to destructive losses due to physiological, mechanical, or pathological deterioration, or combinations of these (Kader, 2005). Worthy of notice is that a certain proportion of food waste is unavoidable, as it includes inedible parts and tissues, such as banana peels, apple cores, etc. (Ju et al., 2017).

Studies conducted by various international and national organizations, including the FAO, European Union (EU), Organization for Economic Co-operation and Development (OECD), the United States Department of Agriculture (USDA), the US and French Natural Resources Defense Councils (NRDC), the UK Waste Resource Action Program (WRAP), the Institution of Mechanical Engineers (IMechE), as well as many other governments, including Japan, China, India, various EU countries, etc., indicated that between 30 and 50% (1.2–2 billion tons) of all food produced on the planet is lost and not consumed (FAO, 2011, 2015; NRDC, 2012, 2015, 2017; WRAP, 2013; IMechE, 2013; Buzby et al., 2014; Okawa 2015; FUSIONS, 2016). The estimated per-capita FLW levels peaks at 280–300 kg per capita per year in high-income European and North American countries and amounts 120–170 kg per capita per year in low-income sub-Saharan African and South and Southeast Asian countries (HPLE, 2014).

Based on studies led by the FAO and other organizations, standard methodologies were developed for accurate measurement of FLW along five key stages (boundaries) of the food supply chain: agricultural production, postharvest handling and storage, processing, distribution, and consumption (FAO, 2011; Lipinski et al., 2013; UNEP, 2014; WRI, 2016). Food loss rates at each stage of the food supply chain are estimated by using the FAO's food balance sheets (FAO, 2011; WRI, 2016). Using FAO (2011) data, the NRDC (2012) report indicated that in North America (i.e., the US and Canada), Australia, and New Zealand, F&V losses totaled: 20% during production; 3% during postharvest handling and storage; 1% during processing and packaging; 12% during distribution and retail marketing, and 28% at the consumer stage (Fig. 1). However, these data did not distinguish between fresh and processed forms of F&V.

Studies indicated that in low-income countries food losses result largely from managerial and technical limitations in harvesting techniques, and storage, transportation, and processing activities, because of lack of proper cooling facilities, infrastructure, and packaging and marketing systems. In contrast, food waste in medium- and high-income countries relates mainly to consumer behavior and strict safety policies and quality standard requirements (FAO, 2011, 2015).

Estimates of FLW vary among food categories, including F&V, roots and tubers, cereals, oilseeds, milk, meat and fish, and sea food (FAO, 2011; Lipinski et al., 2013). According to FAO reports, the categories "F&V" and "roots and tubers" account for 44 and 20% by weight, respectively, of the global total FLW, i.e., fruit and vegetables of all types together account for 66% by weight of total food losses (FAO, 2011; Lipinski et al., 2013). Furthermore, FAO reports indicate that between 45 and 55% of all F&V produced worldwide are lost or wasted along the supply chain (FAO, 2011; Lipinski et al., 2013), and an NRDC report indicated that 52% of all F&V produced in the US, Canada, Australia, and New Zealand combined, are lost or wasted (NRDC, 2012).

According to the USDA, in the US alone F&V losses in the retail and consumption stages are estimated at 18.4 and 25.2 billion pounds, (8.3 and 11.4 million tonnes) respectively (Buzby et al., 2014). More specifically, of the total amount of F&V available for consumption at the retail and consumer levels in the US, 9% of fruit and 8% of vegetables are lost at the retail stage, and a further 19% of fruit and 22% of vegetables are not eaten at the consumption stage; i.e., in the US roughly 28% of fruit and 30% of vegetables are lost in these two stages (Buzby et al., 2014). A material flow analysis study conducted in Japan revealed that the single food category with the highest loss rate comprised vegetables (Ju et al., 2017). It should be remembered that fresh F&V are living organic organisms and, as such, are very perishable food items with relatively short postharvest storage lives (Kader, 2002). Reduction of F&V losses is of great importance, because these commodities are of great importance for human nutrition with respect to vitamins, minerals, phytonutrients, fibers, etc., that are essential for healthy human diets.

Notwithstanding the significance of food loss reduction for ensuring food security, it also has major environmental, economic, and sociological impacts. From the environmental point of view, FLW represent waste of precious natural resources used for food production; including land, fresh water, energy, and fertilizers. In addition, wasted food is commonly dumped in landfills, which results in excessive emission of methane, which is approximately 25 times more harmful to the ozone layer than CO_2. Kummu et al. (2012) reported that 23–24% of total use of water, cropland and fertilizers are used to produce food that gets lost. According to FAO reports (2013), the blue-water footprint of food waste

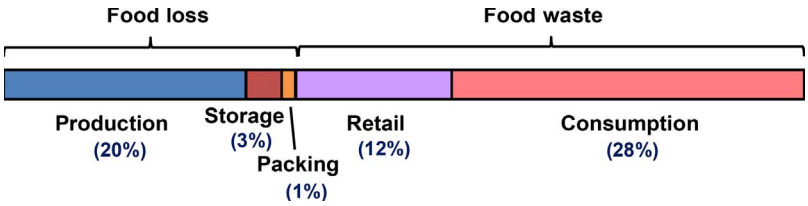

Fig. 1. FLW percentages at each step along the supply chain in USA, Canada, Australia, and New Zealand combined. The data are according to FAO (2011) and NRDC (2012).