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Exploration of logistics and quality control activities in view of context characteristics and postharvest losses in fresh produce chains: A case study for tomatoes

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ABSTRACT

Postharvest losses in fresh produce chains are a major threat to food security, especially in transition countries. To develop effective intervention strategies for postharvest losses reduction, it is important to first understand the core logistics and quality control activities that could affect postharvest losses in these chains. In this study, a diagnostic tool was developed and used to assess the implementation level of core logistics and quality control activities, the vulnerability of the system due to the context in which it operates, and the actual postharvest losses. Based upon a literature review, the context characteristics are divided into product, process, organisation, and supply chain environment characteristics to assess the context vulnerability to postharvest losses. The identified core logistics activities are planning on the amount of fresh produce to harvest and process, selecting issuing policies, selecting mode of transportation and type of vehicle, and vehicle scheduling and routing. Maturity determination at harvest, deciding on harvest moment, harvesting, packing, and storage practices, use of grading standards, package material, temperature monitoring during storage and transportation, and equipment maintenance are the core quality control activities identified. The tool was applied to three groups of farmers operating in a tomato supply chain in Zimbabwe. The major findings are that commercial farmers recorded lower postharvest losses (1%) as compared to subsistence farmers (3%), the context for commercial farmers is less vulnerable to the generation of postharvest losses as compared to that for subsistence farmers, and logistics and quality control activities for commercial farmers are implemented at a more advanced level. The tool provides differentiated assessment that allows users to identify improvement opportunities to achieve higher performance for the activities and to reduce context vulnerability.

1. Introduction

Postharvest losses (PHL) are a major obstacle in achieving sustainable fresh produce chains and have repercussions for food security, especially in transition countries where approximately up to 40% of the harvested fruit and vegetables end up not being acceptable for human consumption (Gustavsson, Cederberg, Sonesson, & Van Otterdijk, 2011; Hodges, Buzby, & Bennett, 2010). Major reasons for these high PHL include inadequate logistics and quality control activities. Poor demand forecasting, inefficient inventory control systems (Kaipia, Loikkanen, & Dukovska-Popovska, 2013), and lack of supply chain coordination (Gustavsson et al., 2011) are typical examples of inadequate logistics control contributing to PHL. Insufficient temperature, humidity, and atmospheric conditions control (Kader & Rolle, 2004), inadequate packaging (Gustavsson et al., 2011; Kitinoja, 2013), and poor product quality control (Kereth, Lyimo, Mbwana, Mongi, & Ruhembe, 2013) are examples of inadequate quality control activities contributing to PHL.

The problem of high PHL in fresh produce chains is exacerbated

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by the complexity of these chains and the environmental circumstances. These chains are characterised by highly perishable products that are heterogeneous in nature (Hertog, Lammertyn, Scheerlinck, & Nicolaï, 2007). Once harvested physiological processes, such as respiration, transpiration, and ethylene biosynthesis continue, resulting in enhanced quality deterioration (Akkerman, Farahani, & Grunow, 2010; Amorim, Meyr, Almeder, & Almada-Lobo, 2011). Fresh produce chains therefore need to be properly managed to minimise the influence of the complexity of these chains and the environmental circumstances on PHL.

Several studies have been conducted on improving logistics management (Dada & Thiesse, 2008; Ahumada & Villalobos, 2011; Amorim et al., 2011; East, 2011; Van der Vorst, van Kooten, & Luning, 2011) and quality management (Buntong, Srilaong, Wasusri, Kanlayanarat, & Acedo, 2013; Kirezieva, Jacxsens, Uyttendaele, Luning, & Van Boekel, 2013a; Sivakumar & Wall, 2013) to minimise PHL in fresh produce chains. However, previous studies (Kirezieva et al., 2013b; Kussaga, Jacxsens, Tiisekwa, & Luning, 2014; Luning et al., 2011a; Nanyunja et al., 2015) discussed and demonstrated that the technical, organisational, and chain environment characteristics of companies operating in (fresh) food chains should be taken into account to understand the effectiveness of quality management systems. These studies showed that companies operating in a high-risk context (typified by uncertainty, ambiguity, and vulnerability to food hazards) with basic systems, i.e., experience-based, not specific, nor formalised, experience a higher risk on food safety failures. Likewise, chain actors in fresh produce chains need to implement logistics control and quality control activities (Kirezieva et al., 2013b) that are aligned with the context characteristics in which they operate. To gain a deeper understanding of the causes of PHL in transition countries, it is necessary to typify and analyse context characteristics that can impact the logistics and quality control activities that can affect the generation of PHL.

The aim of this study is to explore the logistics and quality control activities, and the context characteristics that can affect the generation of PHL in fresh produce chains. For this purpose, literature was examined to identify the core logistics and quality control activities. Subsequently, a diagnostic tool was developed and used to assess the implementation of the core activities in a case of tomato farmers in Zimbabwe. We chose this specific case, because tomato is among the most important vegetable crops grown by farmers in Zimbabwe (eMkambo, 2015), and literature shows that tomatoes in Sub-Saharan countries are also confronted with significant PHL, ranging between 10 and 40% of the harvested crop (Affognon, Mutungi, Sanginga, & Borgemeister, 2015; eMkambo, 2015). Furthermore, tomato supply chains in Zimbabwe are characterised by three different groups of farmers, small-scale subsistence farmers, small-scale commercial farmers, and large-scale commercial farmers, making it possible to test the developed tool on these diverse categories of tomato farmers.

2. Materials and methods

2.1. Identifying core logistics and quality control activities

Core logistics and quality control activities that can affect PHL were determined through a literature search. The search was carried out using online databases: Scopus, Thomson Reuters Web of Science, and Google Scholar. Keywords used in the search are “fresh produce”, “quality control”, logistics control”, “food waste”, “food losses”, and “postharvest losses”. Titles, abstracts, and keywords of all the retrieved documents were reviewed and judged based on the following inclusion criteria: (i) the document is published in a peer-reviewed journal or book, to avoid repetition of the research material itself, such as conference proceedings that are later converted into journal papers, (ii) the document, or part of the document, is about PHL, food waste, food losses, logistics management activities, or quality control activities, (iii) the document, or part of the document, is about fresh produce chain (fruits and vegetables), and (iv) the document was published within the time span of 2000–2014, because in this period there was more research on PHL. The selection led to 37 relevant documents: 19 on logistics control activities, 13 on quality control activities, and five documents contained both logistics and quality control activities.

For both logistics and quality control, an activity was considered core when it has a direct effect on PHL and the effect is underpinned by literature, i.e., supported by more than two scientific studies. The control activities were identified for each postharvest stage in the fresh produce chain, i.e., harvesting, sorting and grading, packing, storage, and transportation. Identified control activities were screened based on the criterion that the effect of the activity on PHL is underpinned by literature, i.e., supported by more than two scientific studies. The screening resulted in six core logistics and 10 core quality control activities.

Context characteristics were identified based on the criteria that the characteristic (i) makes fresh produce vulnerable to PHL if adequate logistics and quality control measures are not implemented, and (ii) cannot be easily changed or cannot be changed at all. The search was carried out using a predefined set of keywords in the following online databases: Scopus, Thomson Reuters Web of Science, and Google Scholar. Context factors, food waste, food losses, and postharvest losses were the keywords used. The search resulted in 16 context characteristics, which were selected based on the criterion that the influence of the context characteristic on PHL is underpinned by literature, i.e., supported by more than two scientific studies.

The identification of core logistics and quality control activities resulted in a conceptual framework (Fig. 1) which was the basis for the diagnostic tool development.

2.2. Diagnostic tool development

2.2.1. The design principles used for diagnostic tool development

The development of the present tool was based on design principles used in earlier diagnostic tools to assess performance of food management systems (Luning, Bango, Kussaga, Rovira, & Marcelis, 2008; Luning et al., 2009, 2011b; Jacxsens et al., 2011; Kirezieva et al., 2013a), i.e., including system context characteristics, focus on core activities, defined system output, and use of judgment grids to enable a differentiated assessment.

The first design principle relates to system activities, such as control activities, which need to be adapted to the context wherein they operate to be effective. It is well elaborated in contingency theory literature (Drazin & Van de Ven, 1985) that the performance of a system or solutions to a set of problems is influenced by external factors. Major context factors included in the current tool are product, process, organisation, and chain characteristics. Product characteristics refer to the inherent properties of initial materials and final products. Production characteristics apply to the conditions during primary production, processing, and handling (Luning et al., 2011a). Organisational characteristics involve administrative conditions, such as requirements on employee competences, assignment of tasks and responsibilities, rules, and procedures, which affect peoples’ decision-making behaviour (Luning & Marcelis, 2007). Chain characteristics refer to the conditions during supply, and relationships with other companies and organisations in the chain (Kirezieva et al., 2013b).

The second principle relates to the focus on core activities. For the current tool, core logistics and quality control activities are