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Improving quality control and transparency in honey peach export chain by a multi-sensors-managed traceability system

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ABSTRACT

China is the world leader in peach production and export. Peaches are prone to rapid deterioration after harvest, especially when honey peach export chain always is longer and complex. Both traceability and Hazard Analysis and Critical Control Point (HACCP) are considered as the effective tools to improve quality control and chain transparency. This paper presents an effort to develop and evaluate a multi-sensors-managed traceability system for honey peach export chain. The key traceable information and quality control point were identified based on the principles of HACCP; a traceability system, integrated multi-sensors and a HACCP based quality control plan, was developed to monitor identified traceable information in real-time and provide the quality evaluation and control decision; The system was evaluated and validated at a sampled honey peach export chain from Shandong, China to Singapore. The results show that the critical ambient parameters (CAPs) in the honey peach export chain are temperature, relative humidity (RH), O_2, CO_2 and ethylene. The temperature influences the change of RH, CO_2 and ethylene. The traceability system can improve the transparency and quality control by tracing the CAPs in honey peach export chain and provide the tracking service. The quality loss of honey peach export chain decreased from 25% to 30% to below 13% based two years' statistics with the system application.

1. Introduction

Peach, belongs to the family Rosaceae, is a typical climacteric stone fruits and one of the most important economical fruit. The main countries that produce peaches are China, Spain, Italy, Greece and USA (FAOSTAT, 2014). China has the largest area planted peaches in the world ($4.52 \times 105\ hm^2$) and the greatest production (4.6×109 kg per year) (Wan, Zhang, Huang, Ji, & Jiang, 2016). Based on texture, shape and skin hair characters, peach cultivars are divided into six groups: crispy, sweet, honey, yellow fleshed, flat and nectarine (Wang et al., 2015). Among them, the honey peach has become increasingly world-popular in recent years because of its high marketing value (Lurie et al., 2005; Shen, Ma, Cai, Yu, & Zhang, 2015; Xie et al., 2010). With the development of technology and the honey peach reputation in the world, the Chinese honey peach export increased gradually in recent years.

However, the export chain for honey peach is more complex than domestic chain: the origin is far away from the destination, involving time through the customs, on board handling in ships, long transportation and more intermediate points. The complexity contributes to highly perishable and rapidly quality loss of honey peach, as manifested by dehydration, shriveling, softening, decrease in ascorbic acid content and decay, often cause greater economic losses and hinders the products export to more regions across the world (Gang et al., 2015; Gao et al., 2016). Therefore, it is critical to improve the quality control and transparency in honey peach export chain, further to increase the export volume.

Traceability is an effective tool for quality management in the food industry and had been adopted in many food supply chains (Abad et al., 2009; Badia-Melis, Mishra, & Ruiz-García, 2015; Chen, 2017; Costa et al., 2013; Xiao, He, Fu, Xu, & Zhang, 2016, 2017; Zhang, Chai, Yang, & Weng, 2011). Furthermore, traceability is becoming a prerequisite for successful export of perishable fruit.

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Since the United States of America, European Union, and many countries have issued relevant laws and regulations that require imported products to be traceable (EU, 2002; PL107-188, 2002). It is of global significance of ensuring exported fruit quality and safety by implementing traceability system due to the massive volume of production and export (Bai et al., 2017; Chen et al., 2017; Mai, Gretar Bogason, Arason, Víkingur Árnason, & Geir Matthíasson, 2010; Thakur, Sørensen, Bjørnson, Forås, & Hurburgh, 2011).

The efficient and effective development of traceability system depends on correcting and validating quality safety management and control information requirements. The Hazard Analysis and Critical Control Point (HACCP) is a systematic approach and management tool to the identification, evaluation and control of hazards in a particular food operation (Panisello et al., 2001), which is recognized as a worldwide guideline for controlling food safety hazards in the international food safety community (Kafetzopoulos & Gotzamani, 2014; Luning et al., 2015). It has been adopted in many sectors, such as aquatic product processing (Al-Busaidi, Jukes, & Bose, 2017; Lupin, Parin, & Zugarramurdi, 2010), milk production (Carrascosa et al., 2016; Vilar et al., 2012), meat processing (Asefa et al., 2011; Tomasevic et al., 2016), and fruit processing (Kafetzopoulos, Psomas, & Kafetzopoulos, 2013; Zhang, Gang, Zhao, & Hu, 2015). However, few researchers focused on how HACCP homogeneously implemented into fruit export chain (Jaffee & Masakure, 2005; Trienekens & Zuurbier, 2008).

Therefore, it is critical to improve quality control and transparency of fruit from harvest to export sale by a traceability system integrated multi-sensors and the HACCP principles. This research contributes to the field of study in the following ways. First, critical ambient parameters (CAPs) and quality control plans of honey peach export chain were determined through the principles of HACCP. Second, the CAPs were real-time monitored and analyzed by a multi-sensors-managed traceability system; the quality was dynamically calculated to evaluate the traceability system and quality control for honey peach export chain. Finally, the system was validated in sampled chain and feedbacks were collected on the improvement of the traceability system and ensure the transparency and quality control of honey peach export chain.

2. Materials and methods

2.1. Export chain example

As Singapore is one of important peach import country for China, Singapore is choose as the sample importer. And Shandong honey peach enjoys the reputation as one of the tastiest fruits in China, the cold chain from Shandong, China to Singapore was sampled as the experiment chain. The distribution route consisted of land transport and marine transport (Fig. 1).

Well known throughout the country for being remarkably sweet, succulent and tender, honey peach 'Chunxue' was obtained from Shandong Province. The specifications of the peaches were: maturity level of 80–90% (turning stage to red stage, according to the standards for maturity scale (Song et al., 2016)). The maximum weight and average weight of individual peach are 500 g and 321 g respectively. Peaches were wrapped with polyethylene (PE) foam bags during growth, until physiologically mature stage. When harvested, the PE will be removed.

2.2. Traceability information and quality control analysis based on HACCP

Both a systematic literature review (Lombardo et al., 2011; Ortmann et al., 2005; Rizzolo et al., 2012; Taylor & Rushing, 2012, pp. 1–10) and a field observation were conducted to trace the information flow and the CAPs that may influence the quality control of honey peach export chain. The field observation lasts over half of a month. The ISO 22000:2005 standard requirements were adopted for the selection and assessment of control measures while conducting hazard analysis and assessment (Pardo et al., 2017; Soman & Raman, 2016). The HACCP based information analysis method as follows:

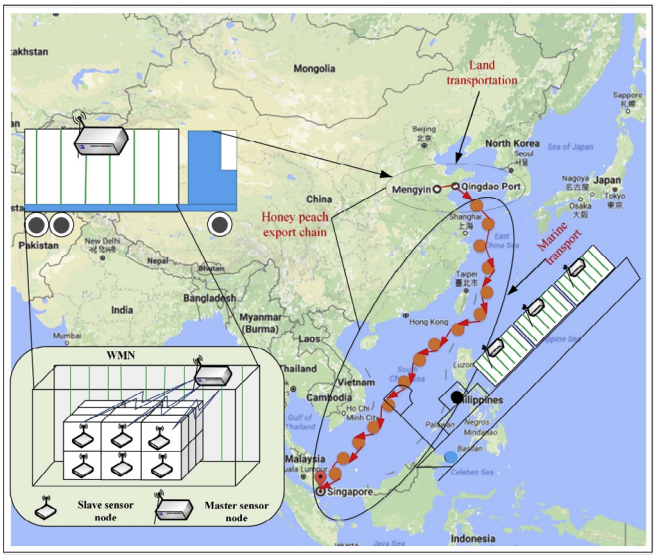

Fig. 1. The export chain route for honey peach.

Step 1: Analyze potential hazards that could be detrimental to fruit quality and safety; Step 2: Identify critical control points (CCP), using a tree or sequence of decisions with a logic reasoning approach (as showed in Fig. 2).

Step 3: The critical limits are defined when a stage is considered as CCP; Step 4: The preventive measures are defined, which could be applied to reduce or annul this hazard; Step 5: Finally, the HACCP plan is implemented for quality control of honey peach export chain.

2.3. Quality measure methods

The values of flesh firmness in each individual peach without skin were measured at three points on the equatorial diameter using a GY-3 firmness tester (Zhejiang Top Instrument Co.Ltd., Zhejiang, China) with an 11-mm diameter flat probe. The fruit mass was measured by a MP2000-2 balance (±0.05 g; Shanghai Balance Instruments Co. Ltd., Shanghai, China). The weight loss was calculated as:

Weight loss $= (W_i - W_f)/W_i \times 100\%$,Where W_i represents the initial sample weight and W_f represents the final sample weight.

Measurement of soluble solids content (SSC) was conducted on juice samples collected from five fruits per treatment, using a handheld refractometer (Model WZS-I, Shanghai Optical Instruments Co., Ltd., Shanghai, China) and expressed as %. The decay rate was calculated as:

Decay rate $= (N - N_1)/N \times 100\%$, Where N represents the initial fruit number and N_1 represents the final good fruit number. Sensory is the overall rating of acceptance, evaluated by five trained experts.

2.4. Traceability system for honey peach export chain

The traceability system for honey peach export chain consists of