Research article

Postharvest Management Options to Improve Tomato Value Chain in Cambodia

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Abstract Tomato (cv. Mongal) value chain practices of a farmers' cooperative as pilot model in Siem Reap, Cambodia, were assessed and improved through the introduction of postharvest technologies and best practices. The existing value chain (EVC) practices included harvesting tomatoes at the breaker stage, use of harvesting container with smooth surface (plastic pail), use of plastic crate in hauling harvested tomatoes to the farmers' house where packaging in ordinary plastic bags at 10 kg fruit per bag was done. No sorting and special storage were practiced except for overnight storage at ambient when harvesting was done in the afternoon. The packed fruit were then transported to the city market about 12 km from the farm or 30-45 minutes ride using a motorcycle-driven carrier (locally named 'TukTuk'). Marketing tomatoes usually took half day. Using the cooperative's simple packhouse which linked farm production and marketing, improved value chain (IVC) practices were introduced, including sorting to ensure more uniform quality and damage-free fruit, sanitizing with 0.01% calcinated calcium (non-chlorine sanitizer) by dipping fruit in the solution for 3 minutes, modified atmosphere packaging (MAP) using perforated 50 µm thick low-density polyethylene bag at 10 kg fruit per bag, and transporting and direct retailing in ice box using a dedicated motorcycle-driven carrier. In another set of trials, three-day storage simulating extended period of distribution and marketing was included using ambient condition in the EVC while in the IVC, three storage options were introduced: ice box (3 kg ice per box with about 25 kg fruit replenished every day); low-cost cold storage using the Coolbot chamber; or evaporative cooler (EC). Results revealed that without storage (direct marketing after harvest) total postharvest loss was about 14% in the EVC; this was remarkably reduced to 4% in the IVC. IVC fruit were also firmer, had higher soluble solids and much reduced microbial load than EVC fruit. No pesticide residue was detected in both EVC and IVC fruit. With the three-day storage, the three storage options in the IVC did not differ much in reducing postharvest loss to about 3-6% from 22% in the EVC. IVC fruit also ripened slowly resulting in higher firmness than EVC fruit. Other quality attributes were not affected. Vitamin C content was slightly higher in IVC fruit than in EVC fruit. From the results, there is potential for integrating postharvest management options in value chains to reduce postharvest loss and enhance quality of tomatoes.

Keywords *Solanum lycopersicum*, value chain improvement, farm-packhouse-market model, postharvest loss reduction

INTRODUCTION

Tomato (*Solanum lycopersicum*) is a major fruit-vegetable in Cambodia with production continually expanding as a result of the introduction of improved varieties and production techniques as well as increased market demand and entry of modern market outlets (e.g. supermarkets, hotels and restaurants) due to the flourishing tourism industry (Buntong et al., 2012). However, poor postharvest practices are a serious problem resulting in poor quality perception and high postharvest losses (Genova et al., 2006; AVRDC-The World Vegetable Center, 2016). Postharvest losses vary with type of produce, location, growing season and the value chain stage (Weinberger and Acedo, 2011; Acedo and Easdown, 2015). Postharvest losses of tomato in Cambodia were estimated at 11-35% in Kandal province (Genova et al., 2006), 23% in traditional and modern supply chains in Kandal and Kampong Speu provinces (Buntong et al., 2012) and 26% in Battambang and Siem Reap provinces (AVRDC-The World Vegetable Center, 2016). Aside from poor postharvest practices and the perishable nature of fresh produce, other factors contributing to losses include the fragmented and unorganized supply chains and the hot and humid tropical climate. Postharvest losses are often absorbed by farmers as reduced farm gate prices and by consumers through an increased purchase price. Postharvest losses contribute to Cambodia's high dependence on vegetable imports from Vietnam and Thailand estimated at about 80% of domestic consumption (Millar, 2017). As part of Cambodia's strategic priorities to achieve inclusive and sustainable development, domestic production and marketing of all kinds of vegetable are being promoted in order to substitute imports (Royal Government of Cambodia, 2018).

Postharvest losses have significant economic, social, and environmental consequences. Globally, food loss amounts to about one-third of total production valued at almost one trillion US dollars in annual economic losses; contributes to hunger and malnutrition; represents about 25% of water used by agriculture; requires cropland area the size of China; and generates about 8% of global greenhouse gas emissions (GHG) which is the third largest after China and USA (FAO, 2013; HLPE, 2014). Reducing postharvest losses is a global agenda embedded in the United Nations Sustainable Development Goal (SDG) 12.3 which targets reducing food waste including postharvest losses by 50% by 2030 (https://sustainabledevelopment.un.org/). About half of the global food losses can be prevented with a more efficient supply chain and the saved food can feed about one billion extra people, thereby reducing the pressure to raise more food to feed an additional two billion people by 2050. Postharvest technologies play a vital role toward this end and can enable developing countries to improve the quality and competitiveness of their horticultural produce in domestic and international markets as they integrate into the world economy and global value chains proliferate. Additionally in Cambodia, reducing postharvest losses could potentially contribute to vegetable import substitution and self-sufficiency.

Postharvest management (PHM) is vital to reduce postharvest losses and contribute to improved food and nutrition security through three different pathways: (1) increasing the availability of food at farm-gate and market level, (2) reducing the price of food and thus enhancing potential access, and (3) reducing the volatility and quality of food availability (Van Gogh et al., 2017). PHM also contributes to food safety which is the most critical dimension of food quality. If the quality has deteriorated to a level that the food is no longer safe for human health, the food needs to be removed resulting in quantitative food loss (Bin Liu, 2016). Economic revenues of improved PHM include both efficiency (positive benefit-cost ratio) and effectiveness (incentives for supply chain stakeholders to engage in PHM activities). Furthermore, PHM increases employment as farmers and other value chain agents are engaged in postharvest loss reduction activities. PHM can also reduce GHG emission and global warming.

A value chain approach on PHM is important to effectively reduce postharvest losses (Batt and Cadilhon, 2007; Van Gogh, 2017). It should target smallholders who are the dominant players in supply chains in developing countries including Cambodia; otherwise, they would be further disadvantaged and marginalized (Van der Meer, 2006; Chan, 2009). PHM can overcome the underperformance in postharvest chains in terms of the loss of quantity and quality of the harvested produce, and hence the loss of revenues and resources. Postharvest losses are not caused by one or two specific links in the chain but are the result of an entire value chain. Tackling these losses therefore requires a value chain approach rather than actions from a single stakeholder or a single solution approach. The value chain approach specifies that the costs incurred in specific parts of the chain to create the added value will be sufficiently compensated by the revenues from the entire value chain. PHM measures are stimulated when there is good prospect of obtaining the revenues in exchange for the costs and risk of investment.

Reducing postharvest losses is context specific, and strategies to developing competitive and sustainable value chains have to be tailored to the socioeconomic and ecological environment in which the value chain operates. The root causes of postharvest losses can be generalizable; however, the magnitude and causes of losses and the measures to reduce losses will differ with supply chain. Attempting one-size-fits-all approaches can create more challenges than they address. In improving value chains, PHM measures need to be tested before commercialization. For example, in the cabbage supply chain in Central Philippines, postharvest loss in the traditional chain was estimated at 34% and introduction of 3-4 wrapper leaf retention and plastic crate packaging at the farm level; 2-3 wrapper leaf retention, 15% alum treatment for bacterial soft rot control and plastic crate packaging prior to transport to market; and 15% alum treatment prior to retail reduced losses to 3%, 6% and 11%, respectively, or a total loss of 20% (Gonzales and Acedo 2016). In the modern chain involving supermarkets, total loss was 25%, and introduction of 3-4 wrapper leaf retention and plastic crate packaging at the farm level; 2-3 wrapper leaf retention, 15% alum treatment and plastic crate packaging prior to transport to market; and 15% alum treatment and individual plastic film wrapping prior to supermarket display reduced losses to 3%, 7% and 6%, respectively, or a total loss of 16%. With the introduction of the different PHM measures, net income and return on investment increased. In Cambodia's tomato traditional chain in Kandal province, improved packaging (20 kg capacity plastic crate with modified atmosphere packaging or MAP using 50 µm-thick low density polyethylene or LDPE), precooling (5 min dip in 5ºC water) and sanitizing (2 min dip in 200 ppm chlorine solution) at the farm level decreased fruit damage at the wholesale and retail stages and reduced weight loss at the retail stage by about two-fold compared to that of fruit conventionally packed in 20 kg capacity 50 µm-thick high density polyethylene (HDPE) and without precooling and chlorine treatments (Buntong et al., 2013). In the tomato modern chain in Kampong Speu province wherein only one intermediary (collector-wholesaler) was involved between farmers and supermarkets, MAP was only required, with 11 µm-thick film overwrap being more effective than LDPE in reducing weight loss and retarding fruit ripening.

In the present study, the existing value chain of tomato in Siem Reap province was improved by introducing selected PHM techniques in two scenarios, with and without storage options to simulate temporary holding prior to marketing and immediate marketing after harvest, respectively. Postharvest loss was quantified and fruit quality (physicochemical and food safety attributes) was determined.

OBJECTIVE

The study aimed to determine the effectiveness of selected PHM techniques in improved value chain in reducing postharvest loss and enhancing physicochemical quality of tomato and assess the comparative advantage of improved value chain over the existing value chain with and without a storage component.

METHODOLOGY

Tomato fruits cv. Mongal at the breaker to turning stage were sourced from local farms of farmer-members of a cooperative in Siem Reap. The harvested fruit were placed in plastic crates and hauled either to the farmers' house representing the existing value chain (EVC) or to the cooperative's simple packhouse located nearby representing the improved value chain (IVC). Ten kg fruit were used for each treatment per replicate. Three replications were used.

Experimental Trials Without Storage Component

In the EVC, after arrival at the farmers' house, tomatoes were packed in ordinary plastic bags at 10 kg fruit per bag without sorting or grading as usually practiced. The bags of fruit were then transported to Siem Reap city wet market using 'TukTuk' (motorcycle-driven rickshaw) about 12 km away or 30-45 min travel time. After the usual half day marketing period, the fruit were assessed for