Crop Protection 79 (2016) 97–104

Contents lists available at ScienceDirect

Crop Protection

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

Losses in litchi at various stages of supply chain and changes in fruit quality parameters

Vinod Kumar*, Sushil Kumar Purbey, Ajit Kumar Dubedi Anal

ICAR-National Research Centre on Litchi, Mushahari, Muzaffarpur, Bihar 842002, India

ARTICLE INFO

Article history:
Received 17 April 2015
Received in revised form
12 October 2015
Accepted 13 October 2015
Available online 28 October 2015

Keywords:
Fruit decay
Litchi chinensis
Quality parameters
Packaging
Postharvest loss
Supply chain

ABSTRACT

During May and June of 2012 and 2013, a study was conducted to assess losses at the farm, wholesale and retail levels in the supply chain of litchi in India. Changes in fruit quality parameters after harvest and the effectiveness of an improved corrugated fibre board (CFB) box versus conventional wooden box packaging to minimize postharvest losses were also studied. Farm-level samples were collected immediately after harvest from farmers' orchards in the Muzaffarpur district of Bihar state. Wholesale market samples were procured from the Delhi market, and retail samples from the Muzaffarpur and Delhi market. Real-time data on losses and quality parameters of fruits were recorded by transporting litchi from Muzaffarpur to Delhi (distance 1000 km) by truck. Studies indicated that the average loss (fruits discarded at sorting) apparent at the farm level during 2012 and 2013 was 30.4% and 25.8%, respectively. The average loss at the wholesale market level in Delhi was 15.8% and 12.4% during 2012 and 2013, respectively. The highest mean loss (up to 20.5%) was observed at the retail level. The mean fruit weight loss during transport to Delhi was 9.42% and 7.07% during 2012 and 2013, respectively. The mean total loss in the supply chain of litchi ranged from 35.3% to 43.8%. The total soluble solids, respiration and ethylene evolution in litchi fruits were found to increase after transport, whereas acidity and colour parameters (L^*, a^* and b^* values) significantly decreased over time. The predominant pathogen associated with fruit decay was *Alternaria alternata* (Fr.) Keissler. CFB packaging significantly reduced various losses, thus indicating its effectiveness in its current use in non-refrigerated trucks for transport.

1. Introduction

Litchi (*Litchi chinensis* Sonn) is a popular fruit in India due to its distinctive taste, pleasant flavour and appealing pinkish-red colour. These fruits are rich in vitamin C, niacin, riboflavin, thiamine, folate and β-carotene. They also contain minerals such as potassium, phosphorous, calcium, magnesium and copper. These low-calorie fruits contain no saturated fats or cholesterol, but are rich in dietary fibre and polyphenols. The demand for litchi fruits and its products continues to increase in both domestic and overseas markets. Litchi is a highly perishable fruit crop. Considerable losses of litchi fruits are incurred every year during harvesting, sorting, transportation and marketing, as its perishability is caused by great physiological changes after harvest (Momen et al., 1993). These changes include browning of the pericarp due to degradation of anthocyanins, which may be caused by pericarp polyphenol oxidase and peroxidase activities (Underhill and Critchley, 1995) accelerated by desiccation, mechanical injury and postharvest decay. These quantitative and qualitative losses in litchi fruits from the time of harvest to the final consumption not only reduce the availability of fruits but also increase the per-unit cost of transport and marketing.

India produces about 594,000 metric tonnes of litchi, of which Bihar contributes 45% (NHB, 2015). The Muzaffarpur district is one of the leading producers of litchi in Bihar. The majority of the litchi grown in Bihar is sent to the wholesale market at Delhi, from where it is transported to retailers. The supply chain of distant markets such as Delhi involves farmers–wholesalers–retailers–consumers, but local markets such as Muzaffarpur involve harvest-–retailers–consumers or preharvest contractors–consumers. The bulk of litchi fruits are transported to distant markets in non-refrigerated trucks. Although postharvest losses in litchi have been estimated in some reports, they have not been empirically assessed in the supply chain. Information on the extent and cause of losses at various levels of handling would be beneficial in

* Corresponding author.
E-mail address: vinod3kiari@yahoo.co.in (V. Kumar).

http://dx.doi.org/10.1016/j.cropro.2015.10.014
0261-2194/

minimizing them. Therefore, we assessed the magnitude of losses in litchi at the farm, wholesale and retail levels in the supply chain, as well as the change in quality parameters of the fruits after harvest until final consumption. We also evaluated an alternative, improved method of packaging compared with the conventional method currently used. The summary of this study is presented in this paper.

2. Materials and methods

2.1. Sampling at harvest, sorting, packaging and transport

The study was conducted at the National Research Centre on Litchi (NRCL), Muzaffarpur, in Bihar state of India during 2012 and 2013. The cultivar of litchi was 'Shahi', which normally matures around 22–30 May. Mature fruits are bright red in colour with flattened tubercles/protuberances on their surface. Samples were collected from farmers' fields in the Muzaffarpur district of Bihar. Twenty representative samples were collected during mid-harvesting season of every year. Each sample consisted of 100–150 fruits randomly taken from harvested fruit heaps immediately after harvest (unsorted lots). They were counted to assess the percent loss in different categories such as sunburn-damaged fruits, cracked fruits, cracked fruits with visible mould, fruits with mechanical damage, fruits with anthracnose (diseased), fruit-borer-infested fruits, fruits discarded during sorting and fruits discarded from the box as perceived by farmers (waste category of fruits rejected by farmers while being sorted and filled in the conventional wooden box (WB) package). After sampling, the fruits were sorted and packed in conventional WBs and in corrugated fibre board (CFB) boxes (seven-ply, dimension 55 × 28 × 25 cm, made up of 150 GSM virgin conifer kraft paper with 'C'-type flute), and then transported in open-top trucks from Muzaffarpur to the Azadpur wholesale market in Delhi (a distance of about 1000 km) for loss studies. The average minimum and maximum temperatures were 30–32 and 38–40 °C, and humidity 54.0 ± 2% and 72.0 ± 2% respectively, inside the truck during transport. Litchi bunches were packed tightly in conventional WBs with litchi leaves as cushioning material, while the litchi bunches in the CFB boxes were placed in individual, non-woven polypropylene bags (white-coloured 16 GSM fabric) with only few litchi leaves at the base of each box. Each WB package contained about 18 kg of fruits whereas the CFB box contained 15 kg of fruits. Harvesting, sorting and packaging were done before 12.00 PM, and loading in the truck was completed at 04.00 PM. The truck departed from Muzaffarpur around 8.00 PM and reached Delhi after about 35 h (i.e., on the second day). One WB of 18–20-kg capacity was priced about US$1.23, whereas one CFB box of 14–16-kg capacity was priced US$0.77.

2.2. Sampling and observations at wholesale and retail levels

Wholesale market samples collected from the Azadpur market in Delhi consisted of three categories: random samples from conventional WB packaging in the market, transported samples in conventional WB packaging and transported samples in CFB box packaging. The truck container was composed of nine tiers of either WB or CFB box packages. The samples were taken from different levels in the vertical stack of the container (first, third, fifth, seventh and ninth tier) at the point of truck arrival. Although 5 kg of fruit sample was drawn from random lots in the wholesale and the retail market, a complete package of litchi transported from Muzaffarpur was considered for the loss studies. Fifteen samples were studied at both the wholesale and retail levels. The retail samples were collected from 15 vendors (one sample from each vendor) at different places in the Delhi and Muzaffarpur market after 72 h from the time of harvest. We observed percent losses on weight basis in various categories: bruised and compressed fruits (mechanical loss), fruit decay such as infection with visible mould growth (pathological loss), browning and mean fruit weight loss (FWL). Pericarp browning was visually assessed based on the browning observed on the percent surface area of individual fruits and categorized as either low (<50% browning) with acceptable marketability or high (>50% browning) with limited marketability. FWL was determined using a precision balance. Pathogens causing fruit decay were isolated on potato dextrose agar medium. They were identified based on colony characteristics and microscopic observations, which were confirmed by a former mycologist at the Indian Type Culture Collection, New Delhi.

2.3. Evaluation of fruit quality parameters

The quality parameters of fruits were based on the concentration of total soluble solids (TSSs), titratable acidity (TA), respiration rate, ethylene evolution and pericarp colour (L^*, a^* and b^* values). These parameters were measured in replicates at three time intervals: immediately after harvest (0 h), and after transportation to Delhi at 48 and 72 h from harvest. Measurements were conducted on four randomly selected fruits per replicate per treatment. The TSS content of the juice was measured using an automatic digital refractometer and expressed as degrees Brix (°Bx). TA was determined by titration with 0.1 N NaOH in the presence of a phenolphthalein indicator and expressed as the percentage of malic acid, the predominant organic acid in litchi fruits. The respiration rate was measured by an auto-gas analyser (Model: Checkmate 9900 O_2/CO_2, PBI Dansensor, Ringsted, Denmark) and expressed in millilitres of CO_2 per kilogram per hour. A gas chromatograph (HP 5890 Series II) equipped with a flame ionization detector, a Porapak-N 80/100 mesh-packed stainless steel column and an HP integrator was used to determine the ethylene content. The pericarp colour was measured at four different points around the equatorial region of each fruit using a colorimeter (Miniscan XE PLUS, Hunter Associates Laboratory, Inc., Reston, VA, USA) and expressed in L^*, a^* and b^* colour space coordinates (CIELAB).

2.4. Statistical analysis

The mean and range were computed for the data on various losses, whereas a two-factor analysis of variance (ANOVA) using a completely randomized design (CRD) was conducted with SAS® 9.2 statistical software for the data on quality parameters. The least significant differences (LSDs) between means at $p = 0.05$ and the standard error (SE) of means were computed.

3. Results

3.1. Losses at harvest (farm level)

During 2012, the data on the mean and range of various losses at the farm level (Fig. 1) indicated that losses due to sunburn, cracking and physical or mechanical damage during harvesting were 1.5–44.5% (mean 14.9%), 0.5–14.0% (mean 5.9%) and 0.0–17.5% (mean 7.6%), respectively. In some cracked fruits, a visible green mould colonization (up to 1.0%) mainly of *Aspergillus flavus* was observed. The incidence of fruit borers (up to 5.0%) and diseased fruits (anthracnose) was low (up to 10.0%). During 2013, the losses due to sunburn cracking and physical or mechanical damage during harvesting were 4.0–27.0% (mean 10.4%), 0.0–14.0% (mean 3.8%) and 3.0–15.0% (mean 8.1%), respectively. Further, a low incidence of visible mould colonization in cracked fruits (up to 2.5%), fruit borer infestation (up to 5.0%) and anthracnose disease (up to 5.0%) was