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MINIMIZING TRANSPORTATION LOSSES IN FRESH FIG (*Ficus carica* L.) FRUITS

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Abstract: The study was undertaken to measure the damage to packaged fig (*Ficus Caria L.*) during transportation and consequent storage. The data presented in this study will assist farmers and packaging material designers in selection of packaging materials to reduce damage in transit. Fresh harvested fig fruits at commercial maturity free from bruises and injury were packed in CFB boxes of 10 kg capacity with internal packaging materials *viz.* newspaper lining, polyethylene foam, polyurethane foam. The packaged fruits were transported for transportation distance of 500 km. After transportation fruits were observed for physiological loss in weight, total soluble solids, firmness and decay loss at room temperature. The results showed that the per cent of damaged fruits differed significantly with different packaging materials. As expected, based on previous work, fruit damage was found to be more in the CFB box with paper lining. Fruits packed in polyurethane foam were more firm with reduced increase in TSS. The results showed that a minimum amount of damage occurred in CFB box with polyurethane compared to all other packaging materials. Decay loss of the fruits was also low in CFB box with polyurethane foam followed by polyethylene foam after five day of storage.

Key words: *fig, packaging material, transportation, losses.*

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INTRODUCTION

Fig (*Ficus carica L.*) belongs to the family *Moraecae* and is the native of Southern Arabia. Its mention has been made as early as 2900 B.C. by King *Urukagina* for its medicinal use. The world's area and production of fig fruit recorded for the year 2009 are 4,53,622 ha, and 11,83,248 tones, respectively. India stands 12th in the world for production of fig (20,700 tonnes) from an area of 6000 ha. Its commercial production is limited to a few pockets of Maharashtra and Karnataka [1]. In Karnataka it is cultivated on commercial scale in northern districts *viz.,* Bellary, Raichur, Gulbarga and Koppal. The total area under fig cultivation is 1498 ha with production of 13,643 tonnes. Bellary (1078 ha and 9234 tonnes) ranks first in area and production followed by Koppal (96 ha and 1178 tonnes), Raichur (78 ha and 1092 tonnes) and Gulbarga (115 ha and 867 tonnes).

The post-harvest losses of fruits and vegetables are high in tropical countries particularly in India and it is in the range of 15-40 %. Fruits and vegetables are subjected to different types of mechanical forces during harvesting, storage and transportation. These forces are impact, vibration, and abrasion, compression, bruising and cut by sharp edge. Vibration injury may cause only one of these damages, or all three. Various studies have been carried out to assess the effects of these stresses on fresh fruits [2]. The total loss of fresh fruits and vegetables during transportation and distribution has been estimated to be 30 % in China [3] whereas 20 % of grains harvested gets spoiled every year [4]. Damage caused by transport vibration was assessed on different species of fruits and vegetables, such as cling peaches, apricots [5], pears [6], apples and tomatoes [6] and potatoes [7].

Fig is one of the most perishable climacteric fruit. To obtain optimum flavor, fig fruit should be harvested when almost fully ripe. However, at this stage, it is soft and susceptible to deterioration [8], limiting post-harvest life to 2 days under ambient and 7 to 14 days under refrigeration condition [9]. Softening and post-harvest diseases limit the storage period and shelf life of figs. Very little research has been done to identify the suitable packaging materials for minimizing the transportation losses and extending post-harvest life of fresh figs. An investigation on effects of vibration and packaging materials on three important fig varieties grown in Turkey showed that packaging materials affected vibration injury of fruit. In local transportation, cardboard boxes were more suitable for transportation than wooden ones [10]. The most important cause of deterioration is incidence of microbial molds and rots that take advantage of the easily damaged epidermis and the high sugar content of figs.

The protection of fig fruits quality in the value chain from harvesting to market is very important. Vibration often causes some damage to the perishable fruits in transportation and reduces their quality [11]. The fruit injury due to vibration is related to the transportation characteristics of vehicles, packaging boxes and the condition of the roads [2]. Sommer (1957b) [12] attempted to prevent transit injury to Bartlett pears by packing the pears in protective materials such as shredded paper, shredded polyethylene film, and 1 in. polyethylene film disks. Sommer found that these materials reduced but did not prevent transit injury. Schulte Pason *et al*. (1990) [13] studied impact bruise damage of apples packed in polyethylene bags, and pulp or foam tray containers for transportation distances up to 584 km (363 mi). Schulte Pason observed upon arrival that the number of unbruised apples packed in bags were greater than those packed in pulp trays and were less than those packed in foam trays. Shulte Pason [13] also found that the number of impacts greater than 20 g were highly correlated to the percent of bruised apples. In contrast it have observed that the skin of Bartlett pears can be severely discolored when vibrated at acceleration levels slightly above 1 g for periods as short as 30 min [14].

Lack of information on post-harvest handling of fig fruits has resulted in huge losses to the tune of 20 to 30 % to the farmers and traders thereby making the fig production uneconomical. Principal causes for post-harvest losses are infection by pathogens, rough handling, improper packaging, mode of transportation and unhygienic storage condition. It is estimated that total losses due to spoilage ranges from 30 to 40 %. In this context, there is a pressing need to identify a suitable packaging system that protects fresh figs against mechanical injuries during post-harvest handling, transportation and storage.

MATERIALS AND METHODOLOGY

Fig fruits (*Poona* variety) at commercial maturity were hand harvested from the orchard located at Shrinivas Nagar village of Bellary district. Bruised and injured fruits were discarded and sound fruits were selected.

Sorted good quality fruits were packed in seven different kind of internal packaging materials *viz.* newspaper lining, paper shavings, polyurethane foam sheet. Packaging materials and their treatments are given below and depicted in Figs. 1, 2 and 3.

P_1 - CFB box with newspaper lining (Control)

P_2 - CFB box with polyethylene foam sheet.

P_3 - CFB box with polyurethane foam sheet.

Figure 1. CFB box with newspaper lining (Control)

Fresh fig fruits having almost same size and without any damage or skin disorders were selected and labelled for observing different responses. One set of 30 fruits were labelled for estimation of physiological loss in weight (*PLW*), another set of 20 fruits for visual observations to estimate decay loss. The labelled fruits were randomly placed in the CFB box.

Figure 2. CFB box with polyethylene foam

Figure 3. CFB box with polyurethane foam

Packed fruits were loaded in transport vehicle and transported for 500 km transportation distances. After transportation fruits were stored at ambient condition and were observed immediately after one day of transportation. Physiological loss in weight (*PLW*) and decay loss of the fruit was estimated during the storage of fresh fig fruits up to complete spoilage of fruits.

Determination of physiological loss in weight (*PLW*)

Observations were recorded every day in respect of the physiological loss in weight of fruits. The weights of the fruits were measured by using a weighing balance of ±0.001g accuracy. Physiological loss in weight was expressed as per cent loss in weight using the formula given below [15].

$$WL = \frac{IFW - OFW}{IFW} \cdot 100 \tag{1}$$

Where:

WL [%] - loss in weight,

IFW [g] - initial weight of fruits,

OFW [g] - weight of fruits on the day of observation.

Firmness

The firmness of the fig fruit was determined using the Texture Analyzer (Make: Stable Micro System; Model: Texture Export Version 1.22). Penetration tests with the help of texture analyzer was used to measure the firmness of fig [16]. The following instrument settings were used during the experiment:

- Type of probe used - 5 mm cylindrical probe
- Test module - Measure force of penetration
- Test option - Return to start
- Pre-test speed - 5.0 $mm \cdot s^{-1}$
- Test speed - 1.0 $mm \cdot s^{-1}$
- Post-test speed - 10.0 $mm \cdot s^{-1}$
- Distance - 10 mm
- Trigger force - 25 g
- Load cell - 5 kg

Three fruits from each treatment were analysed for the firmness. Penetration test was carried out at three different positions on the fruit. After running the test, the force required to penetrate into the fruit for given distance was directly obtained from the data recorder (Computer). Finally, the averages of three fruits from each treatment and replicate and at three different positions were taken as the firmness of fig fruit in that treatment [17].

Estimation of decay loss

The fruits were observed for decay loss every day till complete spoilage of fruits occurred during storage. The decay loss due to bruising was calculated by using the following equation.

$$DL = \frac{DF}{TF} \cdot 100 \tag{2}$$

Where:

DL [%] - decay loss,
DF [-] - number of decayed fruits,
TF [-] - total number of fruits in the cartoon box.

RESULT AND DISCUSSION

The fig fruits were inspected and observation on physiological loss in weight (PLW), Firmness and decay loss. Data was recorded according to the methodology described earlier and presented in Tab. 1.

In the present experiment, the fig fruits showed a gradual increase in the physiological loss of weight with advancement of the storage period in all the treatments, irrespective of packages used. The peak surge in PLW coincided with ripening of fruits. This is mainly attributed to the continuous loss of moisture and other nutrients as the fruits are alive and are actively involved in the physiological processes like respiration and transpiration [18]. Among the packaging materials used, physiological loss in weight of fresh fig fruits was recorded maximum in *CFB* box with newspaper lining. After third day of transportation, maximum weight loss of 17.15 % was observed in in P_1 (*CFB* box + newspaper lining). P_3 (*CFB* box + polyurethane foam sheets) and P_2 (*CFB* + polyethylene foam sheets) recorded minimum physiological loss in weight (14.15 % and 15.33). On the last day of storage (Fig. 1) P_3 (*CFB* box + polyurethane foam sheets) recorded minimum physiological loss in weight (28.65 %).

Table 1. Effect of transportation on fresh fig fruits

Storage days	*PLW*			*Firmness*			*Decay*		
	P1	*P2*	*P3*	*P1*	*P2*	*P3*	*P1*	*P2*	*P3*
Day 1	*6.85*	*5.88*	*5.55*	*3.28*	*3.76*	*4.01*	*25.63*	*16.50*	*10.20*
Day 3	*17.15*	*15.33*	*14.15*	*2.74*	*3.11*	*3.20*	*68.75*	*68.25*	*31.25*
Day 5	*31.44*	*29.74*	*28.86*	*1.31*	*1.50*	*1.80*	*100.00*	*86.88*	*65.60*
C. V.	*3.75*			*3.49*			*3.60*		

P1 - CFB box with newspaper lining (Control)
P2 - CFB box with polyethylene foam
P3 - CFB box with polyurethane foam sheet

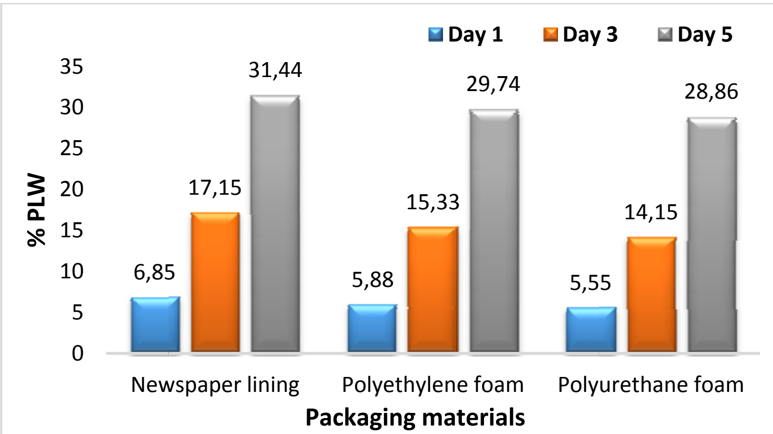

Figure 1. Effect of transportation on physiological loss of fresh fig fruits

Mechanical damage increases the respiration rate [19]. Sommer [12] found that vibration damaged fruit loses moisture more rapidly than undamaged fruit, further reducing the quality of the injured fruit. The higher respiration rate resulted in higher transpiration of water from the fruit surface which led to increase in percentage of weight loss [20]. Therefore as the PLW of fresh fig fruits in P_3 (*CFB* box + polyurethane foam sheets) is minimum it shows the minimum mechanical damage to the fruits and hence the cushioning property of polyurethane foam protects the fruits during transportation.

Effect of different packaging materials for transportation on firmness of the fresh fig fruits during storage at ambient condition are presented in Tab. 1. Polyurethane foam protected the fruits from vibration. More heavily injured fruits had a higher rate of softening during storage at ambient temperature [5]. It was also observed from the Fig. 2, that the firmness of the fig fruits decreased with the duration of the storage period.

The highest and lowest values of firmness were noted for the fresh fig fruits and the samples from the last day of storage respectively. The decrease in fruit firmness was mainly due to ripening during storage period [21]. Similar losses in firmness due to ripening have been reported in six melon cultivars during storage [22].

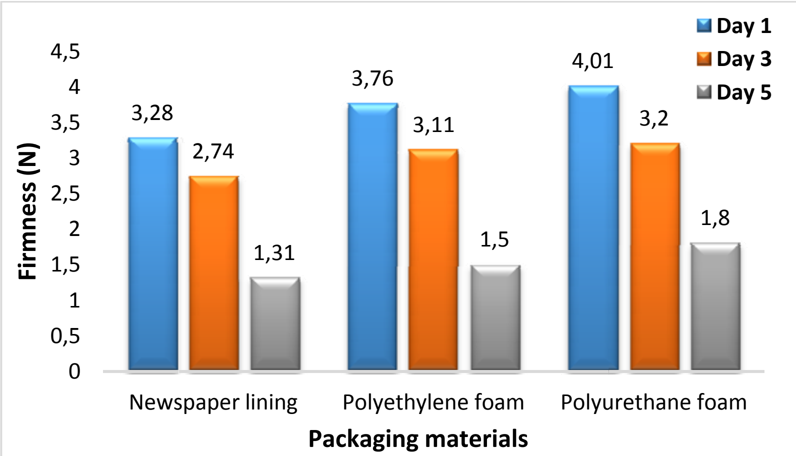

Figure 2. Effect of transportation on firmness of fresh fig fruits

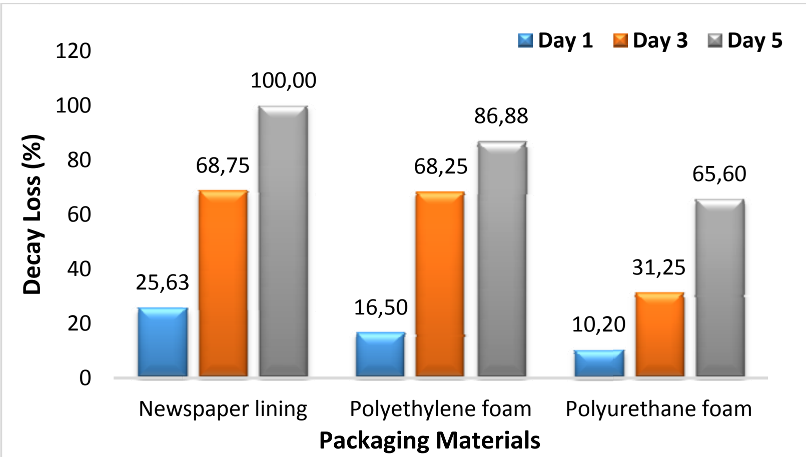

Figure 3. Effect of transportation on decay loss of fresh fig fruits.

The decay loss of fresh fig fruits (Tab. 1) during storage (after transportation) was high in *CFB* box with newspaper lining. Minimum decay loss (Fig. 3) was observed in the fruits packed and transported in *CFB* box with polyurethane foam sheet. During transportation, chances of occurrence of mechanical damage may be higher as the fruits are highly perishable with thin skin and are highly pulpy. Fig fruits are subjected to various types of mechanical forces during transportation [2]. Fig fruits are affected by various post-harvest diseases caused by *Alternaria alternate, Botrytis cinerea, Rhizopus* *stolonifer, Fusarium flocciferum and Cladosorium herbarum* [23]. Hence decay loss is found to be maximum during storage. For the initial days, per cent decay loss was maximum for the fruits packed in *CFB* box with newspaper lining than other packaging materials. On the third day of storage, maximum per cent decay loss was observed for the samples stored in *CFB* box with newspaper lining (68.75 %) fallowed by the fruits packed in *CFB* box with polyurethane foam (68.25 %). The minimum maximum per cent decay loss was observed for the samples stored in *CFB* box with polyethylene foam.

CONCLUSION

Study showed that the transportation packaging materials have significant difference on the transportation losses of fresh fig fruits. More damaged fruits (samples from control packaging material) showed maximum loss in weight and decay loss than less damaged (samples from spongy packaging material) fruits. Packaging materials which having cushioning property protected the fruits from vibration damage.

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STUDIJA MOGUĆNOSTI SMANJENJA GUBITAKA PRILIKOM TRANSPORTA SVEŽE SMOKVE (*Ficus carica* L.)

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Sažetak: U ovoj studiji su utvrđeni gubici koji nastaju prilikom pakovanja, transporta i skladištenja svežih smokvi (*Ficus Caria L.*) Rezultati studije će pomoći farmerima i dizajnerima materijala za pakovanje prilikom odabira odgovarajućeg načina pakovanja kako bi umanjili gubitke u transport. Sveže urbani plodovi smokve se neoštećeni pakuju u *CFB* kutije, u pakovanjima po 10 kg, pri čemu se unutar pakkovanja odvajajau listovima papira, polietilenskom ili poliuretanskom penom. Pakovano voće se potom transportuje u proseku 500 km do odredišta. Na odredištu se plodovi smokve ispituju, pri čemu se obraća pažnja na gubitak u težini, rastvorljivosti suve materije, čvrstoći i kaliranju proizvoda na sobnoj temperaturi. Rezultati ukazuju na to da količina oštećenih plodova bitno zavisi od vrste materijala pakovanja. Oštećenje plodova pakovanih u *CFB* kutije i razdvajanaih papirom je najveće. Plodovi pakovani u poliuretanskoj peni su u čvršći sa sporijim povećanjam *TSS* vrednosti. Rezultati pokazuju da su minimalno oštećeni proizvodi pakovani u *CFB* kutije sa poliuretanom u poređenju sa ostalim načinima pakovanja. Takođe, najmanje su kalirali proizvodi upakovani u *CFB* kutije sa poliuretanom.

Ključne reči: *smokva, materijal pakovanja, transport, gubici*

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