International Journal of Farm Sciences **4(3)** : 100-109, 2014

Transportation losses in fresh fig (*Ficus Carica* L) fruits

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ABSTRACT

The purpose of this study was to measure the damage to packaged fig (*Ficus Caria* L) fruits after transportation. The data presented in this study may assist farmers and package 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 packaging materials with CFB boxes of 10 kg capacity viz newspaper linings, paper shavings and polyurethane. The packaged fruits were transported to distances of 150, 300 and 500 km. After transportation fruits were observed for physiological loss in weight, TSS, firmness and decay loss. 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 boxes with paper lining. 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 after five days of storage.

Keywords: Fig (*Ficus Carica* L) fruits; packaging material; transportation; losses

INTRODUCTION

The post-harvest losses of fruits and vegetables are high in tropical countries particularly in India and these are in the range of 15-40 per cent. Fruits and vegetables are subjected to different types of mechanical forces during harvesting, storage and transportation. These forces are impact, vibration, abrasion, compression, bruising and cut by sharp edges. Vibration injury may cause only one of these damages or all three (Shahbazi et al 2010). Various studies have been carried out to assess the effects of these stresses on fresh fruits (Cakmak et al 2010). The total loss of fresh fruits and vegetables during transportation and distribution has been estimated to be 30 per cent in China (Zhang 2000).

Damage caused by transport vibration was assessed on different species of fruits and vegetables such as cling peaches (O'Brien et al 1965) apricots

(O'Brien and Guillou 1969), loquats (Barchi et al 2002*)*, grapes and strawberries (Fischer et al 1992), pears (Zhou et al 2007*)*, apples and tomatoes (Singh and Singh 1992) and potatoes (Grant et al 1986, Turczyn et al 1986).

Fig is one of the most perishable climacteric fruits (Marei and Crane 1971). To obtain optimum flavour fig fruit should be harvested when almost fully ripe. However at this stage it is soft and susceptible to deterioration (Pantastico et al 1975) limiting post-harvest life to 2 days under ambient and 7 to 14 days under refrigeration condition (Tsantili 1990). 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 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 (Alayunt et al 2000).

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 (Sommer 1957a). The fruit injury due to vibration is related to the transportation characteristics of vehicles, packaging boxes and the condition of the roads (Cakmak et al 2010). Sommer (1957b) attempted to prevent transit injury to Bartlett pears by packing the pears in protective materials such as shredded paper, shredded polyethylene film and in polyethylene film disks. Sommer found that these materials reduced but did not prevent transit injury. Schulte Pason et al (1990) studied impact of bruise damage of apples packed in polyethylene bags and pulp or foam tray containers for transportation distances up to 584 km. They also observed that upon arrival 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. They also found that the number of impacts greater than 20 g were highly correlated to the per cent of bruised apples. In contrast Guillou et al (1962) and Slaughter et al (1993) 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.

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.

MATERIAL and METHODS

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 kinds of internal packaging materials viz newspaper lining, paper shavings and polyurethane foam sheet. Packaging materials and their treatments are given below and depicted in Plate I, II and III.

P_1- CFB box with newspaper lining (control)
P_2- CFB box with paper shavings
P_3- CFB box with polyurethane foam sheet

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 was labelled for estimation of physiological loss in weight (PLW), set of 30 fruits for firmness and one more set of 20 fruits for visual observations to estimate decay loss. The labelled fruits were randomly placed in the CFB box.

Packed fruits were loaded in transport vehicle and transported for three distances, viz 150, 300 and 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), TSS, firmness 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 weight of the fruits was 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 (Kumar 2007):

$$\% \text{ loss in wt} = \frac{\text{Initial wt of fruits (g)} - \text{wt of fruits on day of observation}}{\text{Initial wt of fruits (g)}} \times 100 \quad \ldots\ldots(1)$$

Total soluble solids (TSS)

The total soluble solids of fresh fig fruit juice (pulp) is the summation of all the solids dissolved in water viz sugar, salts, protein, acids etc. Total soluble solids were determined by using hand refractometer at room temperature by placing drop of pulp on absolutely dry refractometer (0-32°Brix). The ÚBrix scale expresses the concentration percentage of the soluble solids content of a sample. Three fruits from each treatment were analyzed for the TSS.

Firmness

The firmness of the fig fruit was determined using the Texture Analyzer (Make: Stable Micro System, Model: Texture Export Version 1.22). Penetration test with the help of texture analyzer was used to measure the firmness of fig. 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/s
Test speed	:	1.0 mm/s
Post-test speed	:	10.0 mm/s
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.

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 (Kumar 2007):

$$\% \text{ decay loss} = \frac{\# \text{ of decayed fruits}}{\text{Total } \# \text{ of fruits in the carton box}} \times 100 \qquad \ldots(2)$$

Statistical analysis

Data obtained in triplicate was analysed in two factorial CRD.

RESULTS and DISCUSSION

The fig fruits were inspected and observations on physiological loss in weight

(PLW), total soluble solids, firmness and decay loss were recorded.

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 (Biale et al 1960). 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 per cent was observed in in P_1 (CFB box + newspaper lining). P_3 (CFB box + polyurethane foam sheets) recorded minimum physiological loss in weight (14.15%). On the last day of storage (Table 1, Fig 1) P_3 (CFB box + polyurethane foam sheets) recorded minimum physiological loss in weight (28.65%). Mechanical damage increases the respiration rate (Domingo et al 2004). Sommer (1957b) 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 (Sammi and Masud 2007). Therefore as the PLW of fresh fig fruits in P_3 (CFB box + polyurethane foam sheets) was minimum it shows the minimum mechanical damage to the fruits and hence the cushioning property of polyurethane foam protects the fruits during transportation.

It can be observed from the table that initial average TSS of fresh fig fruits was 14.38°Brix. Total soluble solids of fresh fig fruits increased with advancement of storage life irrespective of packaging materials and transportation distances. TSS of fresh fig fruits was affected significantly by transportation distance (Table 2, Fig 2). Total soluble solids of the fruits recorded reduced change for D_1 (150 km) than D_2 (300 km) and D_3 (500 km). Packaging materials also affected the TSS of fresh fruits significantly. The minimum values of TSS (14.98°Brix) was observed in P_3 for 150 km transportation distance. Whereas the maximum value of TSS (17.02°Brix) was observed in P_1 packaging for 500 km transportation distance. On third day of storage and for 500 km transportation distance TSS content values of fruits stored in P_1(18.71°Brix) was more than (18.43° Brix) in P_3. However the fruits stored in CFB box with newspaper lining were spoiled and hence their shelflife study was not done.

Effect of different packaging materials for transportation on firmness of the fresh fig fruits during storage at ambient condition are presented in Table 3. Polyurethane foam protected the fruits from

Table 1. Effect of transportation on physiological loss in weight (PLW) of fig fruits

Packaging material	Newspaper			Newspaper shavings			Polyurethane foam		
Transportation distance (km)	150	300	500	150	300	500	150	300	500
Day 1	5.26	6.44	6.85	5.15	5.76	6.31	4.56	4.86	5.55
Day 3	12.55	14.56	17.15	12.5	14.25	16.72	10.86	12.41	14.15
Day 5	28.72	29.99	31.44	28.89	28.89	30.1	21.05	25.63	28.86
CV		3.84			3.85			3.87	

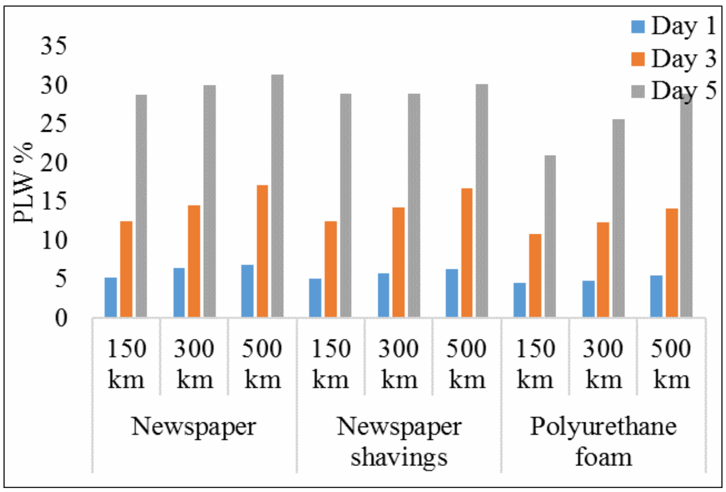

Fig 1. Effect of transportation on PLW fig fruits

vibration. More heavily injured fruits had a higher rate of softening during storage at ambient temperature (Zhou et al 2007). It is also observed from the Fig 3 that the firmness of the fruits decreased with the duration of the storage period. The highest and lowest values of firmness were noted for the fresh fruits and the samples from the last day of storage respectively. The decrease in fruit firmness was mainly due to ripening during storage period (Blazkova et al 2002). Similar losses in firmness due to ripening have been reported in six melon cultivars during storage (Miccolis and Saltveit 1995).

The decay loss of fresh fig fruits (Table 4) during storage (after transportation) was high in CFB box with newspaper lining. Minimum decay loss (Fig

Table 2. Effect of transportation on TSS of fig fruits

Packaging material	Newspaper			Newspaper shavings			Polyurethane foam		
Transportation distance (km)	150	300	500	150	300	500	150	300	500
Day 1	15.18	15.78	16.18	15.18	15.78	16.18	14.98	15.38	15.78
Day 3	17.54	18.11	18.71	17.54	18.11	18.71	16.36	16.9	18.43
Day 5	19.5	18.91	18.91	19.5	18.91	18.91	19.4	17.78	17.98
CV		3.25			3.26			3.28	

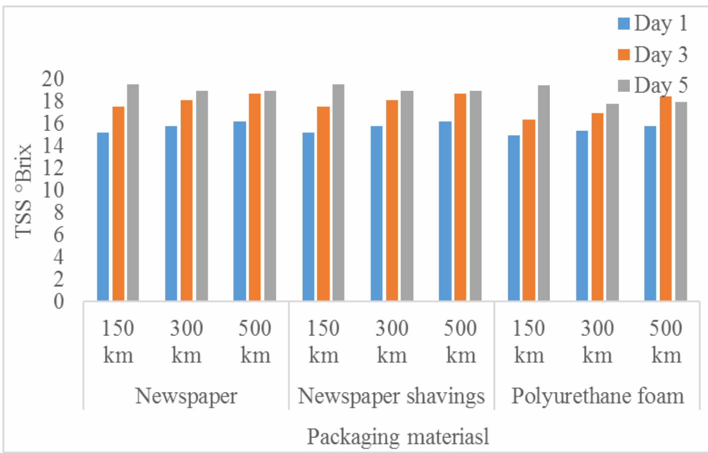

Fig 2. Effect of transportation on TSS of fig fruits

4) 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 (Cakmak et al 2010). Fig fruits are affected by various post-harvest diseases caused by *Alternaria alternate, Botrytis cinerea, Rhizopus stolonifer, Fusarium flocciferum and Cladosorium herbarum* (Montealegre et al 2000). 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%) followed by the fruits packed in CFB box with paper shavings (60.62%). The minimum per cent decay loss was

Table 3. Effect of transportation on firmness of fig fruits

Packaging material	Newspaper			Newspaper shavings			Polyurethane foam		
Transportation distance (km)	150	300	500	150	300	500	150	300	500
Day 1	4	3.78	3.28	4.04	3.81	3.49	4.23	4.09	4.01
Day 3	3.27	3.1	2.74	3.43	3.24	3.11	3.73	3.45	3.2
Day 5	1.94	1.69	1.31	1.73	1.73	1.45	2.8	2.58	1.8
CV		3.34			3.36			3.31	

Table 4. Effect of transportation on decay of fig fruits

Packaging material	Newspaper			Newspaper shavings			Polyurethane foam		
Transportation distance (km)	150	300	500	150	300	500	150	300	500
Day 1	7.5	16.92	25.63	0	10	11.25	0	0	10.2
Day 3	53.25	58.5	68.75	32.6	43.75	60.62	20.75	23.63	31.25
Day 5	100	100	100	99.33	100	100	84.6	95.6	99
CV		3.82			4.21			4.63	

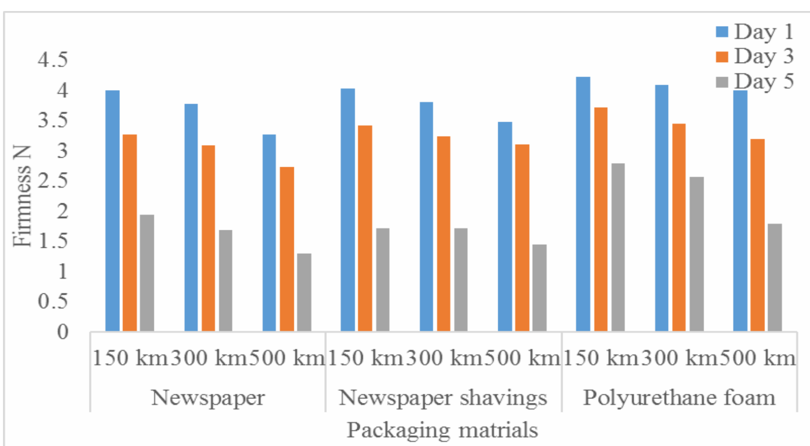

Fig 3. Effect of transportation on firmness of fig fruits

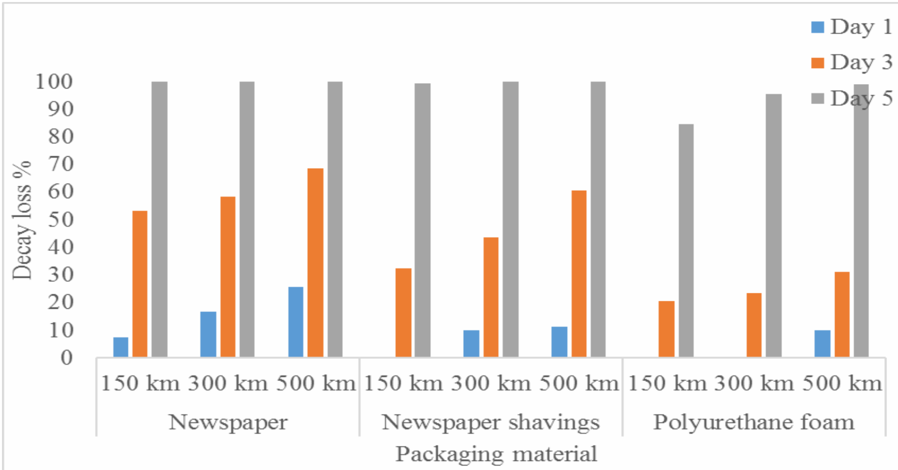

Fig 4. Effect of transportation on decay loss of fig fruits

observed for the samples stored in CFB box with polyethylene foam.

CONCLUSION

Study showed that the packaging materials had significant difference on the losses in fresh fig fruits during transportation. More damaged fruits (samples from control packaging material) showed maximum loss in weight, TSS and decay loss and loss of firmness than less damaged (samples from spongy packaging material) fruits. Packaging materials having cushioning property protected the fruits from vibration damage. Polyurethane foam can be used as best packaging material during transportation of fresh fig fruits.

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Receieved: 24.4.2014 ***Accepted: 17.7.2014***