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Quality response of jujube (*Zizyphus jujuba*) varieties to different packing materials

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Abstract

This study was conducted during 2015-16 to determine the quality response of two jujube varieties (Gola Lemai and Gola White) to different packing materials (wooden crate, paper box and plastic bag) and physico-chemical properties before and after six days of storage under room temperature. The jujube fruits were obtained from the orchard of Jujube Research Station, Agriculture Research Institute, Tandojam. The samples of jujube fruits were brought to the laboratory at the Department of Horticulture, Sindh Agriculture University Tandojam for analysis. The results indicated that the moisture, pH and weight of fruits packed in plastic bags was higher than those packed in wooden crate and paper box, but TSS and specific gravity was lowest; while on the other hand in wooden crate and plastic box, the fruits after six days of storage had higher TSS and specific gravity than those packed in plastic bags. Among varieties, Gola Lemai proved to be better in all the physico-chemical properties investigated as compared to Gola White.

Keywords: Jujube, varieties, postharvest, packing materials, physico-chemical properties

Introduction

Jujube, *Zizyphus jujuba* Mill., is a tree in the Rhamnaceae family originated in China and South Asia and extensively produced in temperate regions including Pakistan, China, Syria, India, Malaysia and Australia (Yoo & Li, 2011). In Pakistan, the jujube is commercially produced in Sargodha, Lahore, Multan, Khairpur and Hyderabad, Divisions. Hyderabad division is well known for production of quality fruit of jujube and most of the jujube fruit produced in Hyderabad is exported to Middle East. Among jujube varieties, Soofi, White Gola, Kheerol and Sanghri are common and White Gola is of two kinds (Green lemai and Golden white). White Gola is an early jujube variety while Green lemai matures bit late. In past generally the jujube fruits were available only for one month of March; but with the commencement of grafted varieties the jujube fruits are available from December to April (Khushk, 2002). The 100g edible

fruit portion of jujube contains 350 calories, 7.3g protein, 1.2g fats, 84g carbohydrate, 4g fiber, 3g ash, 130mg Ca, 168mg P, 3.5mg Fe, 12mg Na, 1050mg K, 125 mg vitamin A , 0.1mg vitamin B_1, 0.18mg vitamin B_2, 2.8mg vitamin B_6 and 300mg vitamin C . Jujube is not only a delicious fruit, but it also acts as herbal remedy, aids weight gain, improves muscular strength and increases stamina (Wonder, 2001).

Postharvest management of jujube fruit in organic form is most important step, because fruit is to be transported to other parts of the country and export as well (Bahadur *et al*., 2006). So proper packaging is of great significance to maintain the fruit quality and avoid injury during transportation and during storage (Mathooko & Kiniiya, 2002). Similarly, packing materials have great impact on the product being transported and storage. The packaging and packing materials should be described for their functions, uses, and limitations by commodity (Min *et al*., 2011 and Sanz *et al*., 2000).

The role of packaging is very important in post harvest operations of horticultural crops but its role is still underestimated in the country. Use of suitable materials for packaging has significance with a purpose to extend storage life of the fruit (Saini *et al*., 2010). Ayhan *et al.* (2001) reported significant effects of packaging materials on fruits and prolonged shelf life and storage quality; while Berlinet *et al*. (2003), Chumillas *et al*. (2007), Polydera *et al*. (2003) were of the opinion that fruit weight loss can be minimized with improved packing materials and storage conditions. Torres *et al.,* (2008) reported that the increase in pH value of the storage fruits means increasing acidity and spoilage of fruit due to poor quality storage conditions. Sumanjit & Singh (2009) reported considerable changes in the TSS levels of fruits under storage conditions with prolonging storage duration. Rab *et al*. (2010) reported that TSS increased with increase in storage duration. Haugaard *et al*. (2011) reported that wooden crates and paper boxes were suitable packing for storage oranges to maintain their market quality for a longer duration. Patel, *et al.,* (2012) and Sanz *et al*., (2000) reported that the ash content may vary in citrus fruits due to varieties and storage quality.

After harvesting of fruits, packaging is a very challenging aspect of farming. There are several types of packing materials for fruits like jujube, such as: different types of paper bags, plastic bags, cardboard boxes, baskets and plastic netting (Grierson, 1997 and Sanz *et al*., 2000). The storage is essential for extending the consumption period of fruits, regulating their supply to the market and also for transportation to long distances. The best organoleptic qualities were observed up to 8 days in mature yellow fruits stored at room temperature in perforated polyethylene bags. Similarly, packing materials have significant effect on horticultural commodities and particularly on the perishable fruits like jujube. The packaging is prepared from different materials such as wood, paper, plastic, etc. and the fruits response to the packaging from these materials differentially (Morton, 1997). Keeping in view the importance of jujube fruits and trend of consumption in Pakistan, the present research was carried out to determine the effect of packing materials on the fruit physico-chemical characteristics of jujube varieties Gola Lemai and Gola Achri (White) at different storage periods at Tandojam.

Materials and Methods

In order to investigate the effect of packing materials on the post harvest quality (physico-chemical properties) of jujube, the laboratory experiment was conducted during 2015-2016. The jujube fruits were obtained from the orchard of Jujube Research Station, Agriculture Research Institute, Tandojam. The sample jujube fruits were brought to the laboratory at the Department of Horticulture, Sindh Agriculture University Tandojam. After arrival of samples, the jujubes were cleaned for packing. The fruits of both the jujube varieties of yellow colours were separated and packed in different packing. The sample fruits were packed in the packaging prepared from different packing materials.

The sample jujube fruits were initially washed with distilled water and dried with muslin cloth. The fruits of both the qualities were weighed and each quality was divided into four groups i.e. A, B, C and D. Fruits in group ‘A’ were packed wooden boxes, while the fruits in group ‘B’ were packed in paper made boxes. Similarly, the fruits of both the qualities (yellow and green) of both the varieties were packed in plastic bags and the fruits in group D were packed in gunny bags. The jujube fruits were examined for their weight at day 1 (fresh) and day 6 after storage. Jujube fruits packed in packaging prepared from different packing materials were stored at room temperature.

Methods and procedures employed for determinations

Moisture content

An empty flat-bottomed dish was weighed and the sample was placed in the weighed dish, the dish was weighed with the sample and the dish was placed in an oven at 70°C and removed the dish after 3 hours, cooled in desiccator for 1 hour and weighed. The moisture content was calculated as per the following formula:

Moisture (%) =

$$\frac{\text{Weight of fresh sample} - \text{Wt of dried sample}}{\text{Weight of sample}} \times 100$$

pH

pH values were determine using with pH meter.

Fruit weight

The fruit weight was examined by the means of electronic balance and the reading so obtained in grams for each fruit.

Total Soluble Solids (TTS)

The Total Soluble Salts (TSS) was determined by the method using hand refractometer. After cleaning, the equipment was adjusted to zero using distilled water. Then a certain quantity of prepared solution of jujube pulp was dropped on the Prism-plate of the refractometer and lid was placed over to cover it. The reading for total soluble solids was recorded.

Specific gravity

Sample jujube fruits were washed with distilled water, dried and weighed one by one. About 1000 ml measuring cylinder was taken and filled with 500 ml distilled water, sample jujube fruits were dipped in measuring cylinder. The volume of water was noted and increased required quantity. The specific gravity was determined by the following formula:

Specific gravity of jujube =

$$\frac{\text{Weight of jujube fruit}}{\text{Volume increase of water}} \times 100$$

The data thus recorded on each proposed parameter were subjected to statistical analysis using analysis of variance to ascertain the significance level of the differences due to treatment, while the LSD (Least Significant Difference) test was employed to compare the mean values for each treatment group, following the statistical methods suggested by Gomez & Gomez (1984). The data were finalized in view of the results of statistical analysis and results are interpreted in the following chapter.

Results and Discussion

Moisture content (%)

The moisture content in jujube fruits may vary between varieties and its variation may also be associated with packing materials and storage period. The data (**Table-1**) suggested significant effect ($P<0.05$) of packing materials, varieties as well as storage period on the moisture content of jujube. The moisture content in jujube fruits before packing in wooden crates on average was 83.08%; while the moisture content in fruits before packing in paper box and plastic bag was 83.26 and 85.19%, respectively. However, the differences in moisture content in jujube fruits before packing were statistically non-significant ($P>0.05$); but significant ($P<0.05$) between varieties. Regardless the packing material, the moisture content in jujube fruits was significantly reduced after six days of storage under room temperature. The moisture content in fruits packed in wooden crates reduced from 83.08 to 79.10%; in fruits packed in paper box reduced from 82.26 to 78.11%; while in fruits packed in plastic bag, the moisture content reduced from 85.19 to 81.25% after six days of storage under room temperature. Apparently the moisture content was maximally reduced after six days of storage in jujube fruits packed in paper box, while the reduction in moisture content was minimal in fruits packed in plastic bag. The moisture content in fruits of variety Gola Lemai reduced from 84.75 to 80.19% after six days of storage under room temperature; while in Gola white, the moisture content was reduced from 82.93 to 78.78%. The overall results for storage period indicated that the moisture content on average before packing the jujube fruits was 83.84% which reduced to 79.48% after six days of storage under room temperature.

Table 1: Moisture content (%) of fruits in two jujube varieties as affected by different packing materials & storage period.

Packing materials	Before storage			After 6 days of storage		
	Gola Lemai (V_1)	Gola White (V_2)	Mean	Gola Lemai (V_1)	Gola White (V_2)	Mean
Wooden crate	84.10	82.06	83.08 b	79.90	78.30	79.10 c
Paper box	84.10	82.42	83.26 b	78.90	77.32	78.11 b
Plastic bag	86.05	84.33	85.19 a	81.78	80.73	81.25 a
Mean	84.75 **(a)**	82.93 **(b)**	83.84 **A**	80.19 **(a)**	78.78 **(b)**	79.48 **B**

	Packing materials	Varieties	Storage periods
S.E.±	0.3612	0.4424	0.3614
LSD 0.05	0.7491	0.9175	0.7493

pH value

The effect of packing materials, varieties as well as storage period on the pH value of jujube fruits was significant ($P<0.05$). The results (**Table 2**) showed that on an average the pH value of jujube fruits before packing in wooden crates was 5.22; while the pH value of fruits before packing in paper box and plastic bag was 5.16 and 5.42, respectively; and the differences in pH value of jujube fruits before packing were statistically significant ($P<0.05$). This indicates that naturally the jujube fruits may vary significantly for pH, probably due to the variation in maturity status of individual fruits. Irrespective of packing materials, the pH value of jujube fruits was significantly increased after six days of storage under room temperature. The pH value in fruits packed in wooden crates increased from 5.22 to 5.85; pH of fruits packed in paper box increased from 5.16 to 5.84; while pH of fruits packed in plastic bag increased from 5.42 to 5.90 after six days of storage under room temperature. The pH value was maximally increased after six days of storage for jujube fruits packed in plastic bag, while the increase in pH value was minimal for fruits packed in wooden crate and paper box. The results further showed that the pH value of fruits of variety Gola Lemai increased from 5.32 to 5.93 after six days of storage under room temperature; while in case of jujube variety Gola white, the pH value was increased from 5.21 to 5.80. The results for storage period showed that the pH value on average before packing the jujube fruits was 5.26 which increased to 5.86 after six days of storage under room temperature. This indicates that with development of storage period under room temperature, the jujube fruit pH was increased.

Table 2: pH value of fruits in jujube varieties as affected by different packing materials

Packing materials	Before storage			After 6 days of storage		
	Gola Lemai (V_1)	Gola White (V_2)	Mean	Gola Lemai (V_1)	Gola White (V_2)	Mean
Wooden crate	5.27	5.16	5.22 b	5.91	5.80	5.85 b
Paper box	5.21	5.11	5.16 c	5.91	5.77	5.84 b
Plastic bag	5.48	5.37	5.42 a	5.96	5.84	5.90 a
Mean	5.32 **(a)**	5.21 **(b)**	5.26 **B**	5.90 **(a)**	5.80 **(b)**	5.86 **A**

	Packing materials	Varieties	Storage periods
S.E.±	0.0166	0.0203	0.0167
LSD 0.05	0.0343	0.0421	0.0344

Fruit weight (g)

The effect of varieties and storage period on the fruit weight of jujube fruits was significant (P<0.05) and non-significant (P>0.05) for packing materials. The results (**Table 3**) showed that on average the fruit weight of jujube fruits before packing in wooden crates was 38.65g; while the fruit weight before packing in paper box and plastic bag was 38.16 g and 38.29g, respectively; but the differences in fruit weight of jujube fruits before packing were statistically non-significant (P>0.05). In spite of packing materials, the fruit weight of jujube was significantly decreased after six days of storage under room temperature. The fruit weight packed in wooden crates decreased from 38.65g to 29.66g; weight of fruits packed in paper box decreased from 38.16g to 29.79g; while weight of fruits packed in plastic bag decreased from 38.29g to 31.57g after six days of storage under room temperature. The maximum decrease in fruit weight after six days of storage was noted when packed in wooden crate and paper box, while the minimum decrease in fruit weight was observed when packed in plastic bag. In case of varieties, the fruit weight of Gola Lemai was naturally higher than the Gola White and there was a simultaneous decrease in fruit weight after six days of storage. The fruit weight of variety Gola Lemai decreased from 39.55g to 31.28g; while in case of variety Gola white, the fruit weight was decreased from 37.18g to 29.40g. The fruit weight on average before packing the jujube fruits was 38.37g which was significantly decreased to 30.34g after six days of storage under room temperature. This showed that with progression of storage period under room temperature, the fruit weight of jujube was adversely affected.

Table 3: Fruit weight (g) of jujube varieties as affected by different packing materials

Packing materials	Before storage			After 6 days of storage		
	Gola Lemai (V_1)	Gola White ($V_{2)}$	Mean	Gola Lemai (V_1)	Gola White ($V_{2)}$	Mean
Wooden crate	39.84	37.45	38.65	30.28	28.74	29.66
Paper box	39.34	36.98	38.16	30.71	28.86	29.79
Plastic bag	39.48	37.11	38.29	32.55	30.60	31.57
Mean	39.55 **(a)**	37.18 **(b)**	38.37**A**	31.28 **(a)**	29.40 **(b)**	30.34**B**

	Packing materials	Varieties	Storage periods
S.E.±	0.3872	0.4742	0.3873
LSD 0.05	0.8030	-	0.8031

Total soluble solids (TSS %)

The effect of different packing materials, varieties and storage period on the TSS of jujube fruits was statistically significant (P<0.05). The results (**Table 4**) showed that on average the TSS in jujube fruits before packing in wooden crates was 11.08 percent; while the TSS content in jujube fruits before packing in paper box and plastic bag was 11.10 and 10.85 percent, respectively; and the differences in TSS content of jujube fruits before packing varied significantly (P<0.05). The TSS in jujube fruits was significantly decreased after six days of storage under room temperature. The TSS in fruits packed in wooden crates decreased from 11.08 to 8.99%; fruits packed in paper box deteriorated TSS content from 11.10 to 8.71%; while TSS content in fruits packed in plastic bag decreased from 10.85 to 8.07% after six days of storage under room temperature. The maximum decrease in TSS after six days of storage was noted when packed in plastic bag, while minimum decrease in TSS was noted when packed in wooden crate and paper box. In case of varieties, the TSS of Gola Lemai was naturally higher than the Gola White and there was a concurrent decrease in TSS after six days of storage. The TSS of variety Gola Lemai decreased from 11.18 to 8.88%; while in case of variety Gola white, the TSS was decreased from 10.84 to 8.29%. The average results on the effect of storage period on TSS content in jujube fruits indicated that before packing the TSS content in jujube fruit was 11.01% which was markedly decreased to 8.59% after six days of storage under room temperature. This showed that with increasing storage of jujube fruits under room temperature, their TSS content is negatively influenced.

Table 4: TSS (%) of jujube varieties as affected by different packing materials

Packing materials	Before storage			After 6 days of storage		
	Gola Lemai (V_1)	Gola White ($V_{2)}$	Mean	Gola Lemai (V_1)	Gola White ($V_{2)}$	Mean
Wooden crate	11.25	10.91	11.08 a	9.13	8.85	8.99 a
Paper box	11.27	10.93	11.10 a	9.34	8.09	8.71 b
Plastic bag	11.02	10.69	10.85 b	8.19	7.94	8.07 c
Mean	11.18 **(a)**	10.84 **(b)**	11.01**A**	8.88 **(a)**	8.29 **(b)**	8.59 **B**

	Packing materials	Varieties	Storage periods
S.E.±	0.0592	0.0725	0.0594
LSD 0.05	0.1228	0.1503	0.1229

Specific gravity

Specific gravity is the ratio of density of a substance compared to the density of fresh water at 4°C (39°F). Since specific gravity is a ratio, so it has no units. The jujube fruit was float in water, if its density was less than the density of water and sink, if its density is greater that that of water. The effect of different varieties and storage period on the specific gravity of jujube fruit was statistically significant ($P<0.05$) and non-significant ($P>0.05$) for packing materials. The results (**Table 5**) indicated that the specific gravity of jujube fruit before packing in wooden crate, paper box and plastic bag was equally 0.92. The specific gravity of jujube fruit was markedly reduced after six days of storage under room temperature. The specific gravity of fruit packed in wooden crate decreased from 0.92 to 0.79; specific gravity of fruit packed in paper box decreased from 0.92 to 0.80; while specific gravity of fruit packed in plastic bag decreased from 0.92 to 0.79 after six days of storage under room temperature. The maximum decrease in specific gravity after six days of storage was noted when packed in wooden crate and plastic bag. In varieties, the specific gravity of Gola Lemai fruit was naturally higher than the Gola White and there was a simultaneous decrease in specific gravity with development of storage period. The specific gravity of variety Gola Lemai decreased from 0.93 to 0.80; while in case of variety Gola white, the specific gravity was decreased from 0.91 to 0.79. Specifically for storage period on average, the specific gravity of fruit before packing was 0.92 which was markedly decreased to 0.80 after six days of storage under room temperature.

Table 5: Specific gravity of jujube varieties as affected by different packing materials

Packing materials	Before storage			After 6 days of storage		
	Gola Lemai (V_1)	Gola White ($V_{2)}$	Mean	Gola Lemai (V_1)	Gola White ($V_{2)}$	Mean
Wooden crate	0.93	0.91	0.92 a	0.80	0.78	0.79 a
Paper box	0.93	0.91	0.92 a	0.81	0.80	0.80 a
Plastic bag	0.93	0.91	0.92 a	0.80	0.78	0.79 a
Mean	0.93 **(a)**	0.91 **(b)**	0.92 **A**	0.80 **(a)**	0.79 **(b)**	0.80 **B**

	Packing materials	Varieties	Storage periods
S.E.±	0.0055	0.0068	0.0055
LSD 0.05	0.0115	-	0.0115

Discussion

The climatic conditions of Sindh province are most favourable for jujube production and several varieties are cultivated for production of quality jujube fruits. At farmer level, the quality parameters are well considered and this fruit keeps export potential to earn foreign exchange. Apart from the production quality, the storage facilities are lacking and a major part of this fruit is either locally consumed or wasted in the orchards. The need is to train farmers for proper harvesting time and about the physiological maturity stage. Moreover, post harvest losses need to be diminished using scientific methods to improve the shelf life of the fruit. The results indicated that after 6 days of storage, the moisture of fruit packed in wooden crates was decreased from 83.08 to 79.10%, pH increased from 5.22 to 5.85, fruit weight decreased from 38.65 to 29.66g, TSS decreased from 11.08 to 8.99%, and specific gravity decreased from 0.92 to 0.79. The moisture of fruit packed in paper box was decreased from 83.26 to 78.11%, pH increased from 5.16 to 5.84, fruit weight decreased from 38.16 to 29.79g, TSS decreased from 11.10 to 8.71%, and specific gravity decreased from 0.92 to 0.79. The moisture of fruit packed in plastic bags was decreased from 85.19 to 81.25%, pH increased from 5.42 to 5.90, fruit weight decreased from 38.29 to 31.57g, TSS decreased from 10.85 to 8.07%, and specific gravity decreased from 0.92 to 0.80 after 6 days storage under room temperature. In case of varieties, after 6 days of storage under room temperature, the fruit moisture of variety Gola Lemai was decreased from 84.75 to 80.19%, pH increased from 5.32 to 5.93, fruit weight decreased from 39.55 to 31.28g, TSS decreased from 11.18 to 8.88%, and specific gravity decreased from 0.93 to 0.80. The fruit moisture of variety Gola White after 6 days of storage under room temperature was decreased from 82.93 to 78.78%, pH increased from 5.21 to 5.80, fruit weight decreased from 37.18 to 29.40g, TSS decreased from 10.84 to 8.29%, and specific gravity decreased from 0.91 to 0.79. On average, the effect of storage period upto 6 days indicated that the fruit moisture decreased from 83.84 to 79.48%, pH increased from 5.26 to 5.86, fruit weight decreased from 38.37 to 30.34g, TSS decreased from 11.01 to 8.59%, and specific gravity decreased from 0.92 to 0.80. These results further supported by Saini *et al*. (2010) who indicated that the use of plastic materials for packing produced better results in relation to physical and chemical properties of the ber fruits and Hiwale & Raturi (2000) stated that the fruits packing response was also varied with different materials such as wooden box and plastic packaging. Similarly, MengJun & Liu (1999) stated high coefficient of variation for packaging and packing materials, which showed a linear effect on the fruits due to different packing materials, while Godara & Kishan (1997) convinced that physico chemical properties were changed when different packing materials were used for packaging fruits. However, Gupta (2000) indicated that the total soluble solids were better in fruits packed in plastic bags, while the pH in fruits was relatively higher in fruits packed in paper boxes.

The study further showed that the moisture, pH and weight of fruits packed in plastic bags was higher than those packed in wooden crate and paper box, but TSS and specific gravity was lowest; while on the other hand in wooden crate and plastic box, the fruits after six days of storage had higher TSS and specific gravity than those packed in plastic bags. Among varieties, Gola Lemai proved to be better in all the physico-chemical properties investigated as compared to Gola White. These results are in concurrence with those of Singh & Ahlawat (2001) who stated that physico-chemical characters were better in ber fruit when packed in wooden boxes, followed by plastic bages, while Zhang & Zhang (2002) mentioned that jujube responsive to packing materials and fruits packed in plastic bags remained well edible upto 14 days which clearly indicated that the shelf life was improved considerably at least for 2 days when the fruits were packed in plastic materials. However, Bandyopadhay & Sen (2003) observed that the packaging and packing materials, the fruits stored at room temperature in plastic bages maintained quality optimally almost up to 13 days as compared to 8-10 and 9-11 days in wooden boxes and polythene bags, while Kishan *et al*. (2004) stated that fruit firmness and specific gravity were not significantly affected by treatments. The comparative analysis of research work carried out by the researcher and the findings reported from different parts of the world coincide that the packing material influence the physico-chemical properties of jujube fruit and the present results are well in agreement with the findings of past researchers.

Conclusions

On the basis of results achieved from the present research it was concluded that the moisture, pH and weight of fruits packed in plastic bags was higher than those packed in wooden crate and paper box, but TSS and specific gravity was lowest; while on the other

hand in wooden crate and plastic box, the fruits after six days of storage had higher TSS and specific gravity than those packed in plastic bags. Among varieties, Gola Lemai proved to be better in all the physico-chemical properties investigated as compared to Gola White.

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