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RESEARCH PAPER

Studies on the effect of packaging on quality and shelf life of the kokum (*Garcinia indica* Choisy) fruits during transportation and storage

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ABSTRACT

The ripe kokum fruits were packed in different packages and were transported by road (480 km) from Dapoli to Mumbai and back to Dapoli. The fruits packed in CFB boxes + paddy straw were good, while those in other packaging material were considerably disturbed. The fruits packed in CFB box with paddy straw showed lower PLW than those in any other packaging. The fruits packed in wooden crate and bamboo baskets without cushioning materials showed the maximum bruising amongst all the packaging material under study. The fruits showed neither spoilage due to microbial infection nor due to shrivelling during transportation. After transportation all the packages were kept at ambient temperature. During this storage it was noticed that the fruits packed in CFB box with paddy straw showed slower rate of spoilage and had higher shelf life (7 days) than any other packaging materials. It was further observed that the fruits packed in CFB box with paddy straw showed delayed and lower shrivelling with the maximum marketable fruits as compared to other packaging material on 7th day of storage. As far as chemical constituents of kokum fruits are concerned, the fruits packed in CFB box with paddy straw recorded the acidity (3.48%) and ascorbic acid (9.21 mg/100g), T.S.S. (14.02^{0}B), total sugars (14.41%) and reducing sugars (5.69%) after transport while during storage they recorded T.S.S. (14.11%), acidity (3.49%) and ascorbic acid (4.40 mg/100 g) and slightly lower total sugars (10.07%). An initial increase, followed by a decrease in T.S.S. content was observed in the fruits packed in all the packaging material during storage. The acidity and the ascorbic acid decreased continuously towards the end of storage period. Thus, the present investigation indicate that, the CFB box with paddy straw as cushioning appeared to be the best for transport for internal as well as external market and equally good for storage of kokum fruits.

Key Words : Kokum, Packaging, Shelf life

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Kokum (*Garcinia indica* Choisy) belongs to the genus *Garcinia*, which is large genus of polygamous evergreen trees and shrubs native of Asia, Southern Africa and Polynesia (Anthony, 1997). The scientific name *Garcinia* is derived from Garcias, who described it in 1974 (Subash Chandran, 1996). The genus belongs to a botanical family Clusiaceae, which consists of tropical trees, lianes (vines) and herbs.

Packaging of fresh fruit has a great significance in reducing the wastage. Packaging provides protection from mechanical damage, undesirable physiological changes and pathological deterioration during storage, transportation and marketing. A wide variety of containers such as wooden boxes, bamboo baskets, Hessian sack or jute bags, C.F.B. boxes are the important packages form used in the transportation and distribution of fruits in most of the developing countries. The

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C.F.B. boxes have many advantages as light in weight, causes less damage of frits, easy to handle and print improve the product image, reduce the fright cost and can be prepared form cheaper wood and other plant cellulose waste.

For transporting fruits and vegetables from production centers to urban markets even it 2 per cent wastage is reduced there will be saving 100– 200 crores per year in India .Therefore, the study was undertaken to assess the extent of post harvest losses and feasibility of different packaging materials for transportation of fruits of Kokan to distant markets.

RESEARCH METHODOLOGY

This experiment was carried out during the year 2002-03 with the following experimental details. The experiment was conducted using different packages with cushioning material.

Experimental details:

Replications: Three
Design : Factorial C.R.D.
Treatments : Twelve

T_1 - Wooden crate
T_2 - Wooden crate with paper shaving
T_3 - Wooden crate with paddy straw
T_4 - Bamboo basket
T_5 - Bamboo basket with paper shaving
T_6 - Bamboo basket with paddy straw
T_7 - Plastic crate
T_8 - Plastic crate with paper shaving
T_9 - Plastic crate with paddy straw
T_{10} - C.F.B. box
T_{11} - C.F.B. box with paper shaving
T_{12} - C.F.B box with paddy straw

The fruits in different packages, were transported by road from Dapoli to Mumbai and back (480 km). The fruits after transportation were stored at ambient temperature and observed for the PLW, chemical composition, ripening and spoilage pattern and shelf life. The fruits were also analysed for chemical composition after transport,total soluble solids (A.O.A.C., 1980), sugars (Ranganna, 1986), Acidity (A.O.A.C., 1980), Ascorbic acid (Ranganna, 1986), physiological loss in weight, shrivelling and spoilage.

RESEARCH AND REMONSTRATION FINDINGS

The results of the present study as well as relevant discussion have been summarized under following heads:

Chemical composition

Total soluble solids (^{0}B):

The T.S.S. (Table 1) were found to increase steadily during transportation and the storage, followed by a decline towards the end of shelf life, irrespective of the packages and the years of cropping. This is probably due to hydrolysis of the starch into sugars after harvesting during respiration and transpiration. The observations identical to these findings were also reported Raut (1999) in sapota.

Further, the data regarding the effect of transportation and the packaging on T.S.S. of the kokum fruits showed that the T.S.S. content did not show much variation within the treatments. The data revealed that non-significant differences were found amongst all the treatments.

As far as changes in content of T.S.S. of kokum during storage are concerned, the maximum T.S.S. were found in T_5 (14.47^0B) treatment followed by T_7, T_{11} (14.17^0B) and T_{11} (14.11^0B) treatment while the minimum in T_1 (13.81^0B) during individual season as well as in pooled data.

There was no much variation with respect to T.S.S. content of the kokum fruits. This could be due to almost similar climatic conditions prevailing during the fruiting season. These findings were analogous to the observations reported by Raut (1999) in sapota.

Reducing sugar:

The reducing sugars (Table 1) content of the kokum fruits was found to increase after transport and further during the storage, followed by steady decline towards the end of shelf life, irrespective of the packaging material used and years of cropping. The steady increasing in reducing sugars upto storage could be due to hydrolysis of starch into sugars, while the decline in reducing sugar content could be due to its utilization in the respiration process. Similar observations were also reported by Raut (1999) in sapota.

There was no appreciable change in the reducing sugars of the kokum fruits both during transport and the storage. This could be due to tropical agro-climatic conditions prevailing in the coastal Konkan region of the Maharashtra state during the fruiting season of the kokum.

The analysis of the data indicated the non-significant differences in all the treatments under study. However, the maximum reducing sugars were observed in T_{12} (6.22%), followed by T_9 (6.04%) and the minimum in T_{11} (5.08) treatments after transportation and the storage of kokum fruits. However, during storage no definite effect of packages on reducing sugars content of kokum fruits were observed as the packages showed non-significant differences among themselves. The pooled analysis of the data with respect to the effect of packaging and the season also recorded non-significant differences in the reducing sugars content of the kokum fruits. There is no reference on this aspect for the comparison of the kokum fruits.

Total sugars (Table 2):

The data showed that there was an increase in the total

Table 1: Effect of different packages and cushioning materials on T.S.S. and reducing sugar of kokum (*Garcinia indica* Choisy) fruits during transportation and the storage at ambient temperature

Sr. No.	Types of packages and cushioning material	Total soluble solids				Reducing sugar (%)			
		Before transportation	After transportation	Before storage	After storage	Before transportation	After transportation	Before storage	After storage
1.	T_1 - Wooden crate	12.86	13.93	16.49	13.81	4.74	5.65	6.80	5.95
2.	T_2 - Wooden crate + paper shaving	12.86	14.12	17.26	14.09	4.74	5.46	6.54	5.51
3.	T_3 - Wooden crate + paddy straw	12.86	14.06	17.14	13.95	4.74	5.40	7.06	5.75
4.	T_4 - Bamboo basket	12.86	14.03	15.99	13.97	4.74	5.41	6.33	5.14
5.	T_5 - Bamboo basket + paper shaving	12.86	13.08	16.58	14.47	4.74	6.01	6.89	5.94
6.	T_6 - Bamboo basket + paddy straw	12.86	14.01	16.32	13.92	4.74	5.82	6.66	5.63
7.	T_7 - Plastic crate	12.86	14.05	17.50	14.17	4.74	5.63	6.82	5.78
8.	T_8 - Plastic crate + paper shaving	12.86	13.95	17.05	14.07	4.74	5.83	6.96	5.68
9.	T_9 - Plastic crate + paddy straw	12.86	14.26	16.70	14.05	4.74	5.76	6.69	6.04
10.	T_{10} -CFB box	12.86	13.88	17.14	14.17	4.74	5.81	6.76	5.72
11.	T_{11} -CFB box + paper shaving	12.86	13.96	14.15	14.17	4.74	5.45	6.02	5.08
12.	T_{12} -CFB box + paddy straw	12.86	14.02	16.89	14.11	4.74	5.59	7.30	6.22
	Average	12.86	14.03	16.67	14.08	4.74	5.69	6.73	5.70
	S.E. $\pm$	0.208	0.172	0.284	0.166	0.360	0.352	0.269	0.269
	C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	0.743

NS=Non-significant

sugars content of the kokum fruits after transportation and steady decline towards the end of storage period, irrespective of the packaging material used and the years of study. The increase in total sugars until the completion of the transport and before storage could be attributed to the conversion of such into sugars (Joshi, 1983). The present finding are similar to the observations reported by Joshi and Roy (1986), Sahani *et al.* (1994) in mango. Further the rise in total sugars, followed by steady fall towards the end of shelf life appeared to be due to their utilization in respiration process. These results are conformity with the findings reported by Raut (1999) in sapota fruits.

Further, the total sugar content during both the transport and the storage did not show appreciable variation with respect to the packaging material as reflected through the statistical analysis of the data.

The data further revealed that the packages used for packing the kokum fruits entitled non-significant differences among themselves with respect to total sugars content of kokum fruits both during transport and the storage. Similar contents were noticed during individual season as well as in the pooled data. Further, as far as total sugar content of the kokum fruit during transportation is concerned the treatment T_{11} (12.3%) recorded the maximum total sugars and treatment T_4 and T_7 recorded the minimum total sugar content. The slow rate of increase in total sugars content of kokum fruits packed in CFB box with paper and paddy straw might be due to slow physiological changes and slow conversion of starch into sugars (Joshi, 1983). The faster rate of increase in the total sugars content observed in the wooden boxes and the bamboo basket might be due to faster rate of respiration and transpiration as compared to other packaging themselves. Analogous observations were also reported by Jagtap and Katradia (1998) and Raut (1999) in sapota fruits.

Acidity (Table 2):

The acidity was found to decrease during transport as well as during storage of kokum fruits continuously upto the end of shelf-life, irrespective of types of packaging used and the yeas of cropping. This appeared to be due to the degradation and utilization of organic acid for respiration of the fruits after harvest during transport and the storage. The decline in acidity till the end of shelf life was also reported by Raut (1999) in sapota fruits.

The packages used for the packing of the kokum fruits under study showed non-significant effect on the changes in acidity during transportation and the storage. The CFB Box with paddy straw shaving (T_{12}) recorded the maximum (3.49%) acidity. This appeared due to variation in packaging material used leading to variation in physiological processes both during transport and the storage of kokum fruits. Further the slow and the minimum decrease in acidity of the fruits packed in CFB box with paddy straw may possibly be due to slow rate of physiological processes.

The analysis of the data indicate the statistically non-significant differences among all the treatments of transportation and the storage. However, the maximum change in the acidity was recorded in the treatments T_1 and the minimum changes (maximum retention or light change at harvest and after storage) in acidity was recorded by T_{12}, T_{11},

Table 2: Effect of different packages and cushioning materials on total sugar and acidity (%) of kokum (*Garcinia indica* Choisy) fruits during transportation and the storage at ambient temperature

Sr. No.	Types of packages and cushioning material	Total sugar (%)				Acidity (%)			
		Before transportation	After transportation	Before storage	After storage	Before transportation	After transportation	Before storage	After storage
1.	T_1 - Wooden crate	11.28	12.74	13.60	12.3	3.80	3.33	3.18	3.18
2.	T_2 - Wooden crate + paper shaving	11.28	11.22	12.59	10.96	3.80	3.29	3.27	3.27
3.	T_3 - Wooden crate + Paddy straw	11.28	11.07	11.81	11.27	3.80	3.12	3.37	3.37
4.	T_4 - Bamboo basket	11.28	10.89	11.64	10.94	3.80	3.42	3.39	3.39
5.	T_5 - Bamboo basket + Paper shaving	11.28	11.16	12.13	11.35	3.80	3.18	3.12	3.12
6.	T_6 - Bamboo basket + Paddy straw	11.28	11.09	11.85	11.45	3.80	3.15	3.27	3.27
7.	T_7 - Plastic crate	11.28	10.95	12.13	10.94	3.80	3.29	3.39	3.39
8.	T_8 - Plastic crate + Paper shaving	11.28	11.03	11.62	10.99	3.80	3.26	3.37	3.37
9.	T_9 - Plastic crate + Paddy straw	11.28	11.18	12.60	11.08	3.80	3.18	3.24	3.24
10.	T_{10} -CFB box	11.28	11.26	11.39	10.82	3.80	3.41	3.38	3.38
11.	T_{11} -CFB box + Paper shaving	11.28	13.03	13.53	10.88	3.80	3.35	3.34	3.07
12.	T_{12} -CFB box + Paddy straw	11.28	14.41	12.23	10.78	3.80	3.48	3.75	3.49
	Average	11.28	11.41	12.23	11.15	3.80	3.62	3.30	3.06
	S.E. $\pm$	0.176	0.505	0.504	0.516	0.264	0.195	0.082	0.079
	C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non-significant

T_7 and T_0 treatments.

Ascorbic acid:

The data are presented in Table 3 regarding the ascorbic acid content of the kokum fruits. They showed the rapid decrease in ascorbic acid content during transportation and the store in all the packaging materials. The continues fall in ascorbic acid content showed by the fruits packed in different packaging material till the end of storage period is in accordance with the observations reported by Joshi and Roy (1986) in mango and Raut (1999) in sapota fruits.

The non-significant differences in the ascorbic acid content were observed in the kokum fruits packed in different treatment during transportation and the storage. The maximum ascorbic acid content in the kokum fruit was in the treatment T_{12} (7.42 and 4.40 mg/100 g) after transportation and the

Table 3: Effect of different packages and cushioning materials on ascorbic acid (mg/100g) and physiological loss in weight (%) of kokum fruits during transportation and the storage at ambient temperature

Sr. No.	Types of packages and cushioning material	Ascorbic acid (mg/100g)				Physiological loss in weight (%)			
		Before transportation	After transportation	Before storage	After storage	Before transportation	After transportation	Before storage	After storage
1.	T_1 - Wooden crate	11.69	8.87	6.76	3.48	0	7.36	16.27	-----
2.	T_2 - Wooden crate + paper shaving	11.69	9.07	6.70	4.03	0	6.07	15.19	-----
3.	T_3 - Wooden crate + Paddy straw	11.69	8.85	6.80	3.96	0	5.25	15.26	-----
4.	T_4 - Bamboo basket	11.69	9.04	7.12	3.77	0	7.78	15.95	-----
5.	T_5 - Bamboo basket + Paper shaving	11.69	8.80	6.76	3.76	0	5.91	15.13	-----
6.	T_6 - Bamboo basket + Paddy straw	11.69	8.68	6.78	3.50	0	6.26	15.09	-----
7.	T_7 - Plastic crate	11.69	9.22	6.84	3.56	0	5.32	15.81	-----
8.	T_8 - Plastic crate + Paper shaving	11.69	9.14	7.00	4.79	0	5.68	15.23	-----
9.	T_9 - Plastic crate + Paddy straw	11.69	9.09	7.04	3.58	0	3.50	14.24	-----
10.	T_{10} -CFB box	11.69	9.03	6.98	3.82	0	5.02	14.43	-----
11.	T_{11} -CFB box + Paper shaving	11.69	8.93	6.80	3.74	0	3.70	13.36	-----
12.	T_{12} -CFB box + Paddy straw	11.69	9.21	7.42	4.40	0	3.47	11.34	15.27
	Average	11.69	8.99	6.91	3.81	0	3.60	10.85	----
	S.E. $\pm$	0.576	0.236	0.054	0.215	-----	0.297	0.028	0.004
	C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non-significant

storage, respectively. The minimum retention of ascorbic acid was found in treatment T_1 (3.48 mg/100 g).

Further the faster decline in ascorbic acid content was observed of the kokum fruit packed in wooden crates and bamboo baskets. On the other hand the maximum retention of ascorbic acid was found in the fruits packed in CFB box (T_{11} and T_{12}) during storage. This might due to proper ventilation minimising the increase in temperature. Similar observations were also reported by Raut (1999) in sapota fruits.

Physiological loss in weight:

The data on physiological loss in weight of kokum fruits are presented in Table 4. They revealed that the physiological loss in weight (PLW) was found to increase during transportation and the storage of kokum fruits, irrespective of packages used and the year of study. This could be due to the loss of moisture through respiration and the transpiration of the kokum fruits (Joshi, 1983).

Further, no much differences in the PLW of the kokum fruit were found between two years of study. This could be attributed to the similar mild tropical agroclimatic conditions prevailing during both the years of study.

The different packages under study recorded significant differences among themselves with respect to PLW of kokum fruits both during transportation and storage. The data further indicated that the significantly minimum PLW was recorded in treatment T_{12} (3.470% and 11.34%) on 3rd and 5th day after storage. The fruits showed 7 days of total shelf life, as compared to the other treatment. The significantly maximum PLW was noticed in treatment T_1 (7.36% and 16.27%) in the 3rd and 5th day of storage.

The shrivelling and the spoilage of kokum fruits:

The data pertaining to the shrivelling and the spoilage pattern of kokum fruits after transportation during storage are presented in Table 5. It is observed that the shrivelling and the spoilage of the kokum fruits increased with an increase in the storage period, irrespective of the packaging material used, during transportation. This could be due to climacteric nature of the fruits, which was responsible for the faster rate of ripening at ambient temperature conditions. The observation analogous to these findings were also reported by Joshi (1983) in mango and Raut (1999) in sapota fruit transportation.

Further the rate of shrivelling and the spoilage of the fruits stored in wooden crates and the bamboo baskets was the fastest due to more bruising of the fruits, while this rate was slow in case of fruits stored in CFB boxes with paddy straw as a cushioning material.

This could be due to slow rate of physiological changes and the less loss of moisture from this packaging material. The observations analogous to these in case of kokum are not reported so far. However, most of the research workers reported that CFB boxes were the good packaging and transportation material in different fruit crops. Hence, in kokum also the CFB box was found to be the good for packaging and transportation material.

Conclusion:

The ripe kokum fruits were packed in different packages and were transported by road (480 km) from Dapoli to Mumbai and back to Dapoli. The fruits packed in CFB boxes + paddy straw were good, while those in other packaging material were considerably disturbed. The fruits packed in CFB box with paddy straw showed lower PLW than those in any other packaging. The fruits packed in wooden crate and bamboo baskets without cushioning materials showed the maximum bruising amongst all the packaging material under study. The fruits showed neither spoilage due to microbial infection nor due to shrivelling during transportation.

After transportation all the packages were kept at ambient temperature. During this storage it was noticed that the fruits packed in CFB box with paddy straw showed slower rate of

Table 4: Physiological loss in weight of kokum fruits stored at different storage conditions

Sr. No.	Treatments	3rd day	5th day	7th day	9th day	11th day	13th day	15th day	17th day	19th day	23rd day	27th day	31st day
1.	T_1	6.45	15.26	----	----	----	----	-----	-----	-----	-----	-----	-----
2.	T_2	3.32	7.46	10.47	13.41	15.22	----	-----	-----	-----	-----	-----	-----
3.	T_3	2.85	4.39	6.65	10.35	12.36	14.31	15.03	-----	-----	-----	-----	-----
4.	T_4	2.85	4.99	7.24	9.86	12.00	13.89	15.18	-----	-----	-----	-----	-----
5.	T_5	2.82	4.69	7.51	10.41	12.37	14.31	15.15	-----	-----	-----	-----	-----
6.	T_6	2.44	3.90	5.45	7.47	9.20	11.48	15.56	15.09	-----	-----	-----	-----
7.	T_7	3.60	----	6.31	----	8.72	----	11.04	-----	13.42	15.06	-----	-----
8.	T_8	3.51	----	5.54	----	7.55	----	9.51	-----	11.52	13.41	15.29	-----
9.	T_9	1.47	----	3.48	----	5.45	----	7.89	-----	9.75	11.42	13.69	15.29
	Avg.	3.25	4.52	8.84	5.72	9.20	6.00	9.52	-----	3.85	4.34	3.22	1.68
	S.E. $\pm$	0.260	0.200	0.340	0.057	0.244	0.0527	0.067	0.00	0.049	0.284	0.0224	0.216
	C.D. (P=0.05)	0.720	0.554	0.940	0.176	0.676	1.458	0.187	0.00	0.136	0.786	0.061	0.059

Table 5: The shrivelling and the spoilage of kokum fruits stored at different storage conditions

Sr. No.	Treatments	3rd day	5th day	7th day	9th day	11th day	13th day	15th day	17th day	19th day	23rd day	27th day	31st day
T_1	Shrivelled	4.17	13.43	16.77	21.01	27.70	30.38	41.00	60.38	-----	-----	-----	-----
	Diseased	1.72	2.94	7.50	14.00	20.33	26.00	31.83	36.00	-----	-----	-----	-----
T_2	Shrivelled	0.00	-----	-----	-----	-----	-----	2.95	-----	-----	-----	-----	-----
	Diseased	-----	-----	-----	2.94	7.23	11.62	14.70	-----	-----	-----	-----	-----
T_3	Shrivelled	-----	2.56	5.60	13.18	-----	-----	-----	-----	-----	-----	-----	-----
	Diseased	-----	-----	2.63	2.69	-----	-----	-----	-----	-----	-----	-----	-----
T_4	Shrivelled	-----	-----	1.35	2.34	3.40	7.25	9.95	-----	-----	-----	-----	-----
	Diseased	-----	-----	-----	1.34	3.48	4.47	6.94	-----	-----	-----	-----	-----
T_5	Shrivelled	-----	-----	-----	1.41	3.48	6.49	9.98	-----	-----	-----	-----	-----
	Diseased	-----	-----	-----	-----	2.20	6.01	7.45	-----	-----	-----	-----	-----
T_6	Shrivelled	-----	-----	-----	-----	2.20	6.01	7.45	-----	-----	-----	-----	-----
	Diseased	-----	-----	-----	-----	2.17	4.17	8.33	-----	-----	-----	-----	-----
T_7	Shrivelled	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Diseased	-----	-----	1.42	2.15	3.05	5.60	-----	8.17	10.25	13.25	15.00	-----
T_8	Shrivelled	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Diseased	-----	-----	1.25	2.25	3.65	5.15	7.25	8.45	11.37	13.25	16.00	-----
T_9	Shrivelled	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Diseased	-----	-----	1.25	2.17	3.17	5.17	6.33	7.15	8.00	10.42	12.32	14.95

spoilage and had higher shelf life (7 days) than any other packaging materials. It was further observed that the fruits packed in CFB box with paddy straw showed delayed and lower shrivelling with the maximum marketable fruits as compared to other packaging material on 7th day of storage.

As far as chemical constituents of kokum fruits are concerned, the fruits packed in CFB box with paddy straw recorded the acidity (3.48%) and ascorbic acid (9.21 mg/100g), T.S.S. (14.03^{0}B), total sugars (14.41%) and reducing sugars (5.69%) after transport while during storage they recorded T.S.S. (14.11%), acidity (3.49%) and ascorbic acid (4.40 mg/ 100 g) and slightly lower total sugars (10.78%). An initial increase, followed by a decrease in T.S.S. content was observed in the fruits packed in all the packaging material during storage. The acidity and the ascorbic acid decreased continuously towards the end of storage period.

Thus, the present investigation indicate that, the CFB box with paddy straw as cushioning appeared to be the best for transport for internal as well as external market and equally good for storage of kokum fruits.

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