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Effect of calcium chloride, polyethylene packaging and storage conditions on physical parameters of Kokum fruits

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Abstract
The experiment was laid out in Factorial completely randomized design with four treatments of calcium and packaging with two storage conditions and replicated four times. The changes in physical parameters were studied at an interval of 5 days. Among the different interactions tried, at 5th day storage interaction T_2S_2 (2% calcium chloride +200 gauge polyethylene bag) recorded minimum increase in PLW and minimum decrease in weight. It also recorded maximum increase in specific gravity during storage. No shriveling or spoilage was observed in all the treatments at cold storage. Maximum shelf life (22.5 days) was reported by the interaction T_2S_2. Among the different interactions under study, interaction T_2S_2 (2% of calcium chloride +200 gauge polyethylene bag and cold storage) was found to be best, as physical parameters are concerned.

Keywords: Kokum, calcium chloride, polyethylene bag, storage conditions, physical parameters

Introduction
Kokum *(Garcinia indica* Choisy*)* a tropical fruit is a native of India can be viewed as a wonder berry that has a pleasant, tangy-sweet taste and a myriad of health benefits. It is an Indian spice used in many parts of the country for making several value added products like chutneys, pickles, *Solkadhi*, *Amrut kokum*, *Amsul*, *Agal* i.e. salted juice etc. Kokum seed is a good source of fat called kokum butter that is used in confectionary, pharmaceutical as well as cosmetic industry. The therapeutic properties of kokum fruits have been described in traditional medicine Ayurveda. Kokum fruit contains hydroxyl citric acid (HCA) is a potential anti-obesity agent, B-complex vitamins, and minerals like potassium, manganese and magnesium, that help in controlling heart rate and blood pressure, offering protection against stroke and coronary heart diseases. This versatile fruit has been used to counter digestive problems such as indigestion, flatulence, acidity and constipation. Kokum fruit possess useful antioxidant, chelating, anti-cancer, anti-fungal, anti-inflammatory, antibacterial, cardio protective and anti-ulcer activities. Life-enhancing antioxidant found in kokum pericarp is called Xanthone. The anthocyanin pigments obtained from it are used as natural colouring agents for food preservation (Anon., 2012) [1].
Processing sector is very vital for this crop as unlike other fruits, kokum cannot be consumed as fresh fruit. It's utility start only after processing. Kokum fruits are perishable in nature and there are limitations for processing of these fruits. Hence, it is necessary to extend storage life of these fruits by giving postharvest treatments with packaging and using different storage conditions.

Material and Methods
The experiment, was laid out in Factorial completely randomized design with four treatments *viz*., T_1-2% calcium chloride, T_2-2% calcium chloride +Polyethylene bag (200 gauge), T_3-2% calcium chloride +Polyethylene bag (200 gauge) with 2% perforation, T_4-Control and two storage conditions, *viz*., ambient temperature (S_1) and cold storage (S_2) and replicated four times. For each treatment combination 95 freshly harvested ripe kokum fruits were selected per replication. Selected fruits were thoroughly washed with clean tap water to remove dirt and dust particles adhered to the pericarp of the fruit and then treated with calcium chloride (2% for 10 minutes) and packed in polyethylene bag as per the treatments. The treated fruits were stored at two different storage conditions *viz*. ambient storage (27-30 ºC) and cold storage (12 ± 2 ºC) and were analyzed for changes in physical parameters during storage.

Ten fruits from each treatment combination were selected for recording weight (g), volume (ml) and specific gravity while another 10 fruits from each treatment combination were selected for PLW (%). Twenty five fruits were thoroughly examined for spoilage (%) and shriveling (%). The end of shelf life was noted when the fruits showed >12 per cent PLW or spoilage. The results were analyzed statistically as per the methods suggested by Panse and Sukhatme (1967) [2]. The above observations were recorded at 5 days interval up to end of shelf life i.e. 0, 5, 10, 15, 20 and 25 days.

Results and Discussion

In this experiment, considering physiological loss in weight (Table 4) and spoilage percentage (Table 6) from 5th day onwards only cold storage fruits were kept for further study as the fruits stored at ambient temperature loss the shelf life as they showed PLW or spoilage more than 12 per cent. From 15th day onwards on the basis of spoilage, the fruits of interaction T_3S_2 were discarded and T_1S_2, T_2S_2 and T_4S_2 were kept for further study. From 20th day onwards on the basis of PLW only T_2S_2 was kept for further study.

The weight and volume of kokum fruits decreased gradually throughout the storage period and maximum decrease observed under ambient condition. The continuous decrease in weight (Table 1) and volume (Table 2) in both the storage conditions and treatments could be due to loss of moisture from the fruit through respiration and transpiration. Under both storage conditions treatment T_2 showed minimum decrease in weight, while among interactions, T_2S_2 recorded minimum loss in weight and volume throughout the storage period, except 5th day. This may be due to calcium application, which has been reported to be effective in terms of membrane integrity maintenance with lower losses of phospholipids and proteins and reduced ion leakage which could be responsible for the lower weight loss and retention of more moisture in unperforated polyethylene bag. Similar findings were also reported by the Bakshi (2013) [3] in peach and Khorshidi (2010) [4] in apple. There was no specific trend in specific gravity of the fruit with respect to treatments (Table 3). Specific gravity of fruits was decreased in ambient condition while in case of cold storage it was constant up to 10 day storage and after that it was increased slowly at 15th day of storage, irrespective of treatments. Increase in specific gravity of fruits after few days during storage, it means that depletion in volume of fruit was more than the corresponding decrease in weight. These findings are analogous to the findings of Pawar (2009) [5] in sapota.

Physiological loss in weight in stored kokum fruits continuously increased throughout the storage period (Table 4). The fastest and maximum increase in PLW was observed at ambient temperature as compared to cold storage. The low temperature and high humidity prevalent in cold storage may be responsible for reduction in PLW by reducing the rate of respiration and transpiration processes. The continuous increase in PLW in both the storage conditions and treatments could be due to loss of moisture from the fruit through respiration and transpiration. Findings of this study are supported by Jadhav (1996) [6], Geeta (2003) [7] and Nimbalkar (2004) [8] in kokum. Treatment T_2 recorded minimum PLW under both storage conditions followed by the T_3. In case of interactions, T_2S_2 recorded minimum PLW during storage. Fruits started shrivelling on 5th and 10th day under ambient and cold storage, respectively (Table 5). Percentage of shrivelled fruits from treatment T_1 and T_4 went on increasing throughout the storage period in both the storage conditions and it was zero with respect to treatments T_2 and T_3 throughout the storage. This may be the effect of polyethylene packaging which retained the moisture in fruits and avoided shriveling. The fruits stored at cold storage remained firm which resulted in minimum shrivelling as compared with ambient temperature storage. Such reduction in shrivelling was due to low temperature and high humidity conditions under cold storage. Among the interactions T_2S_1, T_3S_1, T_2S_2 and T_3S_2 do not showed shriveling up to the end of the shelf life. Nair (1986) [9], Anita (1994) [10] and Geeta (2003) [7] recorded similar results in kokum fruits.

Spoilage of kokum fruits increased with progress of storage, irrespective of treatments and storage conditions (Table 6). Maximum spoilage was noticed in ambient temperature stored fruits as compared to cold stored fruits. Bhosale (2002) [11] also recorded similar observations during storage of aonla fruits. Treatment T_4 (control) recorded minimum spoilage followed by treatment T_1 (2% calcium chloride), irrespective of storage conditions, while among all interactions, minimum spoilage was observed in T_4S_2 during storage. Under ambient condition the treatment T_2 recorded maximum spoilage followed by T_3. This may be due to deposition of more moisture in polyethylene package during storage at ambient condition. In case of cold storage maximum spoilage was recorded by T_3 followed by T_2, due to more attack of fungus in perforated polyethylene bags. While in unperforated polyethylene package more spoilage was due to deposition of moisture. These results are contradictory with the results obtained by Anita (1994) [10] and Geeta (2003) [7] during storage of kokum fruits. According to them rotting of fruits was delayed due to polyethylene packaging and fruit which were packed in perforated polyethylene bags showed late and minimum spoilage as compared to that of the unperforated polyethylene bag. With respect to shelf life, cold storage fruits recorded maximum shelf life as compared to ambient temperature stored fruits (Table 7). Among different interactions tried, maximum shelf life (22.5 days) was observed in T_2S_2 (2% calcium chloride +200 gauge polyethylene bag at cold storage) as the fruits recorded less PLW and spoilage.

From the present findings it can be concluded that calcium chloride treatments, polyethylene packaging and storage conditions improves the quality and shelf life of kokum fruits. Considering weight, volume, specific gravity, PLW, shriveling and spoilage, interaction T_2S_2 (2% of calcium chloride +200 gauge polyethylene bag and cold storage) was found to be best. The maximum shelf life (22.5 days) was recorded by this interaction.

Table 1: Effect of calcium chloride treatments and polyethylene packaging on weight (g) of kokum fruits during storage

Treatment	0 days			5 days			10 days			15 days			20 days			25 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	30.35	31.68	31.02	26.39 (-13.05)	30.30 (-4.36)	28.35 (-8.71)	-	28.88 (-8.85)	-	-	27.83 (-12.18)	-	-	26.54 (-16.24)	-	-	-	-
T_2	31.45	32.61	32.03	31.11 (-1.08)	32.10 (-1.56)	31.60 (-1.32)	-	32.03 (-1.76)	-	-	31.89 (-2.19)	-	-	31.73 (-2.71)	-	-	30.70 (-5.86)	-

T_3	33.23	33.54	33.39	31.95 (-3.85)	32.59 (-2.83)	32.27 (-3.34)	-	32.07 (-4.39)	-	-	31.48 (-6.16)	-	-	-	-	-	-	-	-
T_4	34.92	30.97	32.94	30.67 (-12.17)	29.67 (-4.20)	30.17 (-8.18)	-	28.40 (-8.28)	-	-	27.20 (-12.17)	-	-	25.76 (-16.81)	-	-	-	-	-
Mean	32.49	32.20	32.34	30.03 (-7.54)	31.16 (-3.24)	30.60 (-5.39)	-	30.35 (-5.82)	-	-	29.60 (-8.17)	-	-	-	-	-	-	-	-
	S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		
T	2.095	NS		0.056	0.221		-	-		-	-		-	-		-	-		
S	1.481	NS		0.039	0.156		-	-		-	-		-	-		-	-		
T×S	2.962	NS		0.079	0.312		-	-		-	-		-	-		-	-		

Figures in parenthesis indicates percent decrease in weight

T: Treatments
T1: 2% Calcium chloride
T2: 2% Calcium chloride +Polyethylene bag (200 gauge)
T3: 2% Calcium chloride +Polyethylene bag (200 gauge) with perforation (2%)
T4: Control

S: Storage conditions
S1: Ambient temperature (27-30 0C)
S2: Cold storage (12 + 1 0C)
T×S: Interactions (Treatment × Storage condition)
NS: Non Significant

Table 2: Effect of calcium chloride treatments and polyethylene packaging on volume (ml) of kokum fruits during storage

Treatment	0 days			5 days			10 days			15 days			20 days			25 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	25.10	26.13	25.61	22.22 (-11.47)	25.30 (-3.18)	23.76 (-7.32)	-	24.83 (-4.98)	-	-	23.85 (-8.71)	-	-	22.48 (-13.94)	-	-	-	-
T_2	28.08	29.00	28.54	27.72 (-1.28)	27.90 (-3.79)	27.81 (-2.53)	-	27.81 (-4.10)	-	-	27.21 (-6.18)	-	-	26.61 (-8.23)	-	-	26.21 (-9.63)	-
T_3	29.30	29.78	29.54	28.14 (-3.96)	29.18 (-2.02)	28.66 (-2.99)	-	28.38 (-4.70)	-	-	27.57 (-7.40)	-	-	-	-	-	-	-
T_4	29.43	24.58	27.00	26.61 (-9.58)	23.78 (-3.26)	25.19 (-6.42)	-	22.05 (-10.27)	-	-	21.38 (-12.99)	-	-	21.07 -(14.25)	-	-	-	-
Mean	27.98	27.37	27.67	26.17 (-6.57)	26.54 (-3.06)	26.35 (-4.82)	-	25.77 (-6.01)	-	-	25.00 (-8.82)	-	-	-	-	-	-	-
	S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%	
T	2.365	NS		0.023	0.093		-	-		-	-		-	-		-	-	
S	1.672	NS		0.017	0.066		-	-		-	-		-	-		-	-	
T×S	3.345	NS		0.033	0.131		-	-		-	-		-	-		-	-	

Figures in parenthesis indicates percent decrease in volume

T Treatments
T_1 2% Calcium chloride
T_2 2% Calcium chloride +Polyethylene bag (200 gauge)
T_3 2% Calcium chloride +Polyethylene bag (200 gauge) with perforation (2%)
T_4 Control

S Storage conditions
S_1 Ambient temperature (27-30 ^{0}C)
S_2 Cold storage (12 + 1 ^{0}C)
T×S Interactions (Treatment × Storage condition)
NS Non-Significant

Table 3: Effect of calcium chloride treatments and polyethylene packaging on specific gravity of kokum fruits during storage

Treatment	0 days			5 days			10 days			15 days			20 days			25 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	1.23	1.22	1.22	1.21 (-1.02)	1.20 (-1.64)	1.21 (-1.33)	-	1.17 (-4.25)	-	-	1.18 (-3.20)	-	-	1.20 (-1.99)	-	-	-	-
T_2	1.15	1.15	1.15	1.14 (-0.87)	1.18 (2.62)	1.16 (0.87)	-	1.16 (1.68)	-	-	1.19 (3.84)	-	-	1.21 (5.80)	-	-	1.19 (4.31)	-
T_3	1.15	1.16	1.15	1.15 (0.00)	1.15 (-0.86)	1.15 (-0.43)	-	1.17 (0.41)	-	-	1.18 (1.37)	-	-	-	-	-	-	-
T_4	1.21	1.28	1.25	1.18 (-2.47)	1.26 (-1.56)	1.22 (-2.02)	-	1.31 (2.45)	-	-	1.33 (3.71)	-	-	1.31 (1.85)	-	-	-	-
Mean	1.18	1.20	1.19	1.17 (-1.09)	1.20 (0.00)	1.18 (-0.72)	-	1.20 (0.00)	-	-	1.22 (1.43)	-	-	-	-	-	-	-
	S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%	
T	0.030	NS		0.063	0.249		-	-		-	-		-	-		-	-	
S	0.021	NS		0.045	0.176		-	-		-	-		-	-		-	-	
T×S	0.042	NS		0.089	0.352		-	-		-	-		-	-		-	-	

Figures in parenthesis indicates percent increase in specific gravity, however minus value indicates percent decrease

T Treatments
T_1 2% Calcium chloride
T_2 2% Calcium chloride + Polyethylene bag (200 gauge)
T_3 2% Calcium chloride +Polyethylene bag (200 gauge) with perforation (2%)
T_4 Control

S Storage conditions
S_1 Ambient temperature (27-30 ^{0}C)
S_2 Cold storage (12 + 1 ^{0}C)
T×S Interactions (Treatment × Storage condition)
NS Non-Significant

Table 4: Effect of calcium chloride treatments and polyethylene packaging on PLW (%) of kokum fruits during storage

Treatment	0 days			5 days			10 days			15 days			20 days			25 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	0.00	0.00	0.00	12.12	3.14	7.63	-	7.91	-	-	11.35	-	-	15.45	-	-	-	-
T_2	0.00	0.00	0.00	3.86	0.51	2.18	-	1.78	-	-	2.71	-	-	3.38	-	-	3.79	-
T_3	0.00	0.00	0.00	4.33	1.86	3.09	-	4.32	-	-	4.87	-	-	-	-	-	-	-
T_4	0.00	0.00	0.00	9.71	2.20	5.95	-	6.85	-	-	9.77	-	-	14.07	-	-	-	-
Mean	0.00	0.00	0.00	7.50	1.93	4.72	-	5.21	-	-	7.18	-	-	-	-	-	-	-
	S.Em+	C. D. at 1%		S.Em+	C. D. at 1%		S.Em+	C. D. at 1%		S.Em+	C. D. at 1%		S.Em+	C. D. at 1%		S.Em+	C. D. at 1%	
T	-	-		0.590	2.333		-	-		-	-		-	-		-	-	
S	-	-		0.417	1.650		-	-		-	-		-	-		-	-	
T×S	-	-		0.834	3.300		-	-		-	-		-	-		-	-	

T Treatments
T_1 2% Calcium chloride
T_2 2% Calcium chloride + Polyethylene bag (200 gauge)
T_3 2% Calcium chloride + Polyethylene bag (200 gauge) with perforation (2%)
T_4 Control

S Storage conditions
S_1 Ambient temperature (27-30 ^{0}C)
S_2 Cold storage (12 + 1 ^{0}C)
T×S Interactions (Treatment × Storage condition)
NS Non-Significant

Table 5: Effect of calcium chloride treatments and polyethylene packaging on shriveling (%) of kokum fruits during storage

Treatment	0 days			5 days			10 days			15 days			20 days			25 days		
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
T1	0.00	0.00	0.00	16.00	0.00	8.00	-	1.00	-	-	6.00	-	-	9.00	-	-	-	-
T2	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	0.00	-	-	0.00	-	-	0.00	-
T3	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	0.00	-	-	-	-	-	-	-
T4	0.00	0.00	0.00	16.00	0.00	8.00	-	0.00	-	-	7.00	-	-	11.00	-	-	-	-
Mean	0.00	0.00	0.00	8.00	0.00	4.00	-	0.25	-	-	3.25	-	-	-	-	-	-	-
	S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%	
T	-	-		1.000	3.955		-	-		-	-		-	-		-	-	
S	-	-		0.707	2.797		-	-		-	-		-	-		-	-	
T×S	-	-		1.414	5.594		-	-		-	-		-	-		-	-	

T Treatments
T_1 2% Calcium chloride
T_2 2% Calcium chloride +Polyethylene bag (200 gauge)
T_3 2% Calcium chloride +Polyethylene bag (200 gauge) with perforation (2%)
T_4 Control

S Storage conditions
S_1 Ambient temperature (27-30^{0}C)
S_2 Cold storage (12 + 1^{0}C)
T×S Interactions (Treatment × Storage condition)
NS Non-Significant

Table 6: Effect of calcium chloride treatments and polyethylene packaging on spoilage (%) of kokum fruits during storage

Treatment	0 days			5 days			10 days			15 days			20 days			25 days		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	0.00	0.00	0.00	20.00	0.00	10.00	-	0.00	-	-	3.00	-	-	9.00	-	-	-	-
T_2	0.00	0.00	0.00	48.00	0.00	24.00	-	1.00	-	-	7.00	-	-	10.00	-	-	12.00	-
T_3	0.00	0.00	0.00	44.00	0.00	22.00	-	5.00	-	-	16.00	-	-	-	-	-	-	-
T_4	0.00	0.00	0.00	18.00	0.00	9.00	-	0.00	-	-	1.00	-	-	4.00	-	-	-	-
Mean	0.00	0.00	0.00	32.50	0.00	16.25	-	1.50	-	-	6.75	-	-	-	-	-	-	-
	S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%		S.Em +	C. D. at 1%	
T	-	-		2.327	9.206		-	-		-	-		-	-		-	-	
S	-	-		1.646	6.510		-	-		-	-		-	-		-	-	
T×S	-	-		3.291	13.019		-	-		-	-		-	-		-	-	

T Treatments
T_1 2% Calcium chloride
T_2 2% Calcium chloride + Polyethylene bag (200 gauge)
T_3 2% Calcium chloride + Polyethylene bag (200 gauge) with perforation (2%)
T_4 Control

S Storage conditions
S_1 Ambient temperature (27-30 ^{0}C)
S_2 Cold storage (12 +1 ^{0}C)
T×S Interactions (Treatment × Storage condition)
NS Non-Significant

Table7: Effect of calcium chloride treatments and polyethylene packaging on shelf life (Days) of kokum fruits during storage

Treatment combination	Shelf Life (Days)
T_1S_1	Below 5
T_2S_1	Below 5
T_3S_1	Below 5
T_4S_1	Below 5
T_1S_2	16.25
T_2S_2	22.50
T_3S_2	10.00
T_4S_2	17.50

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