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Preservation of Mango Fruit (*Mangifera indica*, L.) Slices in Darfur

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Abstract: Sun drying of 'Kitchiner', 'Alphonse' and 'Dibsha' mango (*Mangifera indica*, L.) cultivars grown in Darfur, Sudan was conducted to enhance durability, utilization of mango fruits and to reduce the cost of transportation and storage. Slices were soaked in cane-sugar, lime-juice and sodium chloride. Moisture content, pH, titratable acidity, total soluble solids and ascorbic acid were measured initially and every three months. After six months, sensory acceptance of dried slices was determined for the attributes of aroma, flavour, texture and overall acceptance using a hedonic scale. Sugar and lime-juice were found good soaking solutions. Treated slices retained 53-78% of their original ascorbic acid after six months of storage. Panel test showed that dried slices of 'Kitchiner' were the most acceptable. Cane treated samples gave higher scores than lime or salt treated samples based on colour, flavour, taste and texture and is suggested as preservative material for mango slices.

Key words: Mango slices, *Mangifera indica*, dehydration, cane-sugar, lime-juice

INTRODUCTION

Mangoes are grown in tropical and subtropical regions with India leading world production. The fruit is a good source of fibers and vitamins (Tedjo *et al*., 2002) and is described as the most favorite and valuable fruit in world market (Olli *et al*., 1996). Besides, the fruit is rich in antioxidants and therefore, reduces the risk of cardiac disease, anti cancer and anti viral activities (Schieber *et al*., 2003; Barreto *et al*., 2008; Daud *et al*., 2010). Daud *et al*. (2010) indicated that the mangiferin present in mango extracts may have health promoting effects in diseases related to the impaired formation of new blood vessels. In Sudan, mangoes are both popular and valuable fruits. The success of mango cultivation in Sudan could be attributed to the diverse environmental conditions across the country, which extends the fruiting season to eleven months a year (Saeed *et al*., 1975; El Mahdi and El Awad, 1984). In some areas of Darfur mangoes bear fruits twice a year. However, due to poor transportation and storage facilities, mangoes produced in remote areas of Darfur are sold at very low prices compared to prices offered in Khartoum (Ahmed and Ahmed, 2012). To rectify this situation fruits could either be harvested at optimum maturity to extend the shelf-life or preserved into products acceptable in urban communities. Ahmed and Ahmed (2012) studied optimum harvest maturity of mangoes in Darfur and indicated that optimum dates for harvesting 'Kitchiner', 'Alphonse' and 'Dibsha' mango cultivars were 15 and 16, 16 and 17 weeks after flowering, respectively. In this study we explored the dehydration of mango fruits into fruit slices.

Drying is one of mankind's oldest methods of food preservation copied from nature (Desrosier and Desrosier, 1977). Sun-drying is simple and inexpensive compared to dehydration. Dehydrated fruits undergo browning as a result of cellular disruption in the presence of oxygen during peeling, slicing and other preparations before processing (Uzuegbu and Ukeka, 1987). Enzymes, substrate and oxygen are all required for browning (Barreto *et al*., 2008). The activity of polyphenolase enzyme is totally inactivated by heating, decreasing moisture content below 1%, increasing solutes or soluble solids concentrations in plant tissues and by chemical inhibition (Desrosier and Desrosier, 1977; Njoku *et al*., 2011). Desrosier and Desrosier (1977) found that ascorbic acid and beta-carotene were subjected to damage by oxidative processes.

Addition of sulphite to the product before storage inhibits enzymic and nonenzymic browning during storage (Bolin and Steele, 1987). Abdelgader and Ismail (2011) showed that treatment with sodium metabisulphite solution was the best in keeping the nutritive value of mango slices (ascorbic acid). Pott *et al*. (2005) developed an optimum drying routine for producing non-sulphated mango slices. Drying air temperature and drying time were shown to be the primary factors influencing product colour and water activity (Pott *et al*., 2005).

Several additives are used in preservation of mango fruits slices including Gum Arabic (Abdelgader and Ismail, 2011), sucrose (Uzuegbu and Ukeka, 1987; Gujral and Khanna, 2002; Madamba and Lopez, 2006; Moy *et al*., 2007), organic acids (Moy *et al*., 2007), soy

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protein and skim milk powder (Gujral and Khanna, 2002) and rosmarinic and citric acids (Hakkim *et al*., 2012). Addition of Gum Arabic to mango slices prevented browning (Abdelgader and Ismail, 2011). Gujral and Khanna (2002) found that soy protein concentrate lowered the sensory acceptability of mango leather whereas sucrose and skim milk powder at levels of 4.5% each resulted in mango leather with the highest acceptability. Combining acid and sucrose was found to increase moisture removal from papaya by inhibiting gelation (Moy *et al*., 2007). Hakkim *et al*. (2012) reported that rosmarinic acid at 500 µg ml^{-1} significantly reduced browning, maintained the pH and restricted growth of micro-organisms on fresh-cut apple slices. However, due to its low cost, sucrose is the most commonly used additive in mango fruit processing (used for sweetening and preservation). Sucrose is also used for inhibition of enzymes, prevention of browning and osmotic dehydration (Uzuegbu and Ukeka, 1987).

Osmotic dehydration is a complementary treatment in processing dehydrated foods, since it presents some advantages such as minimizing heat damage to colour and flavour, inhibiting enzymatic browning and reducing energy costs (Alakali *et al*., 2006). The technique aims to dehydrate food products by immersing in a hypertonic solution. Water is removed due to difference in osmotic potential between food and the osmotic solution, reducing water activity of food and consequently water availability for chemical and biological deterioration (Torres *et al*., 2006; Torres *et al*., 2007). The increase in solids concentration in fruit slices is achievable by osmosis (Sablani and Rahman, 2003; Hawkes and Flink, 2007). Azoubel and da Silva (2008) indicated that optimum conditions to obtain water removal could be achieved using sucrose at 44% (w/w), temperatures up to 38 C and immersion time up to 80 min.

Drying time, drying temperature and slice thickness are important factors in mango slice preservation. Pott *et al*. (2005) found that drying for 6 h at elevated air temperature of 80°C was optimal, instead of drying for a longer time at 50 or 60°C. No significant colour changes in mango slices were observed, without any chemical or thermal pre-treatment (Pott *et al*., 2005). At increased temperature, drying time was considerably shortened from about 9 h to 6 h, resulting in significant extension of the drying capacity (Pott *et al*., 2005). Pott *et al*. (2005) suggested a novel simple drying method instead of more sophisticated technologies. Rai and Chauhan (2008) reported that the shelf life of papaya-cereal flakes stored at room temperature and 37°C was 40 days, but at 4°C the shelf life of the product was extended to 60 days. Madamba and Lopez (2006) osmotically dehydrated fresh mango slices using four treatment variables: treatment time, temperature, sugar concentration and slice thickness. Treatment variables significantly affected weight reduction, while sugar gain and moisture content were only significantly affected by slice thickness (Madamba and Lopez, 2006). Optimum conditions generated were: treatment time of 6 h, temperature of 35°C and sugar concentration of 65% (w/w) for 5 mm slice thickness (Madamba and Lopez, 2006).

The objectives of this investigation were to study the effect of using different additives materials, locally available and drying methods on the quality of dried mango slices.

MATERIALS AND METHODS

Plant material: Mango fruits of 'Kitchiner', 'Alphonse' and 'Dibsha' cultivars were obtained from trees grown in an orchard located in 'Kajja' Valley at El-Geniena, Western Darfur State, Sudan. Mango trees of each cultivar were uniform in appearance and vigor. All trees received the same cultural practices and a single application of farm manure applied annually following harvest and prior to the beginning of the rainy season.

Preparation of mango slices for drying: A sample size consisting of 40 uniform, firm and ripe fruits was handpicked from each cultivar. Selected fruits were divided into two lots of 20 fruits each. The first lot was cleaned-up using tap water to remove dirt and dust, weighed and then peeled with a stainless steel knife. After cutting-up into slices of 7 mm thick, 4 kg of mango flesh was obtained.

Additives for preserving mango slices: Three different additives, namely: cane-sugar, sodium chloride and lime-juice were used to preserve the slices from spoilage and deterioration during storage. Three mixtures were made with these additives. The mixtures consisted of 200 g of additive dissolved into 1 litre water. One kg of the mango flesh was soaked into each of the mixtures for one hour. After soaking, the prepared mango slices were spread out on a plastic wiremesh frame (Plate 1). The frame measured 200 x 75 cm and fixed on poles 150 cm above ground level. The prepared samples were left to dry under sun for two days.

The second lot of fruit samples were prepared and treated likewise. They were putout to dry in the shade for two days also.

Packaging and storage of dried mango slices: After drying, processed samples of mango slices (Plate 2) were packed. Packaging was done separately into thin polyethylene bags and then kept in a Styrofoam container (30 x 40 x 50 cm). Processed samples were stored at room temperature of 30°C for 0, 3 and 6 months prior to analysis. Temperature inside the container was between 25-30°C from July to October and 20-25°C from October to December.

Plate 1: After soaking in cane-sugar, NaCl and lime juice, prepared slices were spread out on a plastic wiremesh frame and left to dry under sun for 2 days. A second lot of slices prepared and treated likewise, then spread to dry in the shade for 2 days

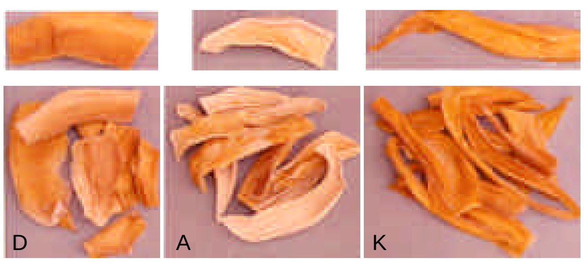

Plate 2: Dried Mango Slices. D: 'Dibsha' slices; A: 'Alphonse' slices; K: 'Kitchiner' slices

Analytical procedure

Drying ratio: The drying ratio of each cultivar was calculated using the following formula described by Ranganna (1979).

$$\text{Drying ratio} = \frac{\text{Weight of prepared samples}}{\text{Weight of dried samples}}$$

Moisture content (%): The toluene distillation method of Ranganna (1979) was used to determine the percentage moisture content of mango slices.

pH Determination: The pH value of processed samples was measured using a rehydration ratio of 1:10 (Ranganna, 1979). To 10 g of dried mango sample, 100 ml of distilled water was added and then blended. The pH of this mixture was measured by a Griffin pH meter model 40.

Titratable acidity (% citric acid): The acidity as % citric acid of rehydrated mango slices was determined by titrating to pH 8,2 with 0,1 N sodium hydroxide (NaOH) as described by Ranganna (1979).

Total soluble solids-TSS (°Brix): Dried samples were rehydrated by adding 100 ml distilled water to 10 g of dried sample. TSS was measured directly from the suspension using a Kruss hand refractometer model HRN-32.

Ascorbic acid determination: The 2,6-dichlorophenalindophenol titration method of Ruck (1963) was used for determination of ascorbic acid content of all dried samples.

Both physical and chemical analyses of processed samples were done at the beginning of the experiment, after three and then after six months of storage to evaluate the keeping quality of the product.

Organoleptic test: After six months of storage, well trained ten panelists evaluated the quality of preserved mango slices according to colour, flavour, taste, texture and overall acceptability. A 10-point hedonic score of 1 to 10 was utilized, where: 1 = an off product, 2-3 = poor, 4-6 = fair, 7-9 = good and 10 = perfect product, according to the score table prepared by the Dehydration Section of the Food Research Centre, Shambat, Sudan.

Experimental design: The experiments were designed as split-split-plots. The three cultivars formed the main treatment and additive materials formed the sub-plots. Additive concentrations and storage periods formed the sub-sub-plot treatment.

RESULTS AND DISCUSSION

Preservation of fruits assures stable markets and enables expansion in production without fear of changes in demand and supply. Removal of moisture brings about substantial reduction in weight and volume, minimizes packaging and transportation costs and enables long time storability of the product under ambient temperatures. The principles of dehydration are essentially based on inhibition of micro-organisms activity and enzymatic reactions which have deleterious effects on palatability and nutritional value of the product (Desrosier and Desrosier, 1977). These can be controlled by addition of preservative materials or by limitation of available water (Alakali *et al*., 2006; Torres *et al*., 2006; Torres *et al*., 2007).

In this study, preservation of mango slices by limitation of available water was used to prevent the loss of seasonal surplus of mangoes in El Geniena, Western Darfur. In this remote area, lack of functional storage facilities and inadequate transportation hinders marketing of fresh mango produce.

Table 1: Effects of different additive materials, drying methods and storage periods on moisture content (%) of dried slices of the three mango cultivars

Mango cultivar	Additive material	Drying method	% Moisture content at different storage periods (in months) 0	3	6
Kitchiner	Cane-sugar	Sun	6.91	6.28	5.08[z]
		Shade	7.32	6.38	5.20[z]
	Lime-juice	Sun	9.41	8.42	7.70[y]
		Shade	9.72	8.48	7.62[y]
	Salt	Sun	10.70	9.48	8.13
		Shade	11.00	9.48	7.93
	Control	Sun	9.75	8.95	8.00
		Shade	10.40	9.50	8.50
Alphonse	Cane-sugar	Sun	9.03	8.30	7.42[z]
		Shade	8.98	8.05	6.72[z]
	Lime-juice	Sun	10.12	8.63	7.55[y]
		Shade	10.13	8.85	7.85[y]
	Salt	Sun	11.82	9.25	8.15
		Shade	12.27	10.12	8.80
	Control	Sun	9.15	7.70	6.75
		Shade	9.40	7.75	6.75
Dibsha	Cane-sugar	Sun	7.87	6.35	4.88[z]
		Shade	8.22	6.52	4.88[z]
	Lime-juice	Sun	9.58	7.95	5.93[y]
		Shade	10.78	9.18	6.73[y]
	Salt	Sun	11.72	10.08	7.55
		Shade	11.77	10.57	8.05
	Control	Sun	8.10	7.50	6.25
		Shade	8.40	7.85	6.25

[z] = (cultivar x cane-sugar additive x 6 months storage): $LSD_{.05}$ = 1.08%
[y] = (cultivar x lime-juice additive x 6 months storage): $LSD_{.05}$ = 1.08%

Drying ratio: The drying ratio for 'Kitchiner', 'Alphonse' and 'Dibsha' mango slices were found to be 5:1, 4.5:1 and 6:1, respectively.

Moisture content: Sun-drying reduced moisture content in mango slices compared to shade-drying, regardless of the cultivar (Table 1). Also, additive materials or storage period did not show any differences of importance. Cane-sugar treated samples showed a lower moisture content in mango slices obtained from the three cultivars throughout the storage period compared to other additives (Table 1).

The moisture content range of dried mango slices was 4.88-12.27% regardless of cultivar, additive material, drying method and storage period (Table 1). This moisture range is within safety range for both fungal and bacterial growth. These results are consistent with those of Gujral and Khanna (2002), Pott *et al.* (2005) and Abdelgader and Ismail (2011) on mango leather and slices. Gujral and Khanna (2002) recommended 10% moisture for the highest acceptability of dried mango leather. Abdelgader and Ismail (2011) reported a moisture content of 3.79% after 9 months in 'Kitchiner' slices treated with Gum Arabic. Pott *et al.* (2005) indicated that microbiological stability of dried slices was achieved at a moisture content of 17% and suggested simple drying methods instead of choosing technically more sophisticated technologies. In this connection, slices were simply dried under the sun which is suitable to the weather in Darfur. However, final moisture content of mango slices was significantly affected by slice thickness (Madamba and Lopez, 2006) and geometry (Sablani and Rahman, 2003).

The pH: Data in Table 2 show that the pH of mango slices tended to remain constant regardless of cultivar, additive material, drying method and storage period. However, significant differences in pH values occurred only in samples treated with cane-sugar, either sun or shade dried and then stored for 0, 3 and 6 months (Table 2). Thus, after 6 months of storage, the pH of cane-sugar treated 'Kitchiner' slices reached 3.88 and 3.68 under sun and shade, respectively (Table 2). These results agree with those reported by Abdelgader and Ismail (2011) and Bernardi *et al.* (2009). The lower value of pH and its stability throughout the storage period may indicate purity of dried mango slices and hence prevents microbial contamination. This was supported by findings by Moy *et al.* (2007) on dehydration of papaya and Hakkim *et al.* (2012) on fresh-cut apple slices. Hakkim *et al.* (2012) showed that citric acid maintained apple slices at acidic condition for 10 days. Combining organic acids and sucrose was found to increase moisture removal from papaya by inhibiting gelation (Moy *et al.*, 2007).

Table 2: Effects of different additive materials, drying methods and storage periods on pH value of dried slices of the three mango cultivars

Mango Cultivar	Additive material	Drying method	pH value at different storage periods (in months) 0	3	6
Kitchiner	Cane-sugar	Sun	3.93[z]	3.93[z]	3.88[y]
		Shade	3.92	3.90	3.86
	Lime-juice	Sun	3.44	3.46	3.43
		Shade	3.54	3.56	3.52
	Salt	Sun	2.72	2.77	2.85
		Shade	2.84	2.91	2.85
	Control	Sun	3.88	3.87	3.68
		Shade	3.78	3.78	3.75
Alphonse	Cane-sugar	Sun	3.57[z]	3.57[z]	3.57[y]
		Shade	3.70	3.74	3.74
	Lime-juice	Sun	3.32	3.33	3.33
		Shade	3.29	3.34	3.34
	Salt	Sun	3.05	3.04	3.04
		Shade	3.10	3.12	3.12
	Control	Sun	3.75	3.78	3.78
		Shade	3.67	3.68	3.68
Dibsha	Cane-sugar	Sun	3.38[z]	3.38[z]	3.38[y]
		Shade	3.29	3.29	3.29
	Lime-juice	Sun	3.11	3.11	3.12
		Shade	3.07	3.07	3.08
	Salt	Sun	2.89	2.89	2.89
		Shade	2.90	2.90	2.90
	Control	Sun	3.31	3.31	3.35
		Shade	3.17	3.17	3.21

[z]** = (cane-sugar x 0 and 3 months storage): $LSD_{.05}$ = 0.07, $LSD_{.01}$ = 0.09

[y]** = (cane-sugar x 6 months storage): $LSD_{.05}$ = 0.2, $LSD_{.01}$ = 0.3

Titratable acidity: Titratable acidity (% citric acid) of mango dried slices was in the range of 1.34-6.54% (Table 3). Preservation of citric acid in dried mango slices was significantly affected by the different cultivars and additive materials used (Table 3). Sodium chloride was found to preserve more citric acid than lime juice and cane-sugar (Table 3). These results disagree with those of Rai and Chauhan (2008) and Abdelgader and Ismail (2011) but however, is supported by the findings of Awad *et al.* (1989) where a concentration of 1.7 mg/100 g citric acid in dried slices of 'Kitchiner' cultivar was reported.

Total soluble solids-TSS (°Brix): Although there were some variations in TSS of the different mango cultivars, no differences in TSS of dried mango slices were recorded (Table 4). These results confirm findings by Abdelgader and Ismail (2011). Awad *et al.* (1989) found 65% total sugar, 47% reducing sugar and 17% sucrose in sun-dried 'Kitchiner' slices.

Ascorbic acid: A reduction in ascorbic acid content of mango slices occurred in the three cultivars, but however, slices retained 53-78% of their original ascorbic acid after six months of storage at room temperature (Table 5). Cane-sugar treated slices tended to contain lower amounts of ascorbic acid compared to lime-juice or salt treated samples (Table 5). Lime-juice significantly raised the levels of ascorbic acid, at the beginning and after 6 months, in sun-dried mango slices obtained from 'Kitchiner' cultivar compared to 'Alphonse' and 'Dibsha' cultivars (Table 5). This is supported by Rai and Chauhan (2008), Abdelgader and Ismail (2011) and Njoku *et al.* (2011). The reduction in ascorbic acid could be attributed to the oxidation of ascorbic acid, which was accelerated by light, oxygen and storage temperature (30°C). Similarly, Rai and Chauhan (2008) attributed losses in ascorbic acid to its sensitivity to light and heat, or to its oxidation at high temperature (Njoku *et al.*, 2011). In this study, the packaging material (polythene) offers no protection against light, oxygen or heat. Sun-dried samples from all cultivars were found to contain higher levels of ascorbic acid compared to shade-dried samples (Table 5). This high retention of ascorbic acid by sun-dried samples might be due to quick evaporation of water from the slices and hence concentration of soluble solids which inhibited the reaction of polyphenolase enzymes (Desrosier and Desrosier, 1977).

Sensory evaluation: The overall score of panel test showed that dried slices of 'Kitchiner' were the most acceptable followed by 'Alphonse' and then 'Dibsha', regardless of additive material used (Table 6). Cane-

Table 3: Effects of different additive materials, drying methods and storage periods on citric acid content (%) of dried slices of the three mango cultivars

Mango cultivar	Additive material	Drying method	(%) Citric acid content at different storage periods (in months) 0	3	6
Kitchiner	Cane-sugar	Sun	1.82	1.82	1.93
		Shade	1.85	1.85	1.83
	Lime-juice	Sun	3.42	3.42	3.86
		Shade	3.69	3.69	3.89
	Salt	Sun	4.29	4.29	4.47
		Shade	4.40	4.40	4.49
	Control	Sun	1.34	1.34	1.86
		Shade	1.40	1.40	2.14
Alphonse	Cane-sugar	Sun	3.06	3.06	3.06
		Shade	2.57	2.57	2.57
	Lime-juice	Sun	3.21	3.21	3.21
		Shade	3.23	3.23	3.23
	Salt	Sun	2.62	2.62	2.62
		Shade	3.42	3.42	3.42
	Control	Sun	2.07	2.07	2.07
		Shade	2.44	2.44	2.44
Dibsha	Cane-sugar	Sun	4.65	4.65	4.65
		Shade	4.60	4.60	4.60
	Lime-juice	Sun	4.93	4.93	4.90
		Shade	4.95	4.95	5.08
	Salt	Sun	6.54	6.54	6.54
		Shade	6.54	6.54	6.41
	Control	Sun	4.40	4.40	4.40
		Shade	4.62	4.62	4.57

^{z*} = (cultivar x cane-sugar additive): $LSD_{.05}$ = 1.8%

^{y**} = (cultivar x salt additive): $LSD_{.05}$ = 1.6%, $LSD_{.01}$ = 2.1%

Table 4: Effects of different additive materials, drying methods and storage periods on total soluble acids TSS (°Brix) of dried slices of the three mango cultivars

Mango Cultivar	Additive material	Drying method	TSS (°Brix) content at different storage periods (in months) 0	3	6
Kitchiner	Cane-sugar	Sun	20	20	20
		Shade	20	20	20
	Lime-juice	Sun	20	20	20
		Shade	19.3	19.3	19.3
	Salt	Sun	20	20	20
		Shade	20	20	20
	Control	Sun	20	20	20
		Shade	20	20	20
Alphonse	Cane-sugar	Sun	21	20.7	20.7
		Shade	20	20	20
	Lime-juice	Sun	20	20	20
		Shade	20	20	20
	Salt	Sun	20	20	20
		Shade	20	20	20
	Control	Sun	20	20	20
		Shade	20	20	20
Dibsha	Cane-sugar	Sun	20	20	20
		Shade	20	20	20
	Lime-juice	Sun	20	20	20
		Shade	20	20	20
	Salt	Sun	20	20	20
		Shade	20	20	20
	Control	Sun	20	20	20
		Shade	20	20	20

sugar treated samples taken from the three cultivars or controls gave higher scores than lime-juice or salt-treated samples as far as colour, flavour, taste and texture were concerned. These results were in agreement with those presented by Desrosier and Desrosier (1977), Rai and Chauhan (2008) and

Table 5: Effects of different additive materials, drying methods and storage periods on ascorbic acid content (mg/100 g) of dried slices of the three mango cultivars

Mango Cultivar	Additive material	Drying method	Ascorbic acid (mg/100g) at different storage periods[†] (in months) 0	3	6
Kitchiner	Cane-sugar	Sun	31.21	28.85	22.30
		Shade	27.59	24.24	18.30
	Lime-juice	Sun	58.75[y]	56.13	45.80[x]
		Shade	38.06	33.69	31.16
	Salt	Sun	69.29	68.32	64.30
		Shade	60.69	57.89	54.78
	Control	Sun	45.18	38.50	27.20
		Shade	26.05	23.63	15.51
Alphonse	Cane-sugar	Sun	32.13	29.01	18.87
		Shade	30.26	27.85	16.49
	Lime-juice	Sun	38.27[y]	35.24	26.77[x]
		Shade	39.96	35.23	27.03
	Salt	Sun	91.25	89.29	69.82
		Shade	77.11	75.34	61.32
	Control	Sun	26.35	22.50	12.16
		Shade	28.30	22.60	14.82
Dibsha	Cane-sugar	Sun	21.46	16.78	11.76
		Shade	23.52	18.06	6.46
	Lime-juice	Sun	29.53[y]	24.73	6.40[x]
		Shade	29.53	24.29	6.56
	Salt	Sun	46.95	44.36	36.91
		Shade	45.54	43.03	36.41
	Control	Sun	20.21	15.26	11.12
		Shade	19.00	14.56	10.21

[z]** = (cultivar x cane-sugar x storage period): $LSD_{.05}$ = 1.3, $LSD_{.01}$ = 5.9.

[y]* = (cultivar x lime-juice x 0 months storage): $LSD_{.05}$ = 10.4.

[x]* (cultivar x lime-juice x 6 months storage): $LSD_{.05}$ = 11.2.

[†](mg/100 g) Periods

Table 6: Effects of using different additive materials on panel test evaluation of dried slices of the three mango cultivars after 6 months of storage

Mango Cultivar	Additive material (20%)	Colour	Flavour	Taste	Texture	Overall acceptability
Kitchiner	Cane-sugar	7.80	6.83	7.30	6.52	7.17
	Lime-juice	6.50	5.80	7.11	6.33	6.00
	Salt	7.20	6.00	6.67	7.13	5.50
	Control	7.00	7.50	7.30	7.13	7.45
	Mean	7.13	6.53	7.60	6.78	6.53
Alphonse	Cane-sugar	7.50	6.00	7.56	7.20	8.11
	Lime-juice	6.50	5.20	6.13	6.83	5.50
	Salt	6.88	5.50	5.63	6.00	5.20
	Control	7.50	5.75	7.45	7.50	7.85
	Mean	7.08	5.61	6.94	6.88	6.67
Dibsha	Cane-sugar	7.70	7.50	7.17	6.33	6.80
	Lime-juice	5.15	5.45	6.20	5.80	4.50
	Salt	6.78	6.00	6.20	6.13	5.20
	Control	7.59	6.67	6.50	6.45	5.50
	Mean	6.81	6.41	5.89	6.18	5.50

Bernardi *et al.* (2009). Gujral and Khanna (2002) indicated that sucrose resulted in the highest acceptability in mango leather. These findings strengthen the efficiency of using cane-sugar as preservative material for mango slices.

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