Effect of Replacing Sucrose with Fructose on the Physico-chemical Sensory Characteristics of Kinnow Candy

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Abstract

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We determine the effect of substitution of sucrose with fructose on the physico-chemical composition and sensory characteristics of kinnow candy. Candy was prepared with peel using sucrose and fructose at the ratio of 100:0, 0:100, 75:25, 50:50, and 25:75 with 70 °B of TSS. Organoleptically, the candy prepared with 100% fructose proved the best but the candy prepared with 25:75 of sucrose to fructose was equally good. The least acceptable was the candy prepared with 100% sucrose, as it had a dull appearance and slight crystallisation was observed during storage. Moisture, acidity and ascorbic acid decreased while total soluble solids, reducing and total sugars and limonin increased with no change in ash content of the candies during four months of storage.

Keywords: limonin; organoleptical characteristics; bitterness; flavour; texture

Kinnow is a hybrid between King Mandarin and Willowleaf (Mediterranean) mandarin (*Citrus nobilis* × *Citrus deliciosa*). It is the number one fruit of Punjab both from the area and production aspect with 4000 ha of area and 7.3 lakh MT of annual production (Anonymous 2009). Kinnow is known for its superior characteristics such as heavy bearing, wide adaptability, fruit quality and high juice content (Nagar 1993). The peel of the fruit, which is generally considered a waste, is more nutritious than juice and can be processed along with fruit in the form of candies. The preparation of candy with peel involves 100% utilisation of the fruit whereas in the preparation of juices/pulps around 50% part of the fruit goes waste as juice residue (Lal *et al*. 1986). In the case of kinnow juice preparation, bitterness develops in the juice after extraction due to conversion of limonate-A-ring to limonin as delayed bitterness. Kinnow candy with peel can also be used in the baking industry in the preparation of cakes, cookies, steamed puddings, sweet breads, mixed candied fruits, and in marmalades (Mehta & Bajaj 1984).

Fructose has been found useful in the production of confectionary, canned fruits, jams, marmalades, and ice cream. Generally, candies made with sucrose have a dull appearance which is not much liked by the consumers (Siddique *et al*. 1990). Duxbury (1992) reviewed the advantages of fructose like prevention of crystallisation, increased stability, improvement of flavour and texture and reduction of calories over sucrose.

Therefore, this study was undertaken to elucidate the use of fructose in the manufacture of kinnow candy and to determine the suitability and level of fructose in its preparation. Thereby, it helps in reducing the bitterness of kinnow and increases its acceptability by candy making.

MATERIAL AND METHODS

The experiment was conducted in the Food Science and Technology Department, Punjab Agricultural University, Ludhiana. Kinnow was procured from the local market of Ludhiana.

After sorting and grading, the fruits of almost uniform size were selected and washed. After washing, the fruit with peel was cut vertically. Then the seeds were removed and the pieces were pricked.

To obtain the best texture the fruit was dipped in a (4%) calcium hydroxide solution for overnight. After calcium hydroxide treatment the fruit was washed with warm water two to three times. On the other hand, the syrup was prepared with different proportions of sucrose and fructose of 100:0, 0:100, 75:25, 50:50, and 25:75.

The pre-treated samples were then dipped in 55% syrup with 0.3% of citric acid and cooked for 2 to 3 min with gentle stirring. It was then kept for equilibration overnight. At this stage the ratio of the syrup to fruit was 2:1. Next day degree Brix of the syrup was increased by 10%, partially by heating at 90°C and partially by the addition of more osmotic agent. It was left for equilibration overnight again. In this manner raising 10 °B daily, the process was continued until the total soluble solid content of the syrup was stabilised at 70%.

The fruit was kept in 70% syrup for about one week. Then the syrup was drained and drying of candy was done at 55°C for 6–7 h in a hot air oven to 16–17% moisture. The samples were packed in polyethylene bags and stored at room temperature for four months.

Physico-chemical analysis. Fresh fruit (without peel), peel and candy (with peel) were analysed (3 replicates of each sample) for total soluble solids using an Abbe refractometer (Erma, Tokyo, Japan) at 20 ± 1°C. Moisture content, acidity (as citric acid), ascorbic acid, reducing and total sugars and ash were determined according to Ranganna (1995). Limonin content was estimated using the colourimetric method of Vaks and Lifshitz (1981) and colour was analysed using a Minolta spectrophotometer in the HunterLab colour mode.

Sensory analysis. Candy was evaluated organoleptically at monthly intervals by a semi-trained panel of eight members. The sensory evaluation was carried out for appearance, flavour, texture and overall acceptability using a 9-point hedonic scale (Amerine *et al*. 1965).

Statistical analysis. The data collected was statistically analysed and subjected to analysis of variance using a completely randomised design to check the significant effect ($P \leq 0.05$) as discussed by Cochran and Cox (1957).

RESULTS AND DISCUSSION

The physicochemical parameters of the fresh kinnow fruit are shown in Table 1. The L^*, a^*, and b^* values analysed on HunterLab colour parameters were observed to be 50.22, 15.97, and 38.42, respectively. Moisture content, total soluble solids, and titratable acidity were found to be 87.12, 10.8, and 0.69%. The ascorbic acid of the fresh fruit was recorded as 18.49 mg/100 g. Total and reducing sugars and ash content were found to be 4.39, 2.86, and 0.46%. Limonin in kinnow was found to be 25 ppm.

The L^*, a^*, and b^* values of the kinnow fruit peel (Table 1) analysed on HunterLab colour parameters were 57.49, 38.55, and 73.27, respectively. Moisture content and total soluble solids were recorded as 78.09 and 12.42%. The kinnow peel was found to contain 1.53% titratable acidity, 40.72 mg/100 g ascorbic acid, 5.97% reducing sugars, and 7.36% total sugars. The ash content was observed to be 0.53% and limonin to be 459 ppm.

The initial data on a comparison of osmotic agents and their combinations is documented in Table 2. It was observed that with the same acidity (0.18%) and TSS (70%) there was a significant difference between the L^*, a^*, and b^* values of the samples. Organolepti-

Table 1. Physico-chemical characteristics of fresh kinnow fruit and its peel (n = 3)

Sample No.	Parameters		Whole fruit	Fruit (peeled)	Peel
1	Hunter colour parameters	L^*	53.9 ± 1.00	50.2 ± 1.1	57.5 ± 0.90
		a^*	27.3 ± 0.90	16.0 ± 0.93	38.6 ± 0.99
		b^*	55.5 ± 0.35	38.4 ± 1.0	73.3 ± 0.65
2	moisture content (%)		82.6 ± 0.75	87.1 ± 0.99	78.1 ± 0.57
3	total soluble solids (%)		11.6 ± 0.58	10.8 ± 0.57	12.4 ± 0.59
4	titratable acidity (%)		1.0 ± 0.06	0.69 ± 0.06	1.5 ± 0.06
5	ascorbic acid (mg/100 g)		29.6 ± 0.5	18.5 ± 0.59	40.7 ± 0.51
6	reducing sugars (%)		4.5 ± 0.4	2.9 ± 0.36	6.0 ± 0.50
7	total sugars (%)		5.8 ± 0.7	4.4 ± 0.57	7.4 ± 0.69
8	limonin (ppm)		225 ± 0.5	25.0 ± 0.93	459 ± 2.0
9	ash (%)		0.5 ± 0.06	0.46 ± 0.06	0.53 ± 0.06

Table 2. Effect of different osmotic agents and their combinations on physico-chemical (n = 3) and organoleptic (n = 8) parameters of candy

Parameters		S (100:0)	F (100:0)	S:F (75:25)	S:F (50:50)	S:F (25:75)	CD ($P \leq 0.05$)
Hunter colour parameters	L^*	39.1 ± 0.29	24.5 ± 0.5	37.2 ± 1.4	36.9 ± 1.3	36.7 ± 0.5	0.02
	a^*	14.2 ± 0.8	7.6 ± 0.5	23.0 ± 0.9	23.8 ± o.53	23.2 ± 1.4	0.03
	b^*	20.0 ± 1.0	10.7 ± 0.37	19.9 ± 0.29	19.9 ± 0.45	19.4 ± 0.99	0.03
Moisture (%)		16.9 ± 0.29	17.5 ± 0.79	17.0 ± 0.33	16.7 ± 0.29	17.8 ± 0.35	0.36
Acidity (%)		0.18 ± 0.02	0.18 ± 0.03	0.18 ± 0.04	0.18 ± 0.02	0.18 ± 0.03	ns
TSS (%)		70 ± 1.09	70 ± 0.57	70 ± 1.6	70 ± 1.3	70 ± 1.2	ns
Organoleptic parameters							
Appearance		7.0 ± 0.21	9.0 ± 0.29	7.8 ± 0.36	8.0 ± 0.21	8.5 ± 0.78	0.73
Flavour		7.2 ± 0.22	8.5 ± 0.71	7.6 ± 0.80	7.9 ± 0.22	8.1 ± 0.22	0.69
Texture		7.0 ± 0.22	8.4 ± 0.57	7.3 ± 0.16	7.6 ± 0.37	8.0 ± 0.45	0.84
Overall acceptability		7.0 ± 0.14	8.6 ± 0.22	7.6 ± 0.22	8.0 ± 0.24	8.4 ± 0.37	0.66

S – sucrose; F – fructose

cally, overall acceptability (8.62) was the highest for 100% fructose, followed by sucrose: fructose in the ratio of 25:75 (8.43), 50:50 (8.00), and 75:25 (7.58). The least acceptable was the sample with 100% sucrose (7.00). The sample with 100% fructose was scored the highest because of its bright appearance and improved flavour and texture as compared to the other samples (Figure 1).

The effect of storage on physico-chemical parameters of kinnow candy is presented in Table 3. Significant ($P \leq 0.05$) losses in the moisture content of candies were observed during the storage probably due to the natural dehydration of candies (Mehta & Bajaj 1984). Total soluble solids of candies were found to increase significantly ($P \leq 0.05$) during storage. This increase seemed to be the result of moisture loss resulting in the concentration of total soluble solids of the samples. Similar observations were reported by Sogi and Singh (2001) in kinnow candy and by Sharma *et al*. (1998) in apple candy.

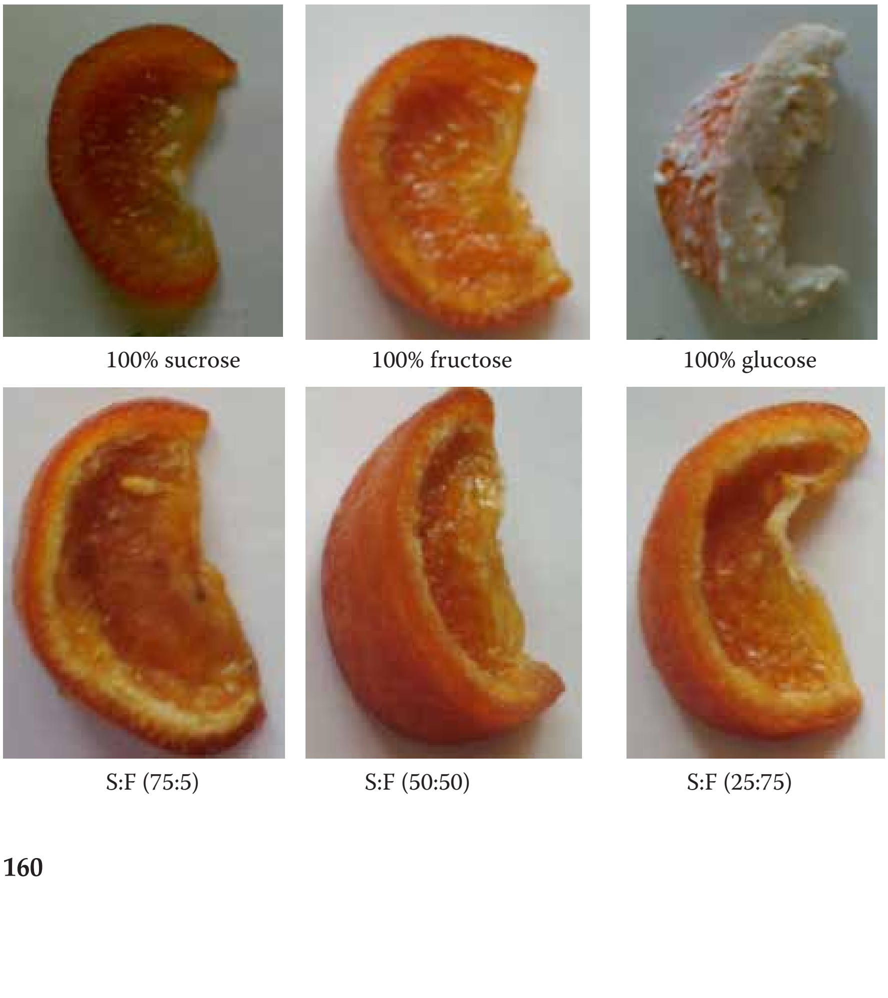

Figure 1. Effect of various osmotic agents: sucrose, fructose, glucose, and their combinations on the quality of candy

Table 3. Effect of storage on physico-chemical (n = 3) parameters of kinnow candy

Sample	Time	Moisture (%)	TSS (%)	Acidity (%)	Ascorbic acid (mg/100 g)	Reducing sugars (%)	Total sugars (%)	Ash (%)	Limonin (ppm)
S:F(100:0)	0	17.5 ± 0.29	70.0 ± 0.22	0.19 ± 0.01	11.4 ± 0.22	9.6 ± 0.37	59.0 ± 0.28	0.53 ± 0.05	410 ± 1.5
	2	13.9 ± 0.22	73.4 ± 0.22	0.12 ± 0.05	6.2 ± 0.24	12.8 ± 0.22	61.3 ± 0.20	0.55 ± 0.05	412 ± 2.9
	4	11.8 ± 0.28	74.4 ± 0.24	0.07 ± 0.05	3.4 ± 0.22	13.9 ± 0.19	62.3 ± 0.22	0.52 ± 0.09	415 ± 2.2
S:F(0:100)	0	17.8 ± 0.22	70.0 ± 0.82	0.20 ± 0.06	11.2 ± 0.22	47.8 ± 0.54	68.0 ± 0.22	0.52 ± 0.01	412 ± 1.4
	2	14.5 ± 0.29	71.6 ± 0.29	0.13 ± 0.03	6.2 ± 0.05	48.6 ± 0.45	68.3 ± 0.28	0.53 ± 0.03	413 ± 2.9
	4	11.3 ± 0.29	72.6 ± 0.45	0.08 ± 0.04	3.6 ± 0.03	49.6 ± 0.33	69.0 ± 0.22	0.52 ± 0.07	415 ± 2.7
S:F(75:25)	0	17.9 ± 0.29	70.0 ± 0.33	0.18 ± 0.05	11.7 ± 0.03	21.4 ± 0.45	47.7 ± 0.22	0.50 ± 0.05	410 ± 2.8
	2	14.2 ± 0.22	71.6 ± 0.35	0.10 ± 0.05	6.1 ± 0.22	22.5 ± 0.33	48.9 ± 0.28	0.52 ± 0.05	411 ± 2.9
	4	12.1 ± 0.28	72.8 ± 0.58	0.07 ± 0.02	3.3 ± 0.22	23.7 ± 0.19	49.8 ± 0.22	0.50 ± 0.03	413 ± 2.2
S:F(50:50)	0	17.1 ± 0.29	70.0 ± 0.33	0.17 ± 0.04	11.6 ± 0.03	30.9 ± 0.29	42.1 ± 0.22	0.52 ± 0.03	408 ± 2.9
	2	13.7 ± 0.22	72.0 ± 0.24	0.11 ± 0.05	6.4 ± 0.22	31.7 ± 0.33	43.7 ± 0.28	0.55 ± 0.05	410 ± 1.4
	4	11.8 ± 0.22	72.6 ± 0.22	0.09 ± 0.02	3.2 ± 0.22	33.0 ± 0.45	45.0 ± 0.28	0.52 ± 0.09	413 ± 1.5
S:F(25:75)	0	17.7 ± 0.22	70.0 ± 0.33	0.18 ± 0.05	11.7 ± 0.29	36.2 ± 0.45	42.0 ± 0.29	0.51 ± 0.05	411 ± 2.2
	2	14.3 ± 0.29	72.4 ± 0.35	0.12 ± 0.04	7.5 ± 0.29	37.4 ± 0.29	43.5 ± 0.29	0.53 ± 0.03	412 ± 2.9
	4	12.05 ± 0.28	73.2 ± 0.58	0.09 ± 0.03	3.3 ± 0.22	38.5 ± 0.22	44.4 ± 0.22	0.51 ± 0.03	414 ± 2.9
CD ($P \leq 0.05$) candies		0.01	0.19	ns	0.01	0.01	0.01	ns	ns
Storage		0.01	0.15	0.01	0.01	0.01	0.01	ns	1.7
Candies × storage		0.03	0.34	ns	0.03	0.02	0.03	ns	0.01

S – sucrose; F – fructose; ns – not significant; time – storage in months

Storage had a significant effect ($P \leq 0.05$) on titratable acidity of candies which decreased with time. Mehta and Bajaj (1984) also reported the continuous decrease in titratable acidity. According to them it may apparently be due to the reaction of acids with basic minerals in the product, interaction of acids with peel components in time or loss of acids mainly due to ascorbic acid during the processing of candy.

Significant ($P \leq 0.05$) losses in ascorbic acid were found during the storage of candies. The loss in ascorbic acid content was found to be due to the effect of light and prevailing high room temperature conditions. A similar pattern of ascorbic acid losses was reported by Mehta and Bajaj (1984), Rani and Bhatia (1985), and Sogi and Singh (2001) while studying the shelf life of citrus peel candy from kinnow and blood red varieties and kinnow candy.

It was observed that reducing sugars in candies prepared with100% sucrose were low as compared to samples prepared with increasing amounts of fructose. Total sugars were recorded the highest in candies prepared with 100% fructose followed by 100% sucrose, then in the samples prepared with a decreasing amount of sucrose. There was a significant ($P \leq 0.05$) increase in reducing and total sugars with advancing storage for all the candies prepared. A similar increasing trend in total and reducing sugars during storage was reported by Mehta and Bajaj (1984) in citrus peel candy from kinnow and blood red cultivars and in apple candy (Sharma *et al.* 1971). Moisture loss and inversion of sucrose were considered by the above authors as major reasons for this increase in total and reducing sugars.

No significant change in ash content was found during the storage of candies. The limonin content was observed to increase significantly ($P \leq 0.05$) during four months of storage of the candies. The L^*, a^*, and b^* values for colour remained almost unchanged with a^* non-significant effect on candies prepared with 100% fructose and sucrose-fructose combinations. But the candy prepared with 100% sucrose showed an increase in L^* and b^* values and a decrease in a^* value during storage which caused a decrease in brightness of the original colour of the candy (Table 4).

The effect of substitution of sucrose by fructose on the sensory attributes of the candies is shown in Table 5. The candies prepared with 100% fructose

Table 4. Effect of storage on Hunter colour parameters (n = 3)

Sample	Storage time (months)	L^*	a^*	b^*	Δ E
	0	39.0 ± 1.8	14.2 ± 0.83	20.0 ± 1.10	64.5 ± 1.70
S:F (100:0)	2	39.4 ± 0.52	13.8 ± 0.24	20.9 ± 0.33	65.7 ± 0.37
	4	41.3 ± 0.73	12.2 ± 0.59	22.1 ± 0.57	68.1 ± 0.38
	0	24.5 ± 0.70	7.6 ± 0.37	10.7 ± 0.78	75.2 ± 0.74
S:F (0:100)	2	24.6 ± 0.88	7.6 ± 0.29	10.7 ± 0.29	75.3 ± 1.20
	4	24.6 ± 0.83	7.6 ± 0.42	10.7 ± 0.26	75.3 ± 1.50
	0	37.1 ± 0.42	23.0 ± 0.24	19.9 ± 1.20	68.4 ± 0.73
S:F (75:25)	2	37.2 ± 1.20	23.0 ± 0.29	19.9 ± 0.99	68.4 ± 0.64
	4	37.2 ± 0.29	23.0 ± 1.02	19.9 ± 1.40	68.5 ± 0.09
	0	36.9 ± 0.91	23.8 ± 0.22	19.9 ± 0.33	69.2 ± 0.35
S:F (50:50)	2	36.9 ± 0.33	23.8 ± 0.22	19.9 ± 0.33	69.2 ± 0.35
	4	36.9 ± 0.91	23.7 ± 0.67	19.9 ± 0.29	69.2 ± 0.35
	0	36.7 ± 0.24	23.1 ± 0.67	19.4 ± 0.33	69.0 ± 0.57
S:F (25:75)	2	36.8 ± 0.29	23.1 ± 0.86	19.4 ± 0.51	69.0 ± 0.71
	4	36.8 ± 0.22	23.1 ± 0.54	19.4 ± 0.22	68.9 ± 0.29
CD ($P \leq 0.05$) candies		0.01	0.02	0.02	0.02
Storage		0.01	0.02	0.01	0.01
Candies × storage		0.02	0.04	0.04	0.04

S – sucrose; F – fructose

ranked superior to all owing to the better retention of taste, flavour, and texture throughout the storage followed by decreasing per cent of fructose to sucrose from 75:25, 50:50, and 25:75. The least acceptable was the sample with 100% sucrose. After two months of storage the candy prepared with 100% sucrose showed crystallisation, which affected its flavour and texture and the candy was found to be

Table 5. Effect of storage on sensory characteristics (n = 3) of kinnow candy

Sample	Storage time (months)	Appearance	Flavour	Texture	Overall acceptability
	0	8.0 ± 0.64	7.9 ± 0.44	7.4 ± 0.71	7.0 ± 0.88
S:F(100:0)	2	7.6 ± 0.08	7.3 ± 0.49	7.0 ± 0.21	6.9 ± 0.16
	4	7.0 ± 0.21	6.9 ± 0.16	6.3 ± 0.40	6.6 ± 0.82
	0	9.0 ± 0.00	8.9 ± 0.35	8.0 ± 0.68	8.4 ± 0.83
S:F(0:100)	2	8.5 ± 0.61	8.4 ± 0.83	7.9 ± 0.44	8.4 ± 0.33
	4	8.3 ± 0.92	8.2 ± 0.55	7.9 ± 0.71	8.0 ± 0.89
	0	7.9 ± 0.71	7.9 ± 0.64	7.6 ± 0.35	7.3 ± 0.22
S:F(75:25)	2	7.7 ± 0.11	7.6 ± 0.49	7.3 ± 0.23	7.2 ± 0.79
	4	7.5 ± 0.35	7.0 ± 0.21	6.9 ± 0.16	7.0 ± 0.21
	0	8.5 ± 0.61	8.2 ± 0.55	7.9 ± 0.71	7.5 ± 0.35
S:F(50:50)	2	8.2 ± 0.55	7.9 ± 0.64	7.8 ± 0.11	7.2 ± 0.88
	4	8.0 ± 0.68	7.6 ± 0.82	7.6 ± 0.82	7.1 ± 0.88
	0	8.6 ± 0.41	8.6 ± 0.41	7.9 ± 0.71	8.6 ± 0.64
S:F(25:75)	2	8.2 ± 0.55	8.3 ± 0.49	7.8 ± 0.11	8.4 ± 0.83
	4	8.1 ± 0.44	8.0 ± 0.82	7.6 ± 0.82	8.0 ± 0.68
CD ($P \leq 0.05$) candies		0.33	0.37	0.39	0.34
Storage		0.25	0.28	0.30	0.26
Candies × storage		ns	ns	ns	ns

S – sucrose; F – fructose; ns – not significant dull in colour. All the other candies were found to have hedonic scoring between 9 and 7 scores during storage with hardly any change in colour and flavour. A non-significant decrease in the sensory scores of candies was noticed during storage.

The results of the study revealed that kinnow candy prepared with 100% fructose at 70% is organoleptically the best. But due to the high cost of fructose the combination of 25:75 (sucrose/fructose) can also be used which was found to be equally good. Kinnow candy along with peel resulted in a high energy (280 kcals/100 g) product of stable shelf quality.

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