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Pushpa Parihar
Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Viswavidyalaya, Krishak Nagar, Raipur, Chhattisgarh, India

Hemant Kumar Panigrahi
Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Viswavidyalaya, Krishak Nagar, Raipur, Chhattisgarh, India

Sangeeta Chandrakar
Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Viswavidyalaya, Krishak Nagar, Raipur, Chhattisgarh, India

Correspondence
Pushpa Parihar
Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Viswavidyalaya, Krishak Nagar, Raipur, Chhattisgarh, India

Preparation of custard apple (*Annona squamosa* L.) squash and estimation of its nutritive value during storage

Pushpa Parihar, Hemant Kumar Panigrahi and Sangeeta Chandrakar

Abstract
The experiment was carried out to standardize the recipe for squash from custard apple and to assess the sensory qualities changes during storage at ambient temperature. This work was carried out during 2016-17 in the Department of Fruit Science, College of Agriculture, IGKV, Raipur (C.G.).
Among all the treatments, 30% pulp with 55% TSS and 2.0% acidity was found best for preparation of squash among all different recipes. During storage reducing sugar, total sugar and acidity increased, while ascorbic acid and non-reducing sugar decreased continuously in squash. The products were organoleptically acceptable for four months.

Keywords: sensory qualities, storage, squash, custard apple, processing etc.

Introduction
Custard apple is one of the most important seasonal fruit, which is botanically known as *Annona squamosa* L., belongs to family Annonaceae. It is indigenous to tropical America. It is one of the important minor fruit of India. Custard apple has immense potentiality of cultivation of rainfed areas.
In Chhattisgarh it is mostly cultivated on wasteland, rice bunds and most of the forest area of Raipur, Bastar, Kanker and Mahasamund. In India, custard apple is grown in an area of 29.87 thousand hectare with an annual productions of 228.37 million tonnes. Chhattisgarh is one of the States in which custard apple is produced in 7.99 thousand hectare having annual productions of 39,730 metric tonnes (Anon., 2014) [2]. However it is not cultivated on commercial scale in Chhattisgarh.
Botanically this fruit is an aggregate fruit. Custard apple is highly valued for its nutritive qualities. It contains 70.5 g moisture, 310 (kj) energy, phosphorus 54 mg and fibre 3.1 g (Wenkam, 1990) [11]. The food value lies mainly in sugar content that varies from 12.4 to 18.5 per cent. The acidity ranges between 0.26 to 0.65 per cent. The variations are attributed to the differences in growing conditions and sampling (Alexander *et al*., 1982) [1]. The edible portion of fruit varies from 28 to 35 per cent.
In tropical countries like India, fruit beverages provide delicious cold drinks during hot summer, although they are in good demand practically, throughout the year. Looking to the demand of natural products there is a great chance for preparation of fruit beverages and other fruit products. The processed product of fruit like squash is easily digestible, highly refreshing, thirst quenching and nutritionally far superior than many synthetic and aerated drinks.
Being a highly perishable nature of fruits, it is most difficult to store and transportation. The excellent nutritive and therapeutic attempts are needed to standardize. The recipes for preparation of new value added products such as RTS, nectar, squash etc. The beverages having not only thirst quenching property but also one of the best ways to improve the health with replacement of non-fruit based cold drinks.
It is a seasonal fruit having short period of availability. Hence there is an urgent necessity to develop some suitable technology for the preparation of custard apple products, which could be economical and made available to a large population. Hence, the preservation of fruits partially solves this problem and also helps to control glut and very low prices in the market.
The fruits are climacteric and perishable in nature and it need immediate processing to avoid post-harvest losses. Looking to the above facts this investigation was carried out.

Materials and Methods

This work was carried out during 2016-17 in the Department of Fruit Science, College of Agriculture, IGKV, Raipur (C.G.) It is situated in the central part of the Chhattisgarh and comes under dry sub-humid agro-climatic region. The maximum temperature of this region may reach as high as 46^0C during summer and minimum may fall to 6^0C during winter and atmospheric humidity is higher from 15th June to 15th October.

Well ripened custard apple fruits cv. Local were procured from the local market and the basic materials used in the present investigation. To evaluate the organoleptic quality of different recipes (Pulp %: TSS %: Acidity %) for squash processing Two Factor Factorial Experiment in Randomized Complete Block Design was used with 9 treatments *viz.*T_1 (Pulp 30%: TSS 45%: Acidity 2%), T_2 (Pulp 30%: TSS 45%: Acidity 2.5%), T_3 (Pulp 30%: TSS 45%: Acidity 3%), T_4 (Pulp 30%: TSS 50%: Acidity 2%), T_5 (Pulp 30%: TSS 50%: Acidity 2.5%), T_6 (Pulp 30%: TSS 50%: Acidity 3%), T_7 (Pulp 30%: TSS 55%: Acidity 2%), T_8 (Pulp 30%: TSS 55%: Acidity 2.5%) and T_9 (Pulp 30%: TSS 55%: Acidity 3%) and 6 replications (6 bottles under each treatment). To study the shelf life of processed products organoleptic evaluation and chemical analysis was done with 6 treatments (at 0, 30, 60, 90, 120, 150 days after processing) and 3 replications in One Factor Complete Randomized Design.

Firm ripe fruits were selected for the preparation of custard apple squash. The fruit were washed, peeled and extracted pulp with the help of pulper and sieved to obtain a fine fruit pulp devoid of seeds and skin. For formulation of recipe, the TSS and total acidity present in the pulp were first determined and then remaining amount of sugar and citric acid were adjusted. One liter squash of each recipe was prepared by mixing the calculated amount of pulp, sugar, citric acid and water. At first sugar syrup was prepared by heating the mixture of sugar water and citric acid then it was blended with fruit pulp. Sieving through a muslin cloth and to obtain a product of uniform consistency filtered the prepared squash. The products were poured into hot, sterilized bottles of 250 ml capacity. After leaving 2 cm head space, bottles were crown corked. The filled bottles were pasteurized in boiling water till the temperature of products reaches 100^0C. It took about 20 minutes to attain required temperature. The bottles of squash were kept at ambient temperature for further studies upto acceptability.

To analyze the physical composition of fruits, weight (g) of fruits, pulp, peel, seeds, weight and number of seeds per fruit, length and diameter of fruit (cm), width and length of seed (cm), thickness of peel(cm), pulp, seed and peel percentage, pulp: seed ratio, moisture percentage, colour of peel, volume of fruits and seeds (cc) were observed.

Under the chemical composition of fruits and squash, Ascorbic acid (mg/100g), Total Soluble Solids (%), Acidity (%), Reducing sugar (%), Non-reducing sugar (%), Total sugar (%) were observed.

The squash prepared from the local cultivar of custard apple were subjected to sensory evaluation by a panel of 9 judges following the hedonic rating test as described by Ranganna (1986) [8]. The products were evaluated for colour and appearance, flavour taste, and aroma. The overall acceptability of products was based upon the mean scores obtained from all the characters studied under the organoleptic test. The product with an overall mean score of 7 or above was considered acceptable. The mean scores obtained by different recipe were calculated.

Results and Discussion

The results of experiment pertaining to various aspects of sensory quality and storage behavior of squash processed from custard apple are summarized as follows:

Organoleptic evaluation of custard apple squash at the time of preparation

Total numbers of treatments were nine, from that to standardize the best recipe, six bottled were kept under each of the treatment (recipe) and six replications per treatment were there. The following results were recorded:

Colour and appearance

The mean value of colour and appearance revealed that highest score of colour appeal (7.87) was observed in T_7 (30% pulp, 55% TSS and 2.0% acidity) followed by T_5 (30% pulp, 50% TSS and 2.5% acidity), T_8 (30% pulp, 55% TSS and 2.5% acidity) and T_9 (30% pulp, 55% TSS and 3.0% acidity) however they are statistically at par. The least score (6.16) got by treatment T_1 (30% pulp, 45% TSS and 2.0% acidity) however T_1, T_2, T_3, T_4, T_6 and T_9 are statistically at par for colour and appearance.

Taste and flavor

The mean value data in respect to taste and flavour revealed that highest score of taste and flavour of squash (7.70) was observed in T_7 (30%pulp, 55% TSS, 2.0% acidity) followed by T_3 (30% pulp, 45% TSS, 3.0% acidity), T_8 (30% pulp, 55% TSS, 2.5 % acidity), T_5 (30% pulp, 50% TSS, 2.5% acidity) and T_9 (30% pulp, 55% TSS, 3.0% acidity) although they all were statistically at par. However least score of taste and flavour (5.95) was observed in T_1 (30% pulp, 45% TSS, 2.0% acidity).

Acceptability

Overall acceptability of the squash is influenced with the levels of acidity and total soluble solids. The data showed that the highest score (8.66) was obtained by T_7 (30% pulp, 55% TSS, 2.0% acidity), T_2 (30% pulp, 45% TSS, 2.5% acidity), although they were statistically at par. However least score (7.08) was obtained by T_4 (30% pulp, 50% TSS, 2.0% acidity).

Chemical analysis of different recipes of squash

For finding the chemical value of processed six bottles of each product were kept under each treatment with three replication and results were obtained as below. Maximum reducing sugar (35.71%) and non-reducing sugar (14.29%) in T_7 (30% pulp, 55% TSS, 2.0% acidity) and minimum reducing sugar (30.90%) found in T_2 (30% pulp, 45% TSS, 2.5% acidity), non-reducing sugar (8.00%) was obtained in T_1 (30% pulp, 45% TSS, 2.0% acidity). Maximum amount of total sugar (50%) recorded under T_7 (30% pulp, 55% TSS, 2.0 % acidity). Maximum ascorbic acid (10.42 mg) was recorded under T_9 (30% pulp, 55% TSS, 3.0% acidity) and minimum (9.17 mg) in T_1 (30% pulp, 45% TSS, 2.0% acidity).

Organoleptic evaluation of squash of custard apple during storage

After standardizing the recipe of squash T_7 (30% pulp, 55% TSS, 2.0% acidity) was found best through sensory evaluation. During storage of squash and jam organoleptic evaluation was recorded at every 30 days interval, starting from the date of preparation and the observations were taken till the acceptability of the product.

Colour and appearance

Mean value revealed that in squash the highest score (8.25) for colour appeal was observed on D1 (date of preparation) and it was found statistically at par with D2 (30 days), D3 (60 days), D4 (90 days) and D5 (120 days). The colour and appearance of the squash remained acceptable upto 120 days with the score of 7.00. The least score (6.37) was observed on D6 (150 days of storage) it indicate the non acceptability of the product.

The decrease in colour in squash during the storage might be due to non enzymatic reaction of organic acid with sugar or oxidation of phenols, which leads to degradation of colour. It may be due to decline in ascorbic acid content, the result obtained are in accordance with the earlier investigation made in guava beverage by Kalra and Tandon (1984) [3], Pal *et al*. (1993) [5].

Taste and flavor

A gradual decrease in taste and flavour during the storage was observed. Score for taste and flavour of squash was highest (8.41) on D1 (date of preparation) followed by D2 (8.16) and D3 (8.16) 30 and 60 days, respectively. Although they were statistically at par. The taste and flavour of squash remained acceptable upto D5 (120 days of storage) (7.00). On D6 (150 days of storage), which indicates the least acceptability.

It might be due to the loss of volatile aromatic substances responsible for taste and flavour which leads to decrease in the score of taste and flavour in storage of ambient condition. The other possible reasons could be certain biochemical changes occurring under low pH and high temperature that leads to production of off-flavour in the squash.

Overall acceptability

In squash the highest score (8.66) for acceptability was observed on D1 (date of preparation) than non-significant decrease was recorded up to D3 (60 days of storage) with the score of (8.33). The least score (6.87) was observed on D6 (150 days of storage), which indicates that squash was non-acceptable and unfit for consumption. There are many extrinsic factors that determine the storage ability of product and temperature play an important role among them. There are certain biochemical changes that occurs under low pH and high temperature that leads to formation of brown pigment and produces off flavour in the processed product. The other possible reason could be the loss of volatile aromatic substance responsible for taste and flavour, which decreased acceptability on storage at ambient temperature.

Chemical changes of standardized product (squash) during storage period

Chemical analysis of squash was recorded from the date of preparation. The data show that chemical changes were started from second observation. Chemical changes were started to record at 30 days interval from the data of preparation. For this purpose 48 bottles were kept under each replication and four bottles were analyzed at a time from each replication.

Acidity

It can be revealed from the observation that there was a gradual increase in acidity, during storage since days of storage found to produce significant effect on acidity of squash.

It was observed that there was no significant difference found up to D2 (30 days of storage) during storage. But from D3 (60 days of storage) acidity differs significantly with initial days of storage. In squash arcsine transformed value 8.19 acidity (inverse transformed value 2.05 per cent) was observed on D1 (date of preparation) and found to increased up to 9.76 transformed value (inverse transformed value 2.88 per cent) on D6 (150 days of storage).

The total acidity of squash increased continuously. It might be due to the formation of organic acids by ascorbic acid degradation as well as progressive decrease in pectin content. It is also due to formation of acids from sugar. An increase in acidity was also reported in Bael and Pomegranate squash by Roy and Singh (1979) [9] and by Prasad and Mali (2000) [7], respectively.

Total soluble solids

In squash, initial increase in total soluble solids from D1 47.85 transformed value (inverse transformed value 55.00 per cent) to D3 47.97 transformed value (Inverse transformed value 55.20 per cent) was found to be non significant. At the end of storage (150 days of storage) it was increased up to 48.35 transformed value (inverse transformed value 55.85 per cent) total soluble solids.

This increasing trend of total soluble solids in squash during storage might be due to solublization of pulp constituents during storage and hydrolysis of polysaccharide. An increase in TSS during storage of squash has been reported in lemon by Palanisami and Muthukrishnan (1974) [6] in phalsa by Khurdiya and Anand (1981) [4] in litchi by Singh and Singh (1994) [10].

Reducing sugar

In the present study, it was observed that the reducing sugar increased gradually during storage in case of squash. Initial observation recorded was 36.98 arcsine transformed value (inverse transformed value 36.20 per cent) which is significantly increase during storage. It was increased up to 38.32 transformed values (inverse transformed value 38.30 per cent).

The rise in reducing sugars might be assigned to the conversion of non-reducing sugar owing to the process of hydrolysis. It might be due to hydrolysis of non reducing sugars due to the presence of organic acid which might now resulted in degradation of disaccharides to mono saccharides.

Non reducing sugar

There was a gradual decreasing trend observed with advancement of storage period in case of non-reducing sugar in squash. In squash upto D3 (60 days of storage) non significant decrease was observed D1 (date of preparation), D2 (30 days of storage), D3 (60 days of storage) were statistically at par. At the end of storage it was found minimum 21.55 arcsine transformed value (inverse transformed value13.50 per cent).

Total sugar

Mean data revealed that in squash initially at D1 (date of preparation) total sugar content was 45.26 (inverse transformed value 50.45 per cent) and maximum amount 46.02 (inverse transformed value 51.80 per cent) was observed at D6 (150 days of storage) that was the end of storage.

The total sugars showed a gradual increase during storage period in all the processed product of fruits. Similar findings were also reported by Palaniswami and Muthukrishnan (1974) [6] in lemon squash.

Ascorbic acid

During the storage period it is observed that there is continuous decrease in ascorbic acid content both in squash. In squash, the initially ascorbic acid content was 9.81 mg/100 ml at D1 (date of preparation). After that, decrease was found significant till the end of storage and minimum 6.57 mg/100 ml was recorded at D6 (150 days of storage). It showed significant difference during the storage.

Ascorbic acid content of squash decreased continuously during storage. The decline in ascorbic acid content might be due to its degradation into dehydro-ascorbic acid or furfural or hydroxyl methyl furfural at ambient condition. Similar loss of ascorbic acid content during storage was also noticed in squash of lemon by Palaniswami and Muthukrishnan (1974) [6]. Similar result was also found by Singh and Singh (1994) [10] in litchi squash.

Table 1: Organoleptic evaluation of different recipes of custard apple squash

Recipes	Colour and Appearance	Taste & flavour	Accep-tability	Rating
T1 (30% pulp, 45% TSS, 2.0% acidity)	6.16^{c}	5.95^{c}	7.87^{c}	LM
T2 (30% pulp, 45% TSS, 2.5% acidity)	6.25^{c}	6.91^{b}	8.33^{ab}	LV
T3 (30% pulp, 45% TSS, 3.0% acidity)	6.16^{c}	7.50^{a}	7.33^{d}	LM
T4 (30% pulp, 50% TSS, 2.0% acidity)	6.41^{c}	7.16^{ab}	7.08^{bc}	LM
T5 (30% pulp, 50% TSS, 2.5% acidity)	7.00^{b}	7.33^{a}	8.08^{d}	LV
T6 (30% pulp, 50% TSS, 3.0% acidity)	6.25^{c}	6.83^{b}	7.16^{d}	LM
T7 (30% pulp, 55% TSS, 2.0% acidity)	7.87^{a}	7.70^{a}	8.66^{a}	LV
T8 (30% pulp, 55% TSS, 2.5% acidity)	6.83^{b}	7.41^{a}	8.16^{b}	LV
T9 (30% pulp, 55% TSS, 3.0% acidity)	6.50^{bc}	7.25^{a}	8.50^{a}	LV
SEm±	0.17	0.25	0.14	
CD at 5%	0.50	0.70	0.39	

Note: LV = Like very much, LM = Like moderately

The superscript letters indicate that the treatment means with same letters are at par at 5% level of significance, while the means with different letters significantly different at 5% level. These letters have been affixed based on CD comparison of treatments means.

Table 2: Organoleptic evaluation of squash from custard apple during storage upto acceptability

S. No.	Days to storage	Colour and appearance	Taste and flavor	Acceptability	Rating
1.	D1 (0 days)	8.25^{a}	8.41^{a}	8.66^{a}	LV
2.	D2 (30 days)	8.00^{a}	8.16^{a}	8.50^{a}	LV
3.	D3 (60 days)	7.50^{a}	7.87^{a}	8.33^{ab}	LV
4.	D4 (90 days)	7.41^{a}	7.20^{b}	8.04^{b}	LV
5.	D5 (120 days)	7.00^{ab}	7.00^{b}	7.91^{b}	LM
6.	D6 (150 days)	6.37^{b}	6.33^{c}	6.87^{c}	LS
SEm±		0.51	0.20	0.17	
CD at 5%		1.21	0.60	0.50	

Note: LV = Like very much, LM = Like moderately, LS = Like slightly

The superscript letters indicate that the treatment means with same letters are at par at 5% level of significance, while the means with different letters significantly different at 5% level. These letters have been affixed based on CD comparison of treatments means.

Table 3: Chemical evaluation of different recipes of squash from custard apple

Recipes	Acidity (%)	TSS (%)	Sugar (%)			Ascorbic Acid (mg/100 ml)
			Reducing	Non-reducing	Total	
T1 (30% pulp, 45% TSS, 2.0% acidity)	2.01	45.01	32.30	8.00	40.30	9.17
T2 (30% pulp, 45% TSS, 2.5% acidity)	2.70	45.00	30.90	9.35	40.25	9.49
T3 (30% pulp, 45% TSS, 3.0% acidity)	3.03	45.00	31.30	9.50	40.80	10.09
T4 (30% pulp, 50% TSS, 2.0% acidity)	2.10	50.02	33.20	9.70	42.90	9.55
T5 (30% pulp, 50% TSS, 2.5% acidity)	2.50	50.00	31.61	10.39	42.00	10.38
T6 (30% pulp, 50% TSS, 3.0% acidity)	3.15	50.03	31.10	11.10	42.20	10.23
T7 (30% pulp, 55% TSS, 2.0% acidity)	2.00	55.01	35.71	14.29	50.00	9.81
T8 (30% pulp, 55% TSS, 2.5% acidity)	2.60	55.00	35.67	14.20	49.87	10.15
T9 (30% pulp, 55% TSS, 3.0% acidity)	3.00	55.00	35.54	14.04	49.60	10.42

Table 4: Effect of storage on chemical constituents of custard apple squash

Days of storage	Acidity (%)	TSS (%)	Sugar (%)			Ascorbic Acid (mg/100 ml)
			Reducing	Non-reducing	Total	
D1 (0 days)	*8.19a (2.05)	47.85a (55.00)	36.98a (36.20)	22.20a (14.29)	45.26a (50.45)	9.81a
D2 (30 days)	8.28a (2.08)	47.90a (55.10)	37.26b (36.65)	22.16a (14.24)	45.51ab (50.93)	8.14b
D3 (60 days)	8.46b (2.17)	47.97ab (55.20)	37.50b (37.10)	22.06ab (14.10)	45.68b (51.20)	7.59c
D4 (90 days)	8.70c (2.30)	48.06bc (55.37)	37.93cd (37.80)	21.59b (13.56)	45.77bc (51.38)	7.01de
D5 (120 days)	9.16d (2.55)	48.19cd (55.59)	38.03de (37.98)	21.57b (13.53)	45.84c (51.45)	6.82ef
D6 (150 days)	9.76e (2.88)	48.35de (55.85)	38.23ef (38.30)	21.55bc (13.50)	46.02cd (51.80)	6.57f
SEm±	0.05	0.04	0.07	0.17	0.10	0.14
CD at 5%	0.16	0.15	0.24	0.54	0.32	0.43

1. The "*" symbol indicates the mean arcsine transformed value
2. Figure in parenthesis are inverse transformed values, in per cent unit of the corresponding mean arcsine transformed values
3. The superscript letters indicate that the treatment means with same letters are at par at 5% level of significance.

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