

STUDIES ON PROCESSING AND PRESERVATION OF
CUSTARD APPLE PULP, SQUASH AND READY-TO
SERVE BEVERAGES

KAVYA D.

DEPARTMENT OF POST HARVEST TECHNOLOGY
KITUR RANI CHANNAMMA COLLEGE OF HORTICULTURE,
ARABHAVI – 591 218
UNIVERSITY OF HORTICULTURAL SCIENCES,
BAGALKOT- 587 102

JUNE, 2014

STUDIES ON PROCESSING AND PRESERVATION OF
CUSTARD APPLE PULP, SQUASH AND READY-TO
SERVE BEVERAGES

*Thesis submitted to the
University of Horticultural Sciences, Bagalkot
in partial fulfillment of the requirements for the
Degree of*

Master of Science (Horticulture)
In
Post Harvest Technology

By
KAVYA D.

DEPARTMENT OF POST HARVEST TECHNOLOGY
KITUR RANI CHANNAMMA COLLEGE OF HORTICULTURE,
ARABHAVI – 591 218
UNIVERSITY OF HORTICULTURAL SCIENCES,
BAGALKOT- 587 102

JUNE, 2014

DEPARTMENT OF POST HARVEST TECHNOLOGY
KITTUR RANI CHANNAMMA COLLEGE OF
HORTICULTURE, ARABHAVI - 591 218
UNIVERSITY OF HORTICULTURAL SCIENCES,
BAGALKOT- 587 102

CERTIFICATE

This is to certify that the thesis entitled "STUDIES ON PROCESSING AND PRESERVATION OF CUSTARD APPLE PULP, SQUASH AND READY-TO-SERVE BEVERAGES." submitted by KAVYA D for the degree of MASTER OF SCIENCE (HORTICULTURE) in POST HARVEST TECHNOLOGY, of the University of Horticultural Sciences, Bagalkot, is a record of research work carried out by her during the period of her study in this university, under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

PLACE: ARABHAVI
DATE: JUNE, 2014

(LAXMAN KUKANOOR)
Chairman
Professor and Head
Department of Post-harvest Technology
K.R.C. College of Horticulture, Arabhavi

Approved by
Chairman:

(LAXMAN KUKANOOR)

Members:

1. _____
(N. K. HEGDE)

2. _____
(R. K. MESTA)

3. _____
(PRAVEEN JHOLGIKER)

4. _____
(PRABHULING. G)

5. _____
(KIRANKUMAR R. GORBAL)

ACKNOWLEDGEMENT

In the light of reaching a milestone in my life, I owe my deep sense of gratitude to all those who helped me in a constructive fashion.

It was indeed an immense pleasure to express my deep sense of gratitude and indebtedness to the Chairman of my Advisory Committee Dr. LAXMAN KUKANOOR for his excellent guidance, continued calm endurance and inspiring encouragement during the course of investigation and preparation of the manuscript. Hard it is not been for his personal interest and preservice, this small venture of mine would not have reached the form it is today. I acknowledge his help to the deep.

I owe this opportunity to express my indebtedness and profound thanks to Dr. N. K. Hegde Professor of plantation, spices, medicinal and aromatic crops College of Horticulture sirs, Dr. G. Prabhuling, Associate Professor, director office UHS Bagalkot, Dr. Praveen Jhologiker Assistant professor College of Horticulture Bidar, Dr. R. K. Mesta professor of plant pathology and Mr. Kirankumar R. Gorbai Assistant professor college of Horticulture Bagalkot are the members of my Advisory Committee, under whose edifying counsels, sensible criticism, constructive suggestions, necessary guidance, advice and help during the course of my investigation.

I am thankful to Dr. S. L. Jagadeesh, Dr. Mukesh Chavan, Dr. G. J. Suresh, Manjula Karadiguddi, Dr. T. N. Pushpa and Srikantaprasad .D for their kind help during the course of my investigation.

I feel the inadequacy of my diction to find a more suitable word for a whole hearted thanks to my parents Sri. Dharmappa, G .B and Smt. Channabasamma, H. P, brother Varun, sisters Nandini, Nayana, Manasa.

I heartily appreciate the help by seniors Bhagya, Lalithya, Archana pattar, Vijay kumar, Manasa, Chaitra and my juniors Archana, Jeevan, Arun, Shewtha, Shruthi, Payal, Deepa, Priyanka, archana PMA, Anjali, and my friends Vinutha, Ravi, Satish, Neela, Shivangi, Reshmika, Rani, Hanamanth, Shivanand, Vandana, Netravati, Laxmi and all other friends who have helped me during the course of my investigation.

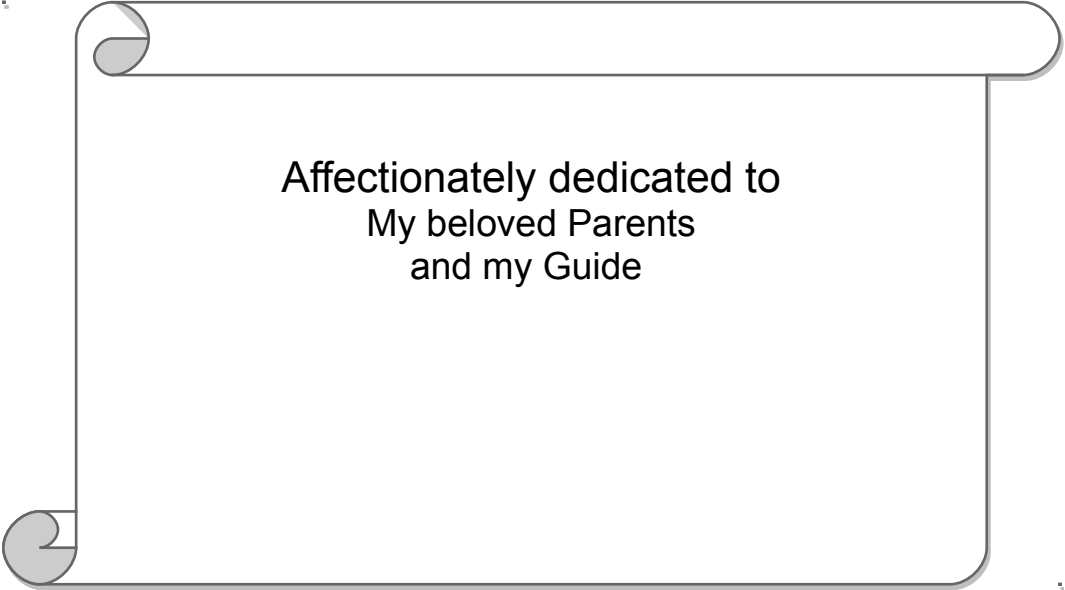
I avail this opportunity to express my heartfelt thanks to Mr. Maruthi, Mr. vittal Mr. Bhimshi, Mr. Mutthu, Mr. Sanju, Mr. Arjun Mr. Yamanappa, Mr. S. N. Ghaste for their kind help during my research programme.

I also thankful and my grateful regards to Sitaram jindal trustee Bangalore for their financial support during my studies. Finally I sincerely wish to thank all those who have helped me directly or indirectly in completing the master degree programme.

ARABHAVI

JUNE, 2014

(KAVYA D.)



Affectionately dedicated to
My beloved Parents
and my Guide

CONTENTS

Sl.	Chapter Particulars
	CERTIFICATE ACKNOWLEDGEMENT LIST OF TABLES LIST OF FIGURES LIST OF PLATES
	LIST OF APPENDIX
1	INTRODUCTION
2	REVIEW OF LITERATURE
	2.1 Effect of chemical preservatives and pasteurization temperature on storage of custard apple pulp
	2.2 Preparation of ready-to-serve (RTS) beverages
	2.3 Preparation of squash beverages
	2.4 Physico- chemical changes in fruit beverage during storage
	2.5 Sensory changes in fruit beverages during storage
	2.6 Storage of fruit beverages
	2.7 Microbial analysis of fruit juice beverages
3	MATERIAL AND METHODS
	3.1 Geographical location and climate
	3.2 Fruit used in the investigation
	3.3 Extraction of custard apple pulp
	3.4 Experimental details
	3.5 Observations recorded
	3.6 Statistical analysis

4	EXPERIMENTAL RESULTS
	4.1 Experiment I: Effect of chemical preservatives on storage of custard apple pulp
	4.2 Experiment II: Effect of pasteurization temperature for preservation of custard apple pulp
	4.3 Experiment III: Preparation and preservation of custard apple RTS
	4.4 Experiment IV: Preparation and preservation of custard apple squash
5	DISCUSSION
	5.1 Preparation and preservation of custard apple pulp by chemical preservatives
	5.2 Preservation of custard apple pulp by pasteurization
	5.3 Preparation and preservation of custard apple RTS
	5.4 Preparation and preservation of custard apple squash
6	SUMMARY AND CONCLUSIONS
	6.1 Effect of chemical preservatives on storage of custard apple pulp
	6.2 Effect of pasteurization on storage of custard apple pulp
	6.3 Preparation and preservation of custard apple RTS
	6.4 Preparation and preservation of custard apple squash
	REFERENCES
	APPENDICES

LIST OF TABLES

Table No.	Title
1	Effect of chemical preservatives on total soluble solids, titratable acidity and ascorbic acid of custard apple pulp during storage
2	Effect of chemical preservative on reducing sugar, non-reducing sugar and total sugar of custard apple pulp during storage
3	Effect of chemical preservative on colour ($L^* a^* b^*$) values of custard apple pulp during storage
4	Effect of treatments chemical preservative on non enzymatic browning, total bacterial count and colour and appearance of custard apple pulp during storage
5	Effect of chemical preservative on mouthfeel, taste and flavour and overall acceptability of custard apple pulp during storage
6	Effect of pasteurization treatments on total soluble solids, titratable acidity and ascorbic acid of custard apple pulp during storage.
7	Effect on pasteurization treatments on reducing sugar, non-reducing sugar and total sugar of custard apple pulp during storage
8	Effect of pasteurization treatments on colour ($L^* a^* b^*$) values of custard apple pulp during storage
9	Effect of pasteurization treatments on non enzymatic browning, total bacterial count, colour and appearance of custard apple pulp during storage
10	Effect of pasteurization treatments on mouthfeel, taste and flavour and overall acceptability of custard apple pulp during storage
11	Effect of treatments on total soluble solids, titratable acidity and ascorbic acid of custard apple RTS during storage
12	Effect of treatments on reducing sugar, non-reducing sugar and total sugar of custard apple RTS during storage
13	Effect of treatments on colour ($L^* a^* b^*$) values of custard apple RTS during storage
14	Effect of treatments on non enzymatic browning, total bacterial count, colour and appearance of custard apple RTS during storage.

15	Effect of treatments on mouthfeel, taste and flavour and overall acceptability of custard apple RTS during storage
16	Effect of treatments on total soluble solids, titratable acidity and ascorbic acid of custard apple squash during storage
17	Effect of treatments on reducing sugar, non-reducing sugar and total sugar of custard apple squash during storage
18	Effect of treatments on colour (L^* a^* b^*) values of custard apple Squash during storage
19	Effect of treatments on non enzymatic browning, total bacterial count and colour and appearance of custard apple squash during storage
20	Effect of treatments on mouth feel, taste and flavour and overall acceptability of custard apple squash during storage

LIST OF FIGURES

Figure No.	Title
1	Effect of different treatments on changes in total soluble solids and ascorbic acid content of chemical treated custard apple pulp
2	Effect of different treatments on changes in reducing sugar and L^* value of pasteurized custard apple pulp.
3	Effect of different treatments on changes in titratable acidity and a^* value of custard apple RTS
4	Effect of different treatments on changes in titratable acidity and a^* value of custard apple squash

LIST OF PLATES

Plate No	Title
1	Process flow chart for custard apple pulp extraction
2	Process flow chart for custard apple RTS
3	Best performed treatment of Chemical preserved custard apple pulp
4	Best performed treatment of pasteurized custard apple pulp
5	Best performed treatment of custard apple RTS
6	Best performed treatment of custard apple squash

LIST OF APPENDICES

Appendix No	Chapter Particulars
1	Meteorological data recorded during the experimental period (January 2013 to December 2013) at Agricultural Research Station, Arabhavi

1. INTRODUCTION

The genus *Annona* contains more than fifty species, of which five produce edible fruits of horticultural importance. The plants are indigenous to tropical America and have distributed in tropical, sub tropical and arid zones of world. Custard apple is sometimes considered as poor man's rich food in the arid zones of South India.

Annonaceous fruits are also highly valued for their medicinal properties and act as blood tonic. The immature fruit seeds, leaves and roots are of considerable medicinal value both in Ayurvedic and Yunani systems of medicine.

Custard apple is a hardy crop which can be grown on marginal lands with minimum care and inputs. In Karnataka an estimated area and production of custard apple is 1706 ha and 12892 M. Tons respectively (Kotecha *et al.*, 1995). It is also grown in Andhra Pradesh, Maharashtra, Karnataka, Panjab, Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Assam, Gujarat, Kerala and Tamil Nadu.

Custard apple plants starts bearing at the age of four to six years and declines after 12 to 15 years. Harvesting may extend from August to November depending on the period of flowering. The fruits are harvested in firm condition when the skin between the segments turns to creamy yellow. An average tree yields 100 to 150 fruits per year, bigger and vigorous tree may yield more and each fruit weighs about 120 to 230 grams (Aziz and Yusof, 1994).

Custard apple is a delicious fruit and mostly consumed as a desert fruit. The fruit has peel, pulp and seed in varying proportions. The fruit has an edible, soft, granular, juicy sugary pulp with a mild flavour. Its pulp is sweet with a pleasant texture and can be mixed with milk or ice-cream to form a good beverage.

Custard apple is highly valued for its nutritive qualities. Fruit contains moisture (70.5%), carbohydrates (23.5%), protein (1.6%), fat (0.4%) mineral matter (0.9%), iron (1.0%), calcium (0.2%), phosphorous (0.04%) and energy value 104 Kcal/100g of edible portion (Gopalan *et al.*, 2004). The edible portion of the fruit varies from 28 to 55 per cent. The fruit contains sugar varying from 12.4 to 18.5 per cent and acidity from 0.26 to 0.65 per cent (Alexander *et al.*, 1982).

In India post harvest losses of fruits account for twenty to forty per cent at different stages viz., harvesting, handling, transporting, storage and marketing of fresh produce. This is a great handicap in exploiting the full potential of this crop area expansion and in increasing their production. Storage of the fresh fruit of *Annona squamosa* in cold storage has a limitation as the fruit skin develops unattractive brown color further the shelf life of fruits can be improved by slowing down the biochemical processes in fruits during storage by various treatments.

The rapid fruit softening (firmness loss) is the main characteristic in reducing the fruit quality, limiting the transportation, processing and commercialization. Pulp extraction from the fruit should be done as rapidly as possible, so as to minimize oxidation of the pulp by naturally occurring enzymes. Custard apple pulp when exposed to air turns pink due to peroxidase activity and becomes bitter when heated above 55°C, which renders preservation by heat treatment inapplicable. To preserve the pulp, it is necessary to add 1 per cent of citric acid together with 0.1 per cent of sodium benzoate, while addition of 50-100 ppm of sulphur dioxide which checks the pink discoloration due to enzymatic activity (Prasanna, 2000).

Fruit has a very limited shelf life of just one to two days and is generally eaten fresh after ripening. It is normally cultivated on a small scale in rural areas and marketed in local mandies. If these fruits are processed into commercial value added products, they form important nutritional products for rural folk. The development of processing technology will help in better utilisation of custard apple fruits through value added products preparation which may avoid glut of fresh fruit in the market and its availability for longer period.

Fruit juice and juice products represent a very important segment of total fruit processing industry. India produces 152 thousand tonnes of ready to serve beverages from various fruit blends per annum however the contribution of custard apple to processing industry as a raw material is negligible. Thus, there is a greater scope for the production of functional beverages on commercial scale by using custard apple.

Therefore, in order to explore the possibilities of utilising the custard apple fruits for processing, an attempt was made to find out the methods of preservation of pulp and to standardise the protocols for development of value added products and to study the storage stability of processed products such as RTS and squash. Keeping this in view, the present investigation was carried out with the following objectives.

Objectives

1. To standardize the chemical preservatives and pasteurization temperature for preservation of custard apple pulp.
2. To standardize the recipes for preparation of RTS and squash from custard apple pulp.
3. To assess the nutritive value and quality of processed products.
4. To evaluate the storage stability and organoleptic acceptability of processed products.

2. REVIEW OF LITERATURE

Custard apple fruits have very short life after harvest which is one of the major limitations for commercial cultivation and further area expansion in this minor important fruit crop cultivated in tropical and subtropical regions of the world. Review of literature reveals that there is scanty research work on various aspects of this crop. More particularly about post harvest handling and processing including storage stability studies. Hence, the available literature reviewed in this chapter includes the work on custard apple and related fruits.

2.1 Effect of chemical preservatives and pasteurization temperature on storage of custard apple pulp

Brenndor *et al.* (1985) found that the mango pulp treated with 0.2% potassium metabisulphite gave the best result for the control of microbial growth during 90 days of storage. Gamage *et al.* (1997) studied custard apple pulp treated with 0.1– 0.5 per cent ascorbic acid and stored in modified atmosphere generating packages at 0°C were of acceptable quality for sensory and microbiological properties throughout the storage period of 4 weeks. Umme *et al.* (1997) suggested that soursop pulp treated at 70°C for 20 minutes with addition of 0.5 per cent ascorbic acid and packed into polythene bags stored for 30 days at 5°C.

Chikhalikar *et al.* (2000) found that custard apple pulp treated with 100 ppm ascorbic acid as antibrowning agent and packed in 200 gauge polyethylene and was frozen at -25°C in an alcohol bath and stored at -18 °C in a deep-freeze and 2% glycerol + 1% propylene glycol + 10% glucose syrup + 10% maltodextrin, on the thawing time of pulp was stored for a period of 3 months. Hussain *et al.* (2003) preserved mango pulp with preservatives and found that potassium meta-bisulphite (KMS) at 1000 ppm, sodium benzoate at 500 ppm and potassium sorbet at 400 ppm were effective against microorganisms and no colonies were formed up to 90 days of storage period.

Sonia *et al.*, (2003) opined that mango pulp stored with the application of sodium benzoate at the concentration of 600 mg and 1200 mg of potassium metabisulphite for 360 days at room temperature without any effect on the sensory characteristics of pulp. Hashmi *et al.* (2007) studied mango pulp preservation with potassium metabisulphite concentration of 1000 mg/kg showed better inhibitory effect on the microbial growth for duration of three months.

Suhali *et al.* (2007) showed that addition of 0.2 per cent potassium metabisulphite packed in plastic containers helped in controlling microbial growth, sensory characteristics and maximum nutrients stability of mango pulp during 90 days of storage. Amin *et al.* (2008) revealed that the use of chemical preservatives such as potassium sorbate 400 ppm, sodium benzoate 500 ppm and potassium metabisulphite 1000 ppm showed the better effect on the control of microorganisms in mango pulp during three months of storage period and organoleptic assessment were acceptable upto nine months of storage. Akhtar *et al.* (2009) studied the chemical preservatives on physico-chemical characteristics, microbiological parameters and sensory attributes of preserved mango pulp the action of potassium metabisulphite (1000 ppm) was shown to be most effective.

Durrani *et al.* (2010) showed that the apple pulp treated with 0.1% potassium metabisulphite + 0.1% citric acid and 0.1% potassium metabisulphite+0.5% citric acid were found most acceptable during physico-chemical and sensory evaluation for a total period of 90 days. Ayub *et al.* (2010) observed pasteurized strawberry juice with 20% sucrose, 0.1% potassium sorbate and 0.1% sodium benzoate were most effective in maintaining the sensory and nutritional quality during 3 months of storage.

Kamble and soni (2010) observed that effect of storage of custard apple pulp at -4 and -18°C temperature on scores for sensorial quality of pulp *viz.*, appearance, color, flavor, taste, texture and overall acceptability increases during 70 days of storage. Pawar *et al.*

(2010) reported custard apple pulp treated with 2000 ppm of ascorbic acid without heat treatment showed highest sensorial properties without discoloration compared to heat treated samples.

Muhammad *et al.* (2011) reported that apple pulp sample treated with 0.1% potassium metabisulphite + 0.1% citric acid was found most acceptable during 90 days of storage. Durrani *et al.* (2011) opined addition of potassium sorbate along with potassium metabisulphite at the level of 0.05% each retained overall eatable quality of mango pulp, colour, flavour and odour during 60 days of storage.

Hiremath and Rokhade (2012) observed that there was no much change in chemical composition of sapota juice preserved with chemical preservatives as compared to fresh juice. Potassium meta-bisulphite reduced the OD value whereas pasteurisation increased the OD value for non-enzymatic browning.

Sakhale *et al.* (2012) observed that the treatment in which mango pulp was preserved with 0.2 per cent potassium meta-bisulphite and stored in glass bottles gave maximum score for overall acceptability and had negligible microbial count. This treatment was found statistically significant over the rest of treatments. It was further observed that the pulp was safe without spoilage up to 90 days.

Nwachukwu and Ezeigbo (2013) showed that the synergistic effect of pasteurization at 60°C for 1 hour, acidified with lime and addition of 0.05 per cent sodium benzoate could be used to extend the shelf-life of soursop juice for up to two weeks.

2.2 Preparation of ready-to-serve (RTS) beverages

RTS is a type of fruit beverage which contains at least 10 per cent of fruit juice and 10 to 15 per cent of total soluble solids besides about 0.3 per cent acid. It is not diluted before serving hence it is known as ready to serve (Srivastava and Sanjeev Kumar, 2012).

The concept and methodology followed for preparation of beverage is same for most of the fruits with certain minor manipulations depending upon the type of fruit that are either highly acidic or extremely low in acidity or those fruits, which exhibit interfering factors such as highly astringent and bitter taste (Giridharilal *et al.*, 1986). A good quality ready to serve guava beverage could be prepared with fruit pulp content equivalent of 5 to 10 per cent peeled fruit, 12.5 per cent TSS and 0.25 per cent acidity (as citric acid) as reported by Jain and Borker (1970). Passion fruit juice was more popular for mixing with other juices. Among the tropical fruit products investigated by Swamy *et al.* (1977) Passion fruit juice has proved to be too acidic for the manufacture of ice cream, but this characteristic is an advantage in the preparation of sherbet. The addition of passion fruit juice at 10 to 15 per cent to the basic sherbet mix is considered to be the optimum for a flavoured product.

The RTS beverage based on 25 per cent jamun juice, 18 °B sugar and 0.6 per cent acidity scored the highest overall organoleptic score (Khuridiya and Roy, 1985). A ready to serve beverage containing 33.3 per cent juice could be prepared from phalsa fruit after cooking and extracting the juice in a basket press (Khuridiya and Anand, 1980). A study has opined that the citrus fruits are the most ideal for making beverage due to the fact that they are juicy, refreshing and retain the characteristic taste and aroma even after few months of their preparation into a beverage (Giridharilal *et al.*, 1986).

Kotecha *et al.* (1995) studied RTS beverage of custard apple showed that the beverage prepared by using 20 per cent juice was the most acceptable superior quality. Singh and Sanjeevkumar (1995) studied that blended RTS of composition 10 per cent Aonla pulp + 2 per cent lime juice + 1 per cent ginger juice with 12 per cent TSS and 0.3 per cent acidity were found ideal.

Jasimahmed (1996) reported that banana RTS prepared from 15 per cent juice, 12° Brix TSS and 0.15 per cent acidity was found ideal. Teotia *et al.* (1997) reported that the RTS

beverage prepared using clarified juice (10%) of muskmelon was excellent in colour, flavour and taste. The RTS prepared from Saradar guava containing 10 per cent guava pulp and 11 per cent TSS with 0.25 per cent acidity was found to be most ideal and better over Allahabad safeda (Pandey and Singh, 1998).

The RTS drink prepared from blending of pulp of Dashehari and Banganpalli (50:50) scored highest marks as compared to the one prepared from individual variety (Srivastava, 1998). In another study, among the four papaya cultivars evaluated for their processing quality, Pusa dwarf was found most suitable for making quality beverages (Sanjeev and Singh, 1998).

Singh *et al.* (2001) evaluated various recipes for preparation of RTS from barhal (*Artocarpus lakoocha* R.) fruits. The composition of 10 per cent juice, 10 per cent TSS and 0.3 per cent acidity for RTS was found excellent for preparation of barhal beverages. Krishnaveni *et al.* (2001) prepared RTS beverage from jackfruit with 10 per cent pulp, 18° Brix TSS and 0.25 per cent acidity. A slight decrease in sensory scores for appearance, colour, flavour, taste and overall acceptability were observed during storage. RTS juices prepared from *Simarouba* fruits with 15 per cent juice, 20° Brix total soluble solids recorded increase in pH, total sugars and considerable raise in reducing sugars, but acidity and ascorbic acid was found to be decreased during a storage period of 5 months with little decrease in the intensity of colour (Ramajayam *et al.*, 2002).

Bael (*Aegle marmelos*) RTS drink prepared with 10 per cent bael pulp, 14 per cent total soluble solids and 0.28 per cent acidity was found most ideal over all the treatments (Surender *et al.*, 2005). Papaya fruits were processed to prepare ready to serve (RTS) beverage using varying levels of pulp percentage (10, 14 and 18%) with 13° Brix TSS and 0.3 per cent acidity. Sensory evaluation indicated that the RTS beverage with 18 per cent pulp, 13° Brix TSS and 0.3 per cent acidity was most highly ranked and thus preferred by the panellists (Saravanan *et al.*, 2004).

Abbo *et al.* (2006) Results have showed that pasteurisation of soursop juice reduced microbial counts from 3×10^5 to $<10 \times 10^1$ cfu/g for mesophilic aerobic counts and 27.5×10^6 to $< 10 \times 10^1$ cfu/g for moulds and yeasts. Verma (2007) also reported that total sugars, reducing sugars and browning were found to increase, whereas acidity and total phenols of bael ready-to-serve drink were decreased during storage period. The ready to serve beverage of stone apple (*Aegle marmelos* correa) with 13 per cent pulp, 14 °Brix TSS and 0.3 percent acidity was considered standard based on organoleptic evaluation. The RTS blended with ginger juice fetched higher sensory acceptability and also standardized the process parameters with respect to biochemical, microbial and sensory acceptance Kalpana *et al.* (2008).

Markam and Singh, (2012) studied the effect of chemical preservative of potassium metabisulphite was studied on the microbial and sensory quality of the custard apple RTS beverage stored at ambient temperature (28-32°C) for 180 days with an interval of 1 month, mean score of test panel for colour, taste, flavour, appearance and overall acceptance significantly decreased, whereas, the microbial contamination was found maximum at 30 days of storage. The RTS beverage prepared from 10 per cent aloe juice with 15° Brix TSS was found to be the most ideal recipe (Vijayalakshmi, 2012).

2.3 Preparation of squash beverages

Squash is a fruit juice beverage, which is altered considerably in its composition before consumption. It may be diluted before serving with plain or aerated water. Squash consists of essentially strained juice containing moderate quantities of fruit pulp and appropriate sugar/acid ratio for good taste. It is a refreshing drink containing vitamins and minerals. According to FPO specification squash should possess minimum juice of 25 per cent, TSS of 40° Brix acidity 1.5 per cent and maximum preservative of SO₂ 350 ppm or benzoic acid 600 ppm (Anon., 1984).

Mangave (1982) noticed that the reducing sugars varied from 11.36 to 22.85 per cent

while non-reducing sugars varied from 0.96 to 5.34 per cent. In a varietal evaluation under Bangalore condition, the reducing sugars ranged from 12.7 to 15.0 per cent, whereas the total sugars ranged from 15.9 to 17.9 per cent. Pruthi *et al.* (1984) found that Squash and RTS beverages prepared from malta orange beverage based and malta orange juice concentrate were found acceptable for six months when stored at room temperature (25-30°C).

Pandey and Singh (1998) studied the preparation and preservation of guava squash. The recipe containing 25 per cent pulp and 45 per cent TSS with 1.0 per cent acidity was found most ideal. The product remained acceptable up to a period of six months under ambient temperature.

Vishal and Sharma (1998) had given an ideal recipe for squash and syrup which includes 25 per cent pulp, 45 per cent TSS, 1 per cent acidity for squash and 25 per cent pulp, 68 per cent TSS and 1.2 per cent acidity for syrup from different varieties of aonla. Squash and syrup prepared from Cv. Chakaiya scored highest for organoleptic quality.

Sanjeevkumar and Singh (1998) studied the recipe for preparation of papaya beverages like nectar and squash, the products were evaluated. Nectar with composition 20 per cent pulp, 13 per cent TSS and 0.3 per cent acidity, squash of composition 25 per cent pulp, 50 per cent TSS and 1.1 per cent acidity were found ideal. Thakur and Barwal (1998) studied the preparation and evaluation of squash from unmarketable kiwi fruit. The squash of 45 °Brix with 25 per cent and 30 per cent pulp of the Cv. Allison had highest taste, flavour and acceptable score during storage period.

Singh *et al.* (2001) reported that preparation of squash from Barhal (*Artocarpus lakoocha* R.) fruits by composition of 25 per cent juice, 45 per cent TSS and 1 per cent acidity was found excellent. Gajanana (2002) revealed that acceptable quality aonla squash could be obtained with the recipe containing 30 per cent aonla with 5 per cent lime juice, 2 per cent ginger juice and TSS adjusted to 40 °Brix.

Ramanjayam *et al.* (2002) reported that the Simarouba squash prepared with 40 per cent juice, 45 per cent TSS recorded maximum ascorbic acid, total sugars and reducing sugar. In addition, this combination had better colour and was rated superior in sensory quality attributes such as appearance, aroma, taste and overall acceptability in organoleptic evaluation.

Vijay *et al.*, (2006) reported that recipe of 40 per cent pulp, 60 per cent TSS and 0.75 per cent acidity was most ideal to prepare squash from aonla. This product remained acceptable up to a period of six months during storage at room temperature. The total soluble solid, reducing sugar and total sugar of the squash increased continuously during storage while the ascorbic acid in contrast decreased. Seabuckthorn fruits in the combination of 25 per cent pulp and 50 per cent TSS were found the best for the preparation of seabuckthorn squash on the basis of sensory evaluation (Rohit *et al.*, 2008). Bael squash was prepared with different sugar concentrations (1.5, 1.75, 2.00 and 2.25 kg/litre of fruit juice) and stored up to 90 days under ambient conditions (Kenghe *et al.*, 2009).

2.4 Physico-chemical changes in fruit beverage during storage

Paul (1979) reported the extent of physico-chemical and sensory changes during the storage of beverage depend on the type of fruit, ingredients used method of processing and storage conditions. Roy and Singh (1979) reported that squash and nectar prepared from bael fruit changed its original colour to light brown during storage. They further observed a decrease in acidity as well as ascorbic acid and increase in total and reducing sugar content of squash and nectar during six months of storage at room temperature.

The nutrients loss was common feature in processed products (Tripathi *et al.*, 1988). They also observed that most of the beverage showed an increase in TSS and reduction in total titratable acidity and ascorbic acid, which was proportional to the storage period. In

guava beverage, the loss of ascorbic acid was in the range of 40 to 56 per cent after one year of storage, whereas, total soluble solids increased slightly over the control during the storage period (Kalra *et al.*, 1988).

Rajani (1998) reported that the extracted fresh custard apple pulp had a pH of 5.3 and soluble solids of 20 °B, acidity of 0.22 per cent, ascorbic acid 3.44 mg per 100 g, reducing sugar 14.04 per cent, non reducing sugar 6.27, total sugar 20-30 per cent, crude fibre 1-96 mg per 100 ml, crude protein 1.56 per cent, nitrogen 0.25 per cent, calcium 0.20 per cent and iron 0.99 per cent.

Five products (juice, squash, ready to serve, cordial, syrup) prepared from four varieties of litchi were stored at room temperature for twelve months and their quality was evaluated at every three months interval. Vitamin C significantly decreased, whereas reducing sugar increased slightly in all the products during the storage period (Karuna *et al.*, 2005).

An increase in reducing sugar and decrease in ascorbic acid with processing and storage of citrus juice was noticed by Ranote and Bains (1982). According to Raghuramaih and Ranganna (1970), darkening of citrus juices during storage is due to the oxidation of ascorbic acid to dehydro-ascorbic acid.

Mango squash prepared from different varieties showed an increase in reducing sugar and loss of acidity during storage, whereas, the TSS did not change much (Palaniswamy *et al.*, 1974). Increase in TSS and reduction in acidity and ascorbic acid was observed in lime juice squash by Palaniswamy and Muthukrishnan (1974).

Garande *et al.* (1995) reported that jamun RTS stored at room temperature showed an increase in TSS, total sugar, reducing sugar and pH. However, a reduction in non reducing sugar and acidity was observed during storage. There was a continuous increase in the values of total sugars (11.2 to 13.6%) and reducing sugars (4.8 to 11.5%) in the RTS beverage prepared from pineapple guava blends during three months of storage (Tripathi *et al.*, 1988).

Damame *et al.* (2002) observed that vitamin C content in aonla products (juice and syrup) goes on decreasing with the advancement of storage period. The physico-chemical changes in jamun (*Syzygium cumini*) fruit products like RTS, squash and syrup during the storage were studied. Total soluble solids and reducing sugar increased whereas, the total sugars and acidity decreased slightly. The total phenolics (tannins) decreased throughout the storage period. The maximum retention of anthocyanin was in syrup, squash and RTS beverage (Kannan *et al.*, 2004). Ready-to-serve beverage was prepared from two varieties of jackfruits with 10 per cent pulp, 18°Brix TSS and 0.25 per cent acidity. The storage study showed an increasing trend in the acidity and reducing sugar and decreasing trend in total sugar, ascorbic acid content. Retention of ascorbic acid and β-carotene contents were much better in the sample stored in green coloured bottles Krishanaveni *et al.*, (2001).

Ramajayam *et al.* (2002) studied the development of value added simarouba and kokum-simarouba squash blends. During 5 months of storage, TSS and pH recorded an increasing trend whereas acidity recorded a decreasing trend. However, there was no conspicuous change in total sugars, reducing sugars and ascorbic acid.

A significant decrease in acidity level with increase in pH level in sapota squash was noticed during storage period of six months (Srinivas *et al.* 2007). An increasing trend in total sugar content (40.84 to 41.76 %) of sapota squash prepared from sapota fruits of CO-2 cultivar after 30 days of storage (Sudha *et al.* 2007).

Kinnow mandarin juice and ginger juice were blended in the ratio of 0:30, 5:25, 10:20, 15:15, and 20:10, 25:5 and 30:0, respectively to prepare squash from these blends. TSS was fixed at 40 to 45°B. A gradual and consistent decrease in acidity was observed in the stored squash (Nath *et al.*, 2005).

Singh *et al.* (2005) studied the standardization of processing technology of bael or blended bael ready to serve beverages. The TSS, TSS-acid ratio and total sugar of ready-to-serve drink increased during storage up to three months. Acidity, non-reducing sugar and phenols decreased, whereas reducing sugars and browning increased during the storage of six months. Choudhary *et al.* (2006) have reported that RTS beverage of guava noted an increase in acidity during its 150 days of storage.

Vijayalakshmi, (2012) reported that ready-to-serve beverage of aloe vera noted an increase in TSS, reducing sugars, total sugars, sugar: acid ratio and pH, whereas titratable acidity, ascorbic acid, non-reducing sugars and polysaccharides decreased during the storage period of six months. Vijayalakshmi, (2012) reported that increasing storage period with increase in TSS, total sugars, reducing sugars, pH, whereas acidity, ascorbic acid, non-reducing sugars decreased during storage in aloe squash.

Relekar *et al.* (2013) reported an increase in the levels of TSS, reducing sugar, total sugar and pH as well as a decline in that of acidity of sapota squash during the storage period of six months.

2.5 Sensory changes in fruit juice beverages during storage

Jasimahmad (1996) found that the banana RTS beverage prepared from 15 per cent juice, 12°Brix TSS and 0.15 per cent acidity recorded highest sensory score for colour, flavour, consistency and overall acceptability.

Sensory evaluation score was higher in the treatments involving blending kinnow juice with pomegranate and ginger juice in the ratio of 87:10:3 due to better consistency and flavour up to the end of storage (Bhardwaj and Mukherjee 2011). The RTS and nectar beverage prepared from blended fruits of grape:mango (3:1) and grape:pineapple (1:1) received the better sensory score as compared to other combinations (Saxena *et al.* 1996).

Carrot drinks fortified with natural or commercial flavours of mango and orange had high quality attributes, sensory parameters and consumer acceptability. The data also revealed that carrot drinks fortified with natural flavours (mango or orange) exhibited higher quality and acceptability than those fortified with commercial flavours (Mohamed, 1997).

Joshi *et al.* (1993) reported that the plum pulp beverage with spice extracts (mint 0.4, ginger juice 0.5, cumin 0.25, cardamom 0.25 and black pepper 0.1 %) having 45°Brix obtained highest organoleptic score. Singh and sanjeevakumar (1995) reported that the RTS beverage prepared from 10 per cent aonla pulp + 2 per cent lime juice + 1 per cent ginger juice having 12 per cent TSS, 0.3 per cent acidity was found to be best with regard to organoleptic quality.

Waskar and Khurdiya (1987) observed that decline in overall acceptability score of phalsa squash from 8.10 to 4.40 after 180 days of storage. Similar declining trend in overall acceptability was noticed by Dwivedi *et al.* (2004) in custard apple toffee and Jadhav *et al.* (2004) in tamarind squash

Bhosale *et al.* (2000) reported that RTS beverage prepared from 80:20 (Aonla: Mango) blend had better consumer appeal and nutritional value over other blends. Gajanana (2002) reported that aonla RTS beverage prepared with recipe of 12 per cent aonla juice, 2 per cent lime juice and 1 per cent ginger and TSS adjusted to 15°Brix was found to be acceptable with higher organoleptic score.

Gajanana (2002) reported that the blended beverage prepared from 12 per cent aonla juice + 2 per cent lime juice + 1 per cent ginger juice + sugar adjusted to a TSS at 15°Brix and blended squash with recipe of 30 per cent aonla juice + 15 per cent lime juice + 2 per cent ginger + sugar adjusted to a TSS of 40°Brix were found to be highly acceptable with higher organoleptic score. Mandal (2003) observed that the blended RTS containing 75 per cent pineapple juice and 25 per cent phalsa juice secured the highest organoleptic score.

Higher overall acceptability and enhanced vitamin C content was achieved by blending goose berry juice with grape juice at 20:80 ratios (Jain and Khurdiya 2004). Jamun RTS beverage prepared with recipe consisting of 14 per cent juice + 0.15 per cent citric acid and adjusted with sugar to TSS of 14° Brix was found to be acceptable with higher organoleptic score (Upale, 2005).

According to Singh *et al.* (2001) 70 per cent mango + 30 per cent papaya pulp squash secured maximum acceptability. Paneer whey beverage prepared from 2.5 per cent kokum juice and 15 per cent sugar with 0.1 per cent jeera powder was found most acceptable sensory quality. Rupanar *et al.* (2009) found that blending of pomegranate and kokum juices in 80:20 per cent gave good TSS, acidity and anthocyanins. The blending of sand pear juice with apple juice in the proportion of 50:50 to 60:40 gave better quality with higher sensory score (Devaraju *et al.*, 2001).

The palmyrah fruit ready-to-serve sample subjected to sensory evaluation showed significant differences between treatments with respect to colour, aroma, taste, consistency and overall acceptability. From the result of quality assessments, the formulated beverage with 12 per cent of pulp concentration was found to be superior in quality and could be stored at 30±2°C for minimum period of six months without any significant changes in quality (Nilugin and Mahendran, 2010).

Patil *et al.* (2011) reported that the mango squash prepared from 40 per cent pulp, 50°Brix TSS and 1.5 per cent acidity secured maximum scores and stood best among all the recipes for colour, flavour, consistency and overall acceptability during 32 days of storage.

Kirtiraja *et al.* (2013) reported that RTS beverage prepared by blending aonla and ginger juice with aspartame scored maximum for all most all sensory quality attributes such as colour, flavour, taste and overall acceptability. Sapota squash with 30 per cent juice and 50°Brix TSS recorded the highest sensory score for flavour and taste (Relekar *et al.*, 2013).

2.6 Storage of fruit juice beverages

Masoodi *et al.* (1992) reported that the perlette grape juice could be stored by addition of different quantity of potassium metabisulphite (350, 450, 550 and 600 ppm) and heating the juice at 88°C for two minutes prior to storage.

Jain *et al.* (1984) observed that an ideal squash could have acidity of 1.00 to 1.50 per cent, whereas in nectar, 0.3 to 0.5 per cent. Acidity prevents development of off-flavour or off-odour during storage of the products.

According to Sudhir and Kilara (1983) temperature plays an important role in storage stability of processed products. Temperature fluctuations, high temperature and unhygienic storage conditions have an adverse effect on the quality of stored processed products caused early deterioration. Jack fruit squash preserved with potassium metabisulphite showed very little changes in its colour, taste and flavour during storage. However, it exhibited an increase in reducing sugar content of the squash irrespective of preservatives used (Deverajaiah, 1987).

Chobe (1999) reported an increasing trend in TSS, pH, reducing sugar, non reducing sugar and total sugar during storage of pomegranate juice both at room and low temperature, while there was decrease in acidity and ascorbic acid.

Saini and Dharmpal (2001) reported that, thermally processed mango RTS beverage showed increase in reducing sugar, total sugar and reduction in non reducing sugar, of the three methods of preservation *viz.*, sulphitation at 600 ppm, benzoate at 1000ppm and 50:50 combinations of SO₂ and sodium benzoate. However, sulphitation retained maximum sugar over a storage period of 24 weeks.

The jamun products like RTS, squash and syrup stored in colourless glass bottles were accepted even after 6 months storage at ambient conditions. The appearance, colour, flavour, taste and overall acceptability were found to be good (Kannan and Thirumaran 2004).

Sorolia and Mukharjee (2002) studied the effect of different preservation methods on keeping quality of lime juice, viz., heating at 85°C, pasteurization, potassium metabisulphite, and sodium benzoate. Among the various treatments, the use of KMS 0.1 per cent was found to be effective in preserving the juice for two and half months. Storage studies showed an increase in sugars, pH, TSS and browning, whereas acidity and ascorbic acid of lime juice decreased.

Vijayanand *et al.* (2003) reported that aonla juice pasteurized at 85 to 90°C and was filled in sterilized bottles, 200 gauge polyethylene pouches and the pouches were blast frozen at -40°C. Both were shelf stable, where as pasteurized juice filled in high density polyethylene bags with class- II preservative was stable up to six months of storage at 10°C.

The tamarind RTS beverages were stored at ambient (33.8± 7.4°C, RH 74.2± 23.8 per cent) and low (7±2°C, RH 90-95%) temperature for 180 days. The changes in chemical composition and overall acceptability score of the products during storage showed that TSS, titratable acidity and total sugar content of the RTS beverage stored at both temperatures increased, whereas ascorbic acid content decreased. The overall acceptability score for the RTS beverage decreased during storage (Kotecha and Kadam, 2003).

2.7 Microbial analysis of fruit juice beverage

Assessment of microbial contamination indicates the sanitary quality of the food products. Microorganisms associated with the food products not only cause the spoilage, but also responsible for the food borne illness. Proper processing and storage conditions can control the growth of the micro organisms in the food products.

In India the chances of transmission of disease through fruit juices are due to unsatisfactory hygiene and adulteration practices. Microorganisms are present both inside as well as outside of fruits and vegetables. At the time of consumption, the majority of bacteria found on the surface are usually gram -ve and belong to the *Enterobacteriaceae*. Many of these organisms are usually non pathogenic to humans. The inner tissues of fruits are usually regarded as sterile. However, bacteria can be present in low number as a result of the uptake of water through certain irrigation or washing procedures.

Microbial load was within permissible level in different squashes of citrus formulated using orange and mosambi immediately after formulation and on storage (Bobby and Radhaisri, 2003).

Chandan (2004) reported an increase in microbial load of aonla RTS during storage at ambient condition. Upale (2005) reported that during three months of storage studies the microbial load of jamun RTS, standard plate count (SPC) for bacteria ranged from 2.50×10^5 CFU per ml to 2.74×10^5 CFU per ml.

Addition of 350 ppm of potassium metabisulphite in whey based kinnow juice concentrate was found to be effective in retarding the growth of yeast and mould counts during storage at refrigerated temperature (4±1°C, 80% RH) for nine months and at ambient temperature (15-35°C, 66-85 % RH) for four months (Khamurau *et al.*, 2004).

Jayalaxmi (2006) reported that the microbial load of sapota juice preserved with pasteurization, chemical preservatives and with combination of both showed lower microbial load as compared to fresh juice (untreated control). However, any of these treatments could not help in extending the storage life as the juice was fermented beyond 15 days.

Sameer (2006) reported that, jamun beverages stored in different storage methods comparatively minimum changes were noticed under refrigerated storage than at ambient storage with respect to all chemical parameters and microbial load.

Yeast, moulds and coliforms were not detected in unpasteurized sweet orange juice stored in sterilized containers at refrigerated conditions ($10\pm 2^{\circ}\text{C}$) up to four days, there after juice exhibited presence of microbes except *Staphylococcus aureas*. Pasteurization and refrigeration inhibited the growth of microbes (Jain *et al.*, 2003).

Effect of thermal processing (92°C for 2 min) and high pressure treatment (500Mpa, 25°C for 10min) on microbial inactivation of tomato juice during refrigerated storage at 4°C for 28 days was investigated by Hsu, *et al.* (2008). It was reported that thermal processing produced microbial stable juice with total viable counts less than 1.0 cfu/ml. No detection of yeast, moulds and *E. coli*. High pressure treatment also resulted in efficient inactivation of all micro organisms with the minimum loss of nutrients.

Nirmal *et al.* (2006) found that in wood apple RTS beverage with addition of sodium benzoate was found to be effective in controlling the growth of micro organisms, as no microbial growth was observed upto 90 days of storage. The microbial analysis of stored whey based papaya juice for 90 days at refrigerated condition was studied by Kumar *et al.* (2005). A slight increase in colonies of bacteria ($1- 2\times 10^{-6}$), yeast (1×10^{-5}) and fungi ($1-2\times 10^{-4}$) were observed during storage. But which are considered as safe for consumption (Madhukar, 2008).

Blend juice of kinnow juice: aonla juice: ginger juice (92:5:3) was better in view of non enzymatic browning (0.081 to 0.10×10^4 CFU) and minimum population of bacteria (4.0×10^3 CFU), mould (1.5×10^3 CFU) and yeast (2.1×10^3 CFU) at the end of 6 months storage. It was also observed that the addition of ginger juice in blends improves the quality and reduces microbial growth. Further, the juice was found acceptable after six months of storage at room temperature (Bhardwaj and Mukherjee, 2011).

3. MATERIAL AND METHODS

Investigation on “Studies on processing and preservation of custard apple pulp, squash and ready-to-serve beverages” were carried out in the Department of Post-Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi, Belgaum district, Karnataka during the year 2013-2014. The methods followed and materials used during the investigation are elucidated here under.

3.1 Geographical location and climate

Arabhavi is situated in northern dry zone (zone-3) of Karnataka. It lies at 16°15' N latitude and 75° 45' E longitudes, at an altitude of 612.05 m from mean sea level. The average annual rainfall at Arabhavi is about 432 mm and it is distributed over a period of eight to nine months (May 2013 to November 2013) with peaks (100.4 mm) during October. The mean maximum temperature goes up to 38.24°C (April) and mean minimum temperature drops down to 9.3°C (January). The relative humidity varies between 55.39% (February) to 88.59% (December).

3.2 Fruits used in the investigation

Custard apple (*Annona squamosa* L.) fruits were procured from Mr. Mahantesh farm located at village Hattaragi of taluk Hukkeri, Belgaum district of Karnataka. Fruits of uniform size, shape and fully matured were selected, packed in corrugated fibre boxes and brought to the laboratory for further experimentation.

3.3 Extraction of custard apple pulp

The selected custard apple fruits were cut opened by hand. The pulp was extracted by scooping and squeezing for de-seeding and kept in sterilized steel container. The pulp obtained was homogenous and free from seeds and fibre. This fine pulp was used for a part of which was used to standardize the pulp preservation method and preparation of processed products like RTS (Ready-to-serve) and squash.

3.4 Experimental details

3.4.1 Experiment I – Studies on effect of chemical preservatives on storage of custard apple pulp

The experiment was conducted in a Completely Randomized Design with three replications. The details of the treatments are as follows.

Treatments details

T₁-Potassium metabisulphite 1000 ppm

T₂- Potassium metabisulphite 1500 ppm

T₃-Sodium benzoate 1000 ppm

T₄-Sodium benzoate 1500 ppm

T₅-Potassium sorbate 1000 ppm

T₆-Potassium sorbate 1500 ppm

T₇-Citric acid 1000 ppm

T₈-Control

3.4.1.1 Methodology for extraction of custard apple pulp:

Selected fruits are cut into 2 halves and scooped out the pulp with stainless steel spoon and pulp was extracted. Acidity level of 0.5% and Total Soluble Solids (TSS) of 26 °Brix was adjusted commonly and the pulp was used for both the experiments on standardization of preservatives and pasteurization treatment. After preparation preservatives were added as per the treatment details to the pulp. The treated pulp was bottled and kept for storage in ambient condition up to 15 days. The observations were recorded at every five days interval to evaluate changes in chemical, organoleptic parameters and total bacterial count. The products were evaluated for sensory qualities viz., colour and appearance, taste and aroma, mouth-feel and overall acceptability by a panel of 10 semi-trained judges using 5 point hedonic scale.

3.4.2 Experiment II – Studies on effect of pasteurization temperature for preservation of custard apple pulp

The design adopted for this experiment was Completely Randomized Design with three replications. The details of the treatments are as given below.

Treatment details

T₁- Pasteurization temperature at 85°C for 20 min

T₂- Pasteurization temperature at 85°C for 25 min

T₃- Pasteurization temperature at 85°C for 30 min

T₄- Pasteurization temperature at 90°C for 20 min

T₅- Pasteurization temperature at 90°C for 25 min

T₆- Pasteurization temperature at 90°C for 30 min

T₇- Control

3.4.2.1 Methodology:

The extracted pulp with 0.5 per cent acidity and 26 °Brix was used for various pasteurization treatments. Further custard apple pulp was bottled and subjected to storage studies at room temperature for a period of 15 days. Samples were drawn initially and at five days interval to evaluate changes in chemical, organoleptic parameters and total bacterial count. The products were evaluated for sensory qualities viz., colour and appearance, taste and aroma, mouth-feel and overall acceptability by a panel of 10 semi-trained judges using 5 point hedonic scale.

3.4.3 Experiment III – Preparation and preservation of custard apple RTS

The design adopted was Completely Randomized Design with nine treatment and three replications.

Treatment details

T₁-Pulp (10%) + TSS (14°B)

T₂-Pulp (10%) + TSS (15°B)

T₃-Pulp (10%) + TSS (16°B)

T₄-Pulp (12%) + TSS (14^oB)

T₅-Pulp (12%) + TSS (15^oB)

T₆-Pulp (12%) + TSS (16^oB)

T₇-Pulp (14%) + TSS (14^oB)

T₈-Pulp (14%) + TSS (15^oB)

T₉-Pulp (14%) + TSS (16^oB)

3.4.3.1 Methodology for preparation of RTS beverage:

For the preparation of custard apple RTS, extracted pulp was mixed with table sugar and water as per recipe mentioned in the treatment details. The TSS of the beverage was adjusted by adding table sugar as specified in the treatment details using digital refractometer (Erma make), acidity levels were adjusted to 0.1 per cent acid by the addition of citric acid in all the treatments. After pasteurization and addition of chemical preservatives, RTS was bottled and subjected to storage studies at room temperature for a period of 3 months. Samples were drawn initially and at monthly interval to evaluate changes in chemical, organoleptic parameters and total bacterial count.

3.4.4 Experiment IV – Preparation and preservation of custard apple Squash

The design adopted was Completely Randomized Design with six treatments and four replications.

Treatment details

T₁-Pulp (25%) + TSS (40^oB)

T₂-Pulp (25%) + TSS (42^oB)

T₃-Pulp (25%) + TSS (44^oB)

T₄-Pulp (25%) + TSS (46^oB)

T₅-Pulp (25%) + TSS (48^oB)

T₆-Pulp (25%) + TSS (50^oB)

3.4.4.1 Methodology for preparation of squash

For the preparation of custard apple squash, the pre-extracted pulp was mixed with table sugar and water as per recipe mentioned in the treatment details. The TSS of the beverage was adjusted by adding table sugar as specified in the treatment details using digital refractometer (Erma make), acidity levels were adjusted to 1 per cent acid by the addition of citric acid in all the treatments. After pasteurization and addition of chemical preservatives, the custard apple squash was bottled and subjected to storage studies at room temperature for a period of 3 months. Samples were drawn initially and at monthly interval to evaluate changes in chemical, organoleptic parameters and total bacterial count.

3.5 Observations recorded

3.5.1 Total soluble solids (%)

The total soluble solids of custard apple pulp, RTS and squash was measured by using an 'Erma' make hand refractometer and expressed as percentage after making necessary corrections.

3.5.2 Sugars (%)

The sugar content of pulp and juice of custard apple products obtained from representative sample under each treatment were estimated and expressed in percentage.

3.5.2.1 Reducing sugar (%)

Reducing sugar in sample was estimated as per the Dinitrosalicylic acid method (Miller, 1972). The values obtained were expressed in percentage.

3.5.2.2 Total sugars (%)

The total sugars present in the fruit pulp and products were estimated by the same method as in case of reducing sugar after inversion of the non-reducing sugars using dilute hydrochloric acid (Anon., 1984). One ml of evaporated extract was taken and kept in boiling water bath till the alcohol completely evaporated and allowed it to cool. Then phenolphthalein indicator was added followed by 1 N sodium hydroxide till the solution turned to pink. Again 0.1 N hydrochloric acid was added to discolour the solution. Then Dinitro-salicylic acid (DNSA) method for reducing sugar was followed. The results obtained were expressed in terms of percentage.

3.5.2.3 Non-reducing sugar (%)

The per cent non-reducing sugars were obtained by subtracting the value of reducing sugar from that of total sugar.

Non-reducing sugar (%) = [Total sugar (%) – reducing sugar (%)] × 0.95

3.5.3 Ascorbic acid (mg/100g)

Ascorbic acid content was estimated by using 2, 6 - Dichlorophenol indophenol dye titrimetrically as per the modified procedure of AOAC (Anon., 1984). Five ml of sample was taken and diluted to a known volume (100 ml) with 4 per cent oxalic acid. This was filtered through muslin cloth to get clear juice. Five ml of aliquot was titrated against 2,6-dichlorophenol indophenols dye till the pink end point which persisted for at least 15 seconds. The result was expressed as milligrams of ascorbic acid per 100 ml.

$$\text{Ascorbic acid (mg/100 ml)} = \frac{\text{Dye factor X Titre value X Vol. made up}}{\text{Aliquot X Vol. of sample}} \times 100$$

3.5.4 Titratable acidity (%)

A known volume of sample (5 ml) was taken and titrated against the standard NaOH using phenolphthalein indicator. The appearance of light pink color was marked as the end point. The value was expressed in terms of citric acid as per cent titratable acidity of juice (Anon., 1984).

3.5.5 Non-enzymatic browning (OD value)

The browning of custard apple pulp and products *viz.*, RTS and squash was carried out. Ten ml of sample was taken and centrifuged at 5000 rpm for 4-5 min and the supernatant was collected. A 40 per cent solution was prepared in ethyl alcohol and mixed thoroughly. Filtered through whatman No.1 paper. Measure the absorbance of the samples at 440 nm for non-enzymatic browning. Prepare 60 per cent ethyl alcohol solution as blank.

3.5.6 Microbial analysis (CFU/ml)

The microbial analysis of custard apple pulp and products *viz.*, RTS and squash was carried out as per the method of Harrigan and Mccance (1966). Ten ml of juice was taken for analysis. The samples were placed on nutrient agar media for bacterial isolation following serial dilution technique. Plates were incubated for two days at $28 \pm 1^\circ\text{C}$ and colonies were counted and CFU per ml was calculated.

3.5.7 Colour ($L^* a^* b^*$)

The colour of the samples was measured using a Lovibond colour meter (Lovibond RT300, Portable spectrophotometer, The Tintometer Limited, Salisbury, UK) fitted with 8mm diameter aperture. The instrument was calibrated using the black and white tiles provided. Colour was expressed in Lovibond units L^* (Lightness/darkness), a^* (redness/greenness) and b^* (yellowness/blueness). Samples were placed under the aperture of the colour meter. Three measurements were performed for each sample and values were averaged.

3.6.8 Organoleptic evaluation (Score out of 5.00)

Organoleptic evaluation of custard apple pulp and products *viz.*, RTS and squash was carried out by a panel of 10 semi-trained judges. The organoleptic characters like colour and appearance, mouthfeel, taste and flavor, and overall acceptability were evaluated on a 5 point Hedonic scale using the score card mentioned below. The scores given by 10 semi-trained judges were used for statistical analysis.

Score card for organoleptic evaluation

Colour and appearance	Mouth-feel	Taste and Flavour	Overall Acceptability	Scores
Highly attractive	Extremely pleasant	Excellent	Extremely acceptable	5
Very attractive	Very pleasant	Very good	Very acceptable	4
Moderately attractive	Moderately pleasant	Good	Moderately acceptable	3
Slightly attractive	Slightly pleasant	Fair	Slight acceptable	2
Not attractive	Not pleasant	Poor	Not acceptable	1

3.6.9 Statistical analysis

The data on the physico-chemical parameters and total bacterial count (TBC) recorded were subjected to completely randomized design analysis in experiments I, II, III and IV. Interpretation of the data was carried out in accordance with Panse and Sukhatme (1967). The level of significance used in 'F' test was $p= 0.01$. Critical difference values were calculated wherever 'F' test was significant.

4. EXPERIMENTAL RESULTS

The experiment entitled “Studies on processing and preservation of custard apple pulp, squash and ready-to-serve beverages” was conducted during 2013-2014 at the Department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi. The results obtained in the present study are presented hereunder.

4.1 Experiment -I: Effect of chemical preservatives on storage of custard apple pulp

4.1.1 Total soluble solids (%)

The data on total soluble solids (TSS) of custard apple pulp as influenced by treatments and storage periods are presented in Table 1.

The TSS was adjusted to 26°Brix commonly in all the treatments at the beginning. However, the results showed significant difference among the treatments for this parameter during storage. The treatment T₂ (Potassium metabisulphite at 1500 ppm) recorded highest TSS of 26.88, 27.73 and 27.80 per cent, respectively at 5, 10, 15 days after storage, followed by treatment T₁ (26.32%) at 5 days after storage which was on par with T₁ (27.33%) and T₄ (27.30%) at 10 DAS; T₁ (27.77%) and T₄ (27.37%) at 15 DAS. The minimum TSS of 25.03, 25.30 and 25.50 per cent was recorded in the treatment T₈ (control) at 5, 10 and 15 days after storage.

4.1.2 Titratable acidity (%)

The titratable acidity was expressed in terms of citric acid as percentage on fresh juice weight basis. The results on total titratable acidity showed significant differences between the treatments and storage periods. The treatment T₂ recorded significantly maximum titratable acidity in chemically preserved custard apple pulp at initial, 5, 10 and 15 days after storage 0.73, 0.68, 0.63 and 0.56 respectively and it was found on par with the treatments T₁ and T₄ at initial days of storage; with T₁, T₃ and T₄ at 5, 10 and 15 days after storage.

The lowest titratable acidity was found in T₈ (0.52, 0.47, 0.42 and 0.37%) at initial, 5, 10 and 15 DAS.

4.1.3 Ascorbic acid (mg/100g)

The data on retention of ascorbic acid content was found to have significant differences among the treatments during the storage period (Table 1). As evident from the grand mean, ascorbic acid content showed decreasing trend with the increase in storage period.

The treatment T₂ (potassium metabisulphite at 1500 ppm) recorded highest ascorbic acid of 4.31, 4.27, 3.72, 3.62 mg/100g respectively at initial, 5, 10 and 15 days after storage and it was on par with treatment T₁, T₃ and T₄ at initial and 5 DAS; T₁, T₃, T₄ and T₆ at 10 and 15 days after storage. However, the ascorbic acid content was significantly lowest in the control (T₈) at initial, 5, 10 and 15 (3.44, 3.41, 3.04, 2.99 mg/100 g) DAS.

4.1.4 Reducing sugar (%)

The data with respect to reducing sugar content of custard apple pulp in different treatments stored up to 15 days are presented in Table 2. Mean values for reducing sugar indicated an increasing trend in their level with increase in storage time.

Significant differences among the treatments were recorded at initial, 5, 10 and 15 days after storage. The treatment T₂ (potassium metabisulphite at 1500 ppm) recorded maximum reducing sugar content of (15.90, 15.92, 16.00, 16.01%) respectively and the

Table 1: Effect of chemical preservatives on total soluble solids, titratable acidity and ascorbic acid of custard apple pulp during storage

Treatments	Total soluble solids (%)				Titratable acidity (%)				Ascorbic acid (mg/100g)			
	Days after storage											
	Initial	5	10	15	Initial	5	10	15	Initial	5	10	15
T ₁ - Potassium metabisulphite at 1000 ppm		26.32	27.33	27.77	0.69	0.61	0.59	0.51	4.14	4.13	3.62	3.52
T ₂ -Potassium metabisulphite at 1500 ppm		26.88	27.73	27.80	0.73	0.68	0.63	0.56	4.31	4.27	3.72	3.62
T ₃ - Sodium benzoate 1000 ppm		26.07	27.07	27.15	0.61	0.56	0.51	0.43	3.95	3.93	3.49	3.39
T ₄ - Sodium benzoate 1500 ppm		26.09	27.30	27.37	0.65	0.60	0.55	0.49	4.13	4.08	3.60	3.49
T ₅ - Potassium sorbate 1000 ppm	26.00	26.03	26.09	26.11	0.57	0.52	0.47	0.39	3.68	3.63	3.16	3.06
T ₆ -Potassium sorbate 1500 ppm		26.04	26.67	26.68	0.58	0.53	0.48	0.39	3.74	3.69	3.31	3.23
T ₇ -Citric acid 1000 ppm		26.00	26.17	26.19	0.55	0.50	0.45	0.38	3.60	3.54	3.14	3.04
T ₈ -Control		25.03	25.30	25.50	0.52	0.47	0.42	0.37	3.44	3.41	3.04	2.99
Mean	26.00	26.06	26.71	26.82	0.61	0.56	0.51	0.44	3.87	3.84	3.34	3.29
S. Em±	---	0.12	0.13	0.13	0.04	0.03	0.04	0.04	0.11	0.11	0.13	0.13
C.D. at 1%		0.49	0.49	0.56	0.14	0.14	0.14	0.12	0.43	0.43	0.49	0.49

Table 3: Effect of chemical preservative on colour (L^* a^* b^*) values of custard apple pulp during storage

Treatments	L^* value				a^* value				b^* value			
	Days after storage											
	Initial	5	10	15	Initial	5	10	15	Initial	5	10	15
T ₁ - Potassium metabisulphite at 1000 ppm	40.43	40.13	39.99	39.92	2.76	2.96	2.98	2.99	4.27	3.98	3.65	3.15
T ₂ - Potassium metabisulphite at 1500 ppm	41.22	40.92	40.72	40.62	2.82	2.96	2.98	3.00	3.57	2.89	2.36	2.13
T ₃ - Sodium benzoate 1000 ppm	43.25	42.95	42.75	42.65	2.80	2.94	2.95	2.96	2.99	3.33	2.99	2.99
T ₄ - Sodium benzoate 1500 ppm	48.47	48.37	48.31	48.21	2.38	2.58	2.78	2.93	2.70	2.78	2.40	2.17
T ₅ - Potassium sorbate 1000 ppm	38.83	38.53	38.33	38.26	2.53	2.73	2.93	2.96	2.46	2.79	2.49	2.50
T ₆ - Potassium sorbate 1000 ppm	35.13	34.93	34.73	34.63	2.19	2.39	2.46	2.46	3.77	2.93	3.89	3.89
T ₇ - Citric acid 1000 ppm	36.78	36.52	36.35	36.25	2.69	2.89	2.96	2.97	3.31	3.31	2.95	2.95
T ₈ - Control	34.55	34.45	34.25	33.81	2.11	2.28	2.41	2.41	1.88	1.81	1.85	1.90
Mean	39.83	39.60	39.43	39.30	2.54	2.72	2.81	2.84	3.19	2.98	2.82	2.71
S.Em±	2.41	2.42	2.43	2.46	0.15	0.14	0.12	0.12	0.19	0.29	0.12	0.17
C.D.at 1%	9.95	10.0	10.04	10.16	0.61	0.57	0.49	0.50	0.78	1.21	0.53	0.66

L^* = Dark - Light, a^* = Green – Red, b^* = Blue –yellow

minimum was associated with the treatment T₈ (14.43, 14.78, 15.13, 15.18%) at initial, 5, 10 and 15 days of storage.

The treatment T₂ was on par with treatments T₁, T₃, T₄, T₆ at initial DAS, T₁, T₃, T₄, and T₅ at 5 and 15 DAS, T₁, T₃, T₄, T₅, and T₆ at 10 DAS.

4.1.5 Non-reducing sugar (%)

The mean values for non-reducing sugar decreased with the progress in the storage period (Table 2). The treatment T₈ recorded maximum non reducing sugar content (3.75, 3.44, 3.15 and 3.12%) respectively and it was on par with T₄ and T₇ at initial days after storage; with T₇ at 5 DAS; with T₁, T₄, and T₇ at 10 DAS; with T₁, T₂, T₃, T₄, and T₇ at 15 DAS.

The minimum non-reducing sugar was observed in the treatment T₆ (2.80 and 2.79%) at initial and 5 DAS respectively and it was on par with all treatments except T₄ at initial DAS; with T₅ and T₆ at 5 DAS. The lowest non- reducing sugar was observed in treatment T₅ (2.71 and 2.70%) at 10 and 15 DAS respectively and it was on par with T₆ at 10 and 15 days after storage.

4.1.6 Total sugar (%)

The treatment showed significant differences at initial days after storage (Table 2). The treatment T₂ (potassium metabisulphite at 1500 ppm) recorded maximum total sugar content of 19.14 per cent and it was on par with T₁ and T₄. The minimum total sugar (18.35%) was observed in the treatment T₅ (potassium sorbate at 1000 ppm) and it was on par with T₃, T₆, T₇ and T₈.

However at 5, 10 and 15 days after storage, the results showed non-difference difference among treatments.

4.1.7 Colour analysis

The data on changes in colour of custard apple pulp during storage was measured by Lovibond colour meter in terms of L*(brightness), a* (red-green) and b* (blue-yellow) and is presented in Table 3.

The mean values of lightness (L*) and blueness (b*) decreased with increasing storage period and whereas redness (a*) showed increasing trend. Significantly maximum L* value was observed in the treatment T₄ (48.47, 48.37, 48.31, 48.21) and it was on par with T₁, T₂, T₃ and T₅ at initial, 5, 10 and 15 days after storage, The minimum L* values of 34.55, 48.37, 48.31 and 48.21 were observed in treatment T₈ at initial, 5, 10 and 15 DAS respectively. It was on par with all treatments except T₄ at initial, 5, 10 and 15 DAS.

The significantly maximum a* value was observed in treatment T₂ (potassium metabisulphite at 1500 ppm) with values of 2.82, 2.96, 2.98 and 3.00 at initial, 5, 10 and 15 DAS respectively and it was on par with T₁, T₃, T₄, T₅ and T₇ at initial, 5, 10 and 15 days after storage with T₃, T₂, T₅, T₆ and T₇ at 10 and 15 DAS. Significantly minimum a* value for T₁ 2.11, 2.28, 2.41 and 2.41 at initial, 5, 10 and 15 DAS respectively and it was on par with T₄, T₅, T₆, and T₇ at initial DAS; with T₄, T₅ and T₆ at 5 DAS; with T₄ and T₆ at 10 DAS; with T₆ at 15 DAS respectively.

Significantly maximum b* value of (4.27 and 3.98) observed in treatment T₁ (potassium metabisulphite at 1500 ppm) at initial and 5 DAS which was on par with T₂ and T₆ at the beginning of storage; with all treatments except T₄ at 5 DAS. At 10 and 15 days after storage treatment T₆ (potassium sorbate at 1000 ppm) with its value being 3.89 and it was on par with T₁. Significantly minimum b* value for custard apple was observed in treatment T₈ (1.88, 1.81, 1.85 and 1.90) at initial, 5, 10 and 15 DAS respectively.

Table 2: Effect of chemical preservative on reducing sugar, non-reducing sugar and total sugar of custard apple pulp during storage

Treatments	Reducing sugar (%)				Non-reducing sugar (%)				Total sugar (%)			
	Days after storage											
	Initial	5	10	15	Initial	5	10	15	Initial	5	10	15
T ₁ - Potassium metabisulphite at 1000 ppm	15.74	15.80	15.91	15.95	3.11	3.10	3.09	3.08	19.01	19.07	19.18	19.19
T ₂ -Potassium metabisulphite at 1500 ppm	15.90	15.92	16.00	16.01	3.08	3.06	3.01	3.00	19.14	19.16	19.16	19.17
T ₃ - Sodium benzoate 1000 ppm	15.55	15.62	15.85	15.86	3.06	3.05	3.04	3.03	18.44	18.79	19.05	19.06
T ₄ - Sodium benzoate 1500 ppm	15.62	15.79	15.95	15.96	3.50	3.13	3.12	3.08	19.06	19.08	19.09	19.10
T ₅ - Potassium sorbate 1000 ppm	15.17	15.51	15.83	15.84	3.02	2.98	2.71	2.70	18.35	18.65	18.68	18.70
T ₆ -Potassium sorbate 1500 ppm	15.46	15.53	15.54	15.56	2.80	2.79	2.78	2.77	18.39	18.42	18.45	18.48
T ₇ -Citric acid 1000 ppm	14.98	15.10	15.39	15.40	3.34	3.25	3.09	3.00	18.49	18.52	18.54	18.56
T ₈ -Control	14.43	14.78	15.13	15.18	3.75	3.44	3.15	3.12	18.38	18.40	18.45	18.46
Mean	15.36	15.51	15.70	15.72	3.21	3.10	3.00	2.97	18.66	18.76	18.83	18.84
S. Em±	0.16	0.17	0.11	0.11	0.14	0.06	0.03	0.06	0.13	0.10	0.14	0.21
C.D. at 1%	0.66	0.68	0.46	0.44	0.57	0.23	0.09	0.23	0.54	NS	NS	NS

NS- Non significant

4.1.8 Non enzymatic browning (OD at 440 nm)

The data on non enzymatic browning of custard apple was measured by optical density at 440 nm and is presented in Table 4. The data indicated with respect to non enzymatic browning showed non significant differences among the treatments.

4.1.9 Microbial analysis (CFU/ml)

The data presented in Table 4 indicate the microbial load of custard apple pulp as influenced by treatments and storage period.

As evident from mean values, bacterial population exhibited an increasing trend in custard apple pulp from the beginning (12.71 CFU/ ml) to 15 days after storage (29.37 CFU/ml). Significantly maximum bacterial population was seen in T₈ (30, 32, 38 and 49.33 CFU/ml) at initial, 5, 10 and 15 DAS respectively and it was followed by T₇ (19, 21, 36.67 and 42 CFU/ml) respectively at initial, 5, 10 and 15 days after storage respectively.

The minimum bacterial population was observed in T₂ (3.33, 5.33, 10 and 15.33 CFU/ml) at initial, 5, 10 and 15 DAS respectively and it was on par with bacterial load in T₁ (5, 7, 11.67 and 17.67 CFU/ml) and T₄ (7.67, 9.67, 18.33 and 21.33 CFU/ml respectively) at initial, 5, 10, 15 days after storage, respectively.

4.1.10 Organoleptic evaluation (Score out of 5.00)

The custard apple pulp was subjected to organoleptic evaluation to assess the sensory attributes like colour and appearance, mouthfeel, taste and flavour, and overall acceptability.

4.1.10.1 Colour and appearance

The data on organoleptic evaluation pertaining to the colour and appearance as influenced by treatments and storage period are presented in Table 4.

The result on colour and appearance varied during storage, the mean score for custard apple pulp colour and appearance irrespective of treatments decreased from an initial value of 3.57 to 1.95 at the end of 15 days after storage. The highest score (4.50, 4.45, 3.40 and 3.30) respectively was observed in treatment T₂ (potassium metabisulphite at 1500 ppm) and it was on par with T₁ at initial; T₃ at 5 days; followed by T₄ at 10, 15 DAS.

The least score was obtained in treatment T₈ (2.71, 1.70, 1.55 and 1.08) on par with T₇ at initial and 5 DAS; followed by T₅ and T₆ during 10 and 15 days after storage respectively.

4.1.10.2 Mouth feel

The data on organoleptic evaluation pertaining to the mouth-feel as influenced by different treatments and storage period are presented in Table 5.

The results on mouth feel of custard apple pulp indicated that, highest score for mouth feel was observed in treatment T₂ (4.08, 4.02, 3.87 and 3.80) at initial, 5, 10 and 15 days after storage respectively. There was no-significantly difference among the treatments in the beginning and 5 DAS. During 10 and 15 days of storage significantly maximum score was recorded in T₂ and it was on par with T₃ at 10 and 15 DAS.

Table 4: Effect of chemical preservative on non enzymatic browning, total bacterial count and colour and appearance of custard apple pulp during storage

Treatments	Non enzymatic browning (OD at 440 nm)				Total bacterial count (CFU/ml)				Colour and appearance (Score out of 5.0)			
	Days after storage											
	Initial	5	10	15	Initial	5	10	15	Initial	5	10	15
T ₁ - Potassium metabisulphite at 1000 ppm	0.18	0.19	0.20	0.21	5.00	7.00	11.67	17.67	3.89	3.50	2.24	1.41
T ₂ -Potassium metabisulphite at 1500 ppm	0.19	0.20	0.21	0.22	3.33	5.33	10.00	15.33	4.50	4.45	3.40	3.30
T ₃ - Sodium benzoate 1000 ppm	0.18	0.19	0.20	0.21	11.67	13.67	22.00	26.33	3.78	3.74	2.40	1.38
T ₄ - Sodium benzoate 1500 ppm	0.18	0.19	0.20	0.21	7.67	9.67	18.33	21.33	3.15	3.10	3.04	3.01
T ₅ - Potassium sorbate 1000 ppm	0.18	0.19	0.20	0.21	13.00	15.00	24.00	30.00	3.87	3.40	2.07	1.37
T ₆ -Potassium sorbate 1500 ppm	0.18	0.19	0.20	0.21	12.00	14.00	33.67	35.67	3.64	3.20	2.10	1.31
T ₇ -Citric acid 1000 ppm	0.18	0.19	0.20	0.21	19.00	21.00	36.67	42.00	3.00	2.95	2.75	2.70
T ₈ -Control	0.18	0.18	0.19	0.20	30.00	32.00	38.00	49.33	2.71	1.70	1.55	1.08
Mean	0.18	0.19	0.20	0.21	12.71	14.71	24.29	29.71	3.57	3.26	2.44	1.95
S. Em±	1.11	0.75	0.83	0.75	1.92	1.92	2.51	1.54	0.13	0.12	0.15	0.02
C.D. at 1%	NS	NS	NS	NS	7.91	7.91	10.37	6.36	0.96	0.85	0.03	0.14

CFU = Colony forming unit, NS- Non significant, OD-optical density

Table 5: Effect of chemical preservative on mouthfeel, taste and flavour and overall acceptability of custard apple pulp during storage

Treatments	Mouth feel (Score out of 5.0)				Taste and flavour (Score out of 5.00)				Overall acceptability (Score out of 5.00)			
	Days after storage											
	Initial	5	10	15	Initial	5	10	15	Initial	5	10	15
T ₁ - Potassium metabisulphite at 1000 ppm	3.58	3.50	3.49	2.77	3.83	3.42	3.35	2.18	3.32	3.77	2.52	2.37
T ₂ -Potassium metabisulphite at 1500 ppm	4.08	4.02	3.87	3.80	4.68	3.83	3.50	3.08	3.95	3.53	3.52	3.28
T ₃ - Sodium benzoate 1000 ppm	3.83	3.91	3.77	3.70	3.67	3.43	3.25	2.15	3.25	3.23	3.20	3.18
T ₄ - Sodium benzoate 1500 ppm	3.67	3.51	3.50	3.25	3.71	3.10	3.04	3.00	3.70	3.43	3.08	3.03
T ₅ - Potassium sorbate 1000 ppm	3.75	3.58	3.08	3.06	3.60	3.67	3.07	2.62	3.13	2.90	2.78	2.13
T ₆ -Potassium sorbate 1500 ppm	4.04	3.58	3.01	3.00	3.61	3.25	3.15	2.50	3.58	3.57	3.50	3.17
T ₇ -Citric acid 1000 ppm	3.58	3.52	3.03	2.80	3.85	3.60	3.43	2.33	3.50	2.92	2.52	2.33
T ₈ -Control	3.17	2.87	1.33	1.08	3.50	3.05	2.42	1.03	2.80	2.75	1.72	1.03
Mean	3.71	3.56	3.14	2.93	3.81	3.42	3.15	2.36	3.40	3.19	2.86	2.57
S. Em±	0.17	0.48	0.46	0.24	0.02	0.12	0.01	0.17	0.12	0.02	0.17	0.14
C.D. at 1%	NS	NS	1.52	1.70	0.21	NS	0.15	1.21	NS	0.13	1.20	0.99

NS- Non significant

Whereas lowest score was noted in T₈ (3.17, 2.87, 1.33 and 1.08) at initial, 5, 10 and 15 days after storage and it was on par with T₁ at 10 DAS; followed by T₆ at 15 DAS respectively.

4.1.10.3 Taste and flavour

At the beginning, the highest score (4.68) was registered in treatment T₂ (containing potassium metabisulphite at 1500 ppm). The lowest score was observed in control, T₈ (3.50).

The treatment T₂ (4.68, 3.83, 3.50, 3.08) continued to record the highest score for taste and flavour at 5, 10 and 15 days after storage and it was followed by T₇ at initial; on par with T₁ at 10 DAS; T₄ at 15 DAS. The lowest score for taste and flavour was observed in treatment T₈ (3.50, 3.05, 2.42 and 1.03) during storage at initial, 5, 10 and 15 days after storage respectively. and followed by T₄ at 10 DAS; on par with T₁ at 15 DAS.

4.1.10.4 Overall acceptability

The highest score for overall acceptability of custard apple at the beginning was observed in treatment T₂ contain potassium metabisulphite at 1500 ppm scored (3.95, 3.53, 3.52 and 3.28) at 0, 5, 10 and 15 DAS respectively and it was followed by T₆ at 5 DAS; on par with T₆ and T₃ at 10 and 15 DAS.

The lowest score was obtained by the treatment T₈ (2.80, 2.75, 1.72 and 1.03) respectively at 0, 5, 10 and 15 DAS, and it was followed by T₅ at 5 and 15 DAS; on par with T₇ at 10 DAS.

4.2 Experiment II: Effect of pasteurization temperature for preservation of custard apple pulp

4.2.1 Total soluble solids (%)

The data on changes in total soluble solids with respect to different treatments and storage periods are presented in Table 6. Initially TSS was commonly adjusted to 26% in all the treatments. The total soluble solids of pasteurized pulp were found to increase with the increase in storage period. The result on total soluble solids of pulp indicated no significant differences among the treatments during storage.

4.2.2 Titratable acidity (%)

The data on titratable acidity was expressed in terms of citric acid as. During storage, the mean titratable acidity content decreased (0.69, 0.65, 0.61 and 0.50%) at 0, 5, 10 and 15 DAS respectively.

The treatment T₂ (0.79%) recorded significantly maximum titratable acidity and it was found to be on par with the treatments T₁ (0.68), T₅ (0.68) and T₆ (0.75) and minimum value was observed in T₇ (0.59%) at initial days after storage. At 5, 10 and 15 days the data indicated with respect to titratable acidity showed non-significant differences among the treatments.

4.2.3 Ascorbic acid (mg/100g)

In general, ascorbic acid content of custard apple pulp was found to decrease with the storage period in all the treatments. The data indicated for ascorbic acid showed no significant differences among the treatments (Table 6).

Table 6: Effect of pasteurization treatments on total soluble solids, titratable acidity and ascorbic acid of custard apple pulp during storage

Treatments	Total soluble solids (%)				Titratable acidity (%)				Ascorbic acid (mg/100g)			
	Days after storage											
	Initial	5	10	15	Initial	5	10	15	Initial	5	10	15
T ₁ - Pasteurization temperature at 85 °C for 20 min		26.07	26.08	26.10	0.68	0.63	0.60	0.50	5.39	4.34	4.24	4.14
T ₂ - Pasteurization temperature at 85 °C for 25 min		26.10	26.12	26.15	0.79	0.74	0.67	0.57	5.26	4.32	4.21	4.18
T ₃ - Pasteurization temperature at 85 °C for 30 min		26.05	26.09	26.10	0.65	0.60	0.57	0.47	5.50	4.35	4.28	4.23
T ₄ - Pasteurization temperature at 90 °C for 20 min	26.00	26.06	26.08	26.14	0.67	0.62	0.59	0.47	5.43	4.34	4.27	4.16
T ₅ - Pasteurization temperature at 90 °C for 25 min		26.06	26.09	26.11	0.68	0.66	0.63	0.49	5.56	4.35	4.32	4.26
T ₆ - Pasteurization temperature at 90 °C for 30 min		26.04	26.06	26.09	0.75	0.71	0.67	0.53	5.40	4.34	4.31	4.18
T ₇ - Control		26.04	26.06	26.08	0.59	0.57	0.54	0.44	5.15	4.31	4.16	4.11
Mean	26.00	26.06	26.08	26.11	0.69	0.65	0.61	0.50	5.38	4.34	4.26	4.18
S.Em±	---	0.05	0.05	0.05	0.03	0.02	0.05	0.05	0.17	0.05	0.05	0.03
C.D.at 1%		NS	NS	NS	0.12	NS	NS	NS	NS	NS	NS	NS

NS- Non significant

4.2.4 Reducing sugar (%)

The data regarding sugar content of pasteurized custard apple pulp as influenced by different treatments and storage periods are presented in Table 7.

The reducing sugar content of all the treatments was found to increase with the progress in storage period. Fresh pulp had considerably maximum reducing sugar in treatment T₃ (16.24 %) which was on par with T₁, T₂, T₄ and T₅. The minimum reducing sugar content was observed in treatment T₇ (15.38%).

After 5, 10, 15 days after storage, the maximum reducing sugar content was observed in treatment T₃ (16.29, 16.32, 16.36%) respectively and it was on par with T₁, T₂, T₄ and T₅. The minimum reducing sugar content was observed in treatment T₇ (15.51%), T₆ & T₇ (15.60%) and T₇ (15.68%) at 5, 10 and 15 DAS.

4.2.5 Non-reducing sugar (%)

The result on non-reducing sugar content was found to decrease with storage period (Table 7). Maximum non-reducing sugar (3.44, 3.41, and 3.37 %) was recorded in the treatment T₇ and it was on par with T₆ at initial, 5 and 15 DAS. The minimum non-reducing sugar content was observed in treatment T₃ (2.65, 2.64, 2.57%) respectively followed by T₁ and T₄ at initial, 5 and 15 days after storage respectively. However, at 10 days of storage showed non-significant difference between the treatments.

4.2.6 Total sugar (%)

The mean values of total sugar increased with stages of storage periods of pasteurized pulp. However, the treatment did not show any significant differences among the treatments at fresh as well as during storage.

4.2.7 Colour analysis

The data on changes in *L** (brightness), *a** (red-green) and *b** (blue-yellow) of custard apple as influenced by treatment and storage are presented in Table 8.

The mean values of lightness (*L**) and greenness (*b**) decreased with increasing storage period where as redness (*a**) showed an increasing trend. Custard apple pulp had significantly maximum brightness in treatment T₁ (45.54, 44.57, 42.54, 40.54) respectively over all other treatments. However, it was on par with T₃, T₄ and T₆. The significantly minimum *L** value observed in treatment T₇ (35.80, 34.78, 32.76 and 30.69) and it was on par with T₅ at initial, 5, 10 and 15 DAS respectively.

The maximum *a** values was observed in treatment T₃ (1.41 and 1.51) and it was on par with T₂ and T₄. It showed significantly more redness than any other treatments at 0 and 5 DAS. But at 10 and 15 DAS, T₄ (1.80 and 1.86) was on par with T₂ and T₃. The minimum *a** values was observed in treatment T₆ and T₇ (1.01) at 0 DAS and T₇ (1.02, 1.04, and 1.34) at 5, 10 and 15 DAS respectively.

The significantly maximum *b** value was observed in treatment T₃ (5.89, 5.78, 5.71 and 5.61) and it was on par with T₂, T₄, T₅ and T₆ at initial as well as 5, 10 and 15 days after storage respectively. The minimum *b** value was observed in treatment T₇ at all the periods of observation (4.65, 4.55, 4.54 and 4.54).

4.2.8 Non enzymatic browning (OD at 440 nm)

Table 7: Effect of pasteurization treatments on reducing sugar, non-reducing sugar and total sugar of custard apple pulp during storage

Treatments	Reducing sugar (%)				Non-reducing sugar (%)				Total sugar (%)			
	Days after storage											
	Initial	5	10	15	Initial	5	10	15	Initial	5	10	15
T ₁ - Pasteurization temperature at 85 °C for 20 min	15.88	15.90	15.94	15.98	3.04	3.03	3.01	3.00	19.08	19.19	19.29	19.42
T ₂ - Pasteurization temperature at 85 °C for 25 min	15.86	15.91	15.93	15.70	3.13	3.12	3.11	3.10	19.15	19.30	19.41	19.49
T ₃ - Pasteurization temperature at 85 °C for 30 min	16.24	16.29	16.32	16.36	2.65	2.64	2.63	2.57	19.03	19.23	19.30	19.38
T ₄ - Pasteurization temperature at 90 °C for 20 min	15.80	15.88	15.94	15.98	3.07	3.02	3.01	3.00	19.04	19.27	19.32	19.41
T ₅ - Pasteurization temperature at 90 °C for 25 min	15.87	15.90	15.93	16.02	3.07	3.05	3.04	3.03	19.06	19.17	19.29	19.35
T ₆ - Pasteurization temperature at 90 °C for 30 min	15.49	15.52	15.60	16.23	3.39	3.36	3.31	3.04	19.06	19.16	19.29	19.43
T ₇ - Control	15.38	15.51	15.60	15.68	3.44	3.41	3.40	3.37	19.01	19.10	19.25	19.34
Mean	15.79	15.84	15.89	15.99	3.11	3.09	3.07	3.02	19.06	19.20	19.31	19.40
S.Em±	0.10	0.11	0.11	0.10	0.05	0.04	0.22	0.06	0.12	0.09	0.07	0.05
C.D.at 1%	0.45	0.45	0.44	0.46	0.15	0.13	NS	0.29	NS	NS	NS	NS

NS- Non significant

Table 8: Effect of pasteurization treatments on colour ($L^* a^* b^*$) values of custard apple pulp during storage

Treatments	<i>L</i> * value				<i>a</i> * value				<i>b</i> * value			
	Days after storage											
	Initial	5	10	15	Initial	5	10	15	Initial	5	10	15
T ₁ - Pasteurization temperature at 85 °C for 20 min	45.54	44.57	42.54	40.54	1.11	1.21	1.41	1.43	4.86	4.83	4.75	4.65
T ₂ - Pasteurization temperature at 85 °C for 25 min	38.87	37.87	37.87	35.87	1.37	1.47	1.67	1.77	5.30	5.19	5.18	5.14
T ₃ - Pasteurization temperature at 85 °C for 30 min	43.83	42.83	40.83	38.83	1.41	1.51	1.71	1.81	5.89	5.78	5.71	5.61
T ₄ - Pasteurization temperature at 90 °C for 20 min	43.85	42.85	40.85	38.85	1.26	1.33	1.80	1.86	5.53	5.33	5.20	5.10
T ₅ - Pasteurization temperature at 90 °C for 25 min	36.80	35.82	33.84	31.71	1.06	1.10	1.24	1.51	5.78	5.48	5.28	5.21
T ₆ - Pasteurization temperature at 90 °C for 30 min	43.54	42.54	40.54	37.54	1.01	1.08	1.13	1.71	5.44	5.24	5.11	5.04
T ₇ - Control	35.80	34.78	32.76	30.69	1.01	1.02	1.04	1.34	4.65	4.55	4.54	4.54
Mean	41.17	40.17	38.46	36.32	1.18	1.25	1.43	1.63	5.35	5.20	5.12	5.04
S.Em±	0.68	0.68	0.55	0.55	0.06	0.08	0.07	0.05	0.22	0.20	0.19	0.18
C.D.at 1%	2.86	2.86	2.34	2.34	0.27	0.33	0.29	0.21	0.95	0.83	0.78	0.75

*L** = Dark - Light, *a** = Green – Red, *b** = Blue –yellow

The data on non enzymatic browning of custard apple pulp was measured by optical density at 440 nm and is presented in Table 9. Non enzymatic browning did not showed any significant differences among the treatments at all the days of storage.

4.2.9 Microbial analysis (CFU/ml)

The perusal of data presented in Table 9 indicate that microbial load of pasteurized custard apple pulp varied significantly in the treatments as influenced by treatments and storage period.

As evident of the mean values, microbial population showed an increasing trend from fresh (30.24 CFU/ml) to 15 days after storage (54.29 CFU/ml). Significantly minimum microbial load of (17, 30, 39.33 and 41.67 CFU/ml) was observed in treatment T₂ (pasteurization temperature at 85 °C for 25 min) in the beginning as well as after 5, 10 and 15 days after storage respectively and it was on par with treatment T₁ and T₅ at initial DAS, treatment T₁, T₃, T₄ and T₅ at 5, 10 and 15 days after storage. The maximum microbial population was observed in treatment T₇ (60, 71.67, 74.33 and 75.67 CFU/ml) and it was on par with T₆ (31.33, 46.67, 64 and 66 CFU/ml) at initial, 5, 10 and 15 days after storage respectively.

4.2.10 Organoleptic evaluation (Score out of 5.00)

Organoleptic evaluation of custard apple pulp involving various treatments was carried out to assess its consumer acceptability by a panel of semi trained judges.

4.2.10.1 Colour and appearance

The data pertaining to the colour and appearance of pulp as influenced by treatments and storage period are presented in Table 9.

Significantly highest score (4.92, 4.85, 3.83 and 2.92) respectively at the beginning, 5, 10 and 15 DAS respectively was observed in treatment T₅ (pasteurization temperature at 90 °C for 25 min) and it was on par with T₄ at initial; T₃ at 5 DAS; followed by T₆ at 10 DAS; T₃ at 15 DAS.

The lowest score was observed in treatment T₇ (3.74, 2.83, 2.67 and 1.62) at initial, 5, 10 and 15 DAS respectively and it was on par with T₂ in the beginning; T₁ at 5 DAS; followed by T₂ at 10 and 15 DAS.

4.2.10.2 Mouth feel

In pasteurized pulp, the highest score (4.92, 4.84, 4.57 and 4.03) for colour and appearance was observed in treatment T₅ (pasteurization temperature for 90 °C at 25 min) at initial, 5, 10 and 15 DAS respectively it was on par with T₃ at initial and 5 DAS; T₂ at 15 DAS.

The lowest score was observed in treatment T₇ (3.82, 3.33, 2.50 and 1.90) at initial, 5, 10 and 15 DAS, respectively and it was followed by T₄ at initial and 5 DAS; followed by T₁ at 15 DAS (Table 10).

4.2.10.3 Taste and flavour

The sensory scores for taste and flavour of pulp indicate a linear decrease in mean values from 3.41 at initial stage to 2.36 at the end of 15 days after storage. The significantly maximum taste and flavour was observed in the treatment T₅ (4.17, 3.58, 3.17 and 3.14) at initial, 5, 10 and 15 days after storage respectively and it was followed by T₁ at initial; on par with T₂ at 5 DAS; T₃ at 10 and 15 DAS. The minimum taste and flavour was observed in

Table 9: Effect of pasteurization treatments on non enzymatic browning, total bacterial count, colour and appearance of custard apple pulp during storage

Treatments	Non enzymatic browning (OD value)				Total bacterial count (CFU/ml)				Colour and appearance (Score out of 5.0)			
	Days after storage											
	Initial	5	10	15	Initial	5	10	15	Initial	5	10	15
T ₁ - Pasteurization temperature at 85 °C for 20 min	0.28	0.28	0.30	0.39	24.67	33.67	43.00	47.33	4.69	4.67	3.75	3.00
T ₂ - Pasteurization temperature at 85 °C for 25 min	0.23	0.24	0.27	0.34	17.00	30.00	39.33	41.67	3.83	3.58	2.67	2.27
T ₃ - Pasteurization temperature at 85 °C for 30 min	0.24	0.25	0.28	0.34	28.67	36.33	46.00	49.33	4.85	4.83	3.72	3.50
T ₄ - Pasteurization temperature at 90 °C for 20 min	0.25	0.25	0.27	0.34	26.33	38.33	43.67	44.67	4.88	4.50	3.92	3.17
T ₅ - Pasteurization temperature at 90 °C for 25 min	0.22	0.23	0.27	0.34	23.67	35.33	54.00	55.33	4.92	4.84	4.57	4.03
T ₆ - Pasteurization temperature at 90 °C for 30 min	0.26	0.26	0.27	0.34	31.33	46.67	64.00	66.00	4.40	4.25	4.17	3.14
T ₇ - Control	0.22	0.22	0.25	0.33	60.00	71.67	74.33	75.67	3.82	3.33	2.50	1.90
Mean	0.24	0.25	0.27	0.35	30.24	41.71	52.05	54.29	4.48	4.29	3.61	3.00
S.Em±	0.03	0.03	0.02	0.05	1.90	2.64	4.44	3.82	0.02	0.03	0.03	0.01
C.D.at 1%	NS	NS	NS	NS	7.99	11.11	18.69	16.07	0.18	1.13	0.11	0.12

CFU= Colony forming unit, NS- Non significant, OD-optical density

treatment T₇ (2.50, 1.45, 1.40 and 0.48) throughout the study and it was followed by T₄ at initial; T₁ at 5 DAS; on par with T₁ at 10 and 15 DAS.

4.2.10.4 Overall acceptability

The maximum score for overall acceptability was observed in treatment T₅ (pasteurization temperature at 90°C for 25 min) with score of 4.75, 3.67, 3.47 and 3.32 at initial, 5, 10 and 15 days after storage respectively and it was followed by T₂ at initial and 10 DAS; T₃ at 5 and 15 DAS.

The minimum overall acceptability was observed in treatment T₇ (3, 1.55, 1.17 and 0.68) at initial, 5, 10 and 15 days after storage respectively and it was on par with T₆ at initial; followed by T₂ at 5, 10, 15 DAS.

4.3 Experiment III – Preparation and preservation of custard apple RTS

In the present study, different recipes containing three (10, 12, 14%) levels of pulp and 14, 15, 16% of TSS were used to develop custard apple RTS. The results of the study are presented hereunder.

4.3.1 Total soluble solids (%)

The data on total soluble solids (TSS) of custard apple RTS as influenced by treatments and storage periods were presented in Table 11. The treatments found significant differences with respect to TSS content throughout the study. There was a general increase in the TSS content in all the treatments as the storage period prolonged.

The maximum TSS was observed in treatments T₉ (14% pulp +16% TSS) with the highest TSS of 16.33, 16.52 and 16.74 per cent at 1, 2 and 3 months after storage respectively. The minimum TSS was recorded in treatment T₄ (14.21, 14.35 and 14.51%) and it was on par with T₇ (14.23, 14.46, 14.66 %) at 1, 2 and 3 months after storage respectively.

4.3.2 Titratable acidity (%)

The titratable acidity content (expressed in terms of citric acid) of the fresh custard apple RTS decreased as the storage period increased (Table 11).

At initial, 1, 2 and 3 months after storage, the data showed non-significant difference between the treatments.

4.3.3 Ascorbic acid (mg/100g)

The mean ascorbic acid content over the different periods of observation indicates that the ascorbic acid content gradually increased with the increase in storage period. The treatments differed significantly among themselves at different periods of storage.

In custard apple RTS, significantly maximum ascorbic acid content was noticed in treatment T₉ (2.56, 2.51, 2.46 and 2.42 mg/100ml) at initial, 1, 2 and 3 MAS respectively and it was on par with treatments T₆, T₇ and T₈ at initial and 1 month after storage, and treatment T₅, T₆, T₇ and T₈ at 2 and 3 MAS. A significantly minimum ascorbic acid content (2.17, 2.14, 2.09 and 2.01 mg/100ml) was observed in T₁ (10% pulp + 14 % TSS) and on par with T₂, T₃, and T₄ at initial, 1, 2 and 3 MAS respectively.

4.3.4 Reducing sugar (%)

The data on reducing sugar as influenced by treatments and storage periods are presented in Table 12. The reducing sugar at initial days was found to non-significant.

Table 10: Effect of pasteurization treatments on mouthfeel, taste and flavour and overall acceptability of custard apple pulp during storage

Treatments	Mouth feel (Score out of 5.0)				Taste and flavour (Score out of 5.0)				Overall acceptability (Score out of 5.0)			
	Days after storage											
	Initial	5	10	15	Initial	5	10	15	Initial	5	10	15
T ₁ - Pasteurization temperature at 85 °C for 20 min	4.17	3.16	3.08	2.17	3.92	2.67	1.75	0.75	3.18	3.11	3.09	3.05
T ₂ - Pasteurization temperature at 85 °C for 25 min	4.83	4.33	3.00	3.02	3.67	3.27	3.09	3.03	3.93	2.60	1.55	1.17
T ₃ - Pasteurization temperature at 85 °C for 30 min	4.85	4.77	3.83	2.25	3.33	3.12	3.11	3.08	3.17	3.13	3.09	3.05
T ₄ - Pasteurization temperature at 90 °C for 20 min	4.08	3.07	3.05	3.01	3.08	3.02	3.01	3.00	3.92	2.75	2.00	1.27
T ₅ - Pasteurization temperature at 90 °C for 25 min	4.92	4.85	3.83	2.92	4.17	3.58	3.17	3.14	4.75	3.67	3.47	3.32
T ₆ - Pasteurization temperature at 90 °C for 30 min	4.18	3.15	3.13	3.06	3.19	3.07	3.05	3.02	3.05	3.04	3.03	3.02
T ₇ - Control	3.74	2.83	2.67	1.62	2.50	1.45	1.40	0.48	3.00	1.55	1.17	0.68
Mean	4.40	3.74	3.23	2.58	3.41	2.88	2.65	2.36	3.57	2.84	2.49	2.22
S.Em±	0.02	0.02	0.18	0.03	0.03	0.09	0.12	0.13	0.03	0.03	0.01	0.02
C.D.at 1%	0.14	0.15	NS	0.14	0.16	0.62	0.92	0.92	0.16	0.10	0.18	0.17

NS- Non significant

Table 11: Effect of treatments on total soluble solids, titratable acidity and ascorbic acid of custard apple RTS during storage.

Treatments	Total soluble solids (%)				Titrable acidity (%)				Ascorbic acid (mg/100g)			
	Months after storage											
	Initial	1	2	3	Initial	1	2	3	Initial	1	2	3
T ₁ - Pulp (10%) + TSS (14°B)	14.00	14.67	14.91	15.20	0.06	0.05	0.04	0.03	2.17	2.14	2.09	2.01
T ₂ - Pulp (10%) + TSS (15°B)	15.00	15.84	15.98	16.21	0.03	0.02	0.02	0.01	2.27	2.22	2.18	2.11
T ₃ - Pulp (10%) + TSS (16°B)	16.00	16.28	16.42	16.58	0.03	0.02	0.02	0.01	2.29	2.24	2.20	2.15
T ₄ - Pulp (12%) + TSS (14°B)	14.00	14.21	14.35	14.51	0.05	0.04	0.03	0.02	2.32	2.29	2.24	2.17
T ₅ - Pulp (12%) + TSS (15°B)	15.00	15.27	15.45	15.65	0.04	0.04	0.03	0.02	2.36	2.32	2.29	2.24
T ₆ - Pulp (12%) + TSS (16°B)	16.00	16.26	16.44	16.67	0.04	0.03	0.02	0.02	2.41	2.34	2.30	2.25
T ₇ - Pulp (14%) + TSS (14°B)	14.00	14.23	14.46	14.66	0.04	0.03	0.02	0.02	2.45	2.42	2.38	2.32
T ₈ - Pulp (14%) + TSS (15°B)	15.00	15.14	15.34	15.55	0.03	0.02	0.02	0.02	2.51	2.46	2.42	2.33
T ₉ - Pulp (14%) + TSS (16°B)	16.00	16.33	16.52	16.74	0.06	0.05	0.04	0.03	2.56	2.51	2.46	2.42
Mean	---	15.36	15.54	15.75	0.04	0.03	0.03	0.02	2.37	2.33	2.28	2.22
S.Em±	---	0.03	0.06	0.07	0.05	0.04	0.03	0.02	0.05	0.05	0.06	0.02
C.D.at 1%		0.19	0.23	0.28	NS	NS	NS	NS	0.16	0.17	0.17	0.22

NS- Non significant

The significantly maximum reducing sugar level was existent in treatment T₉ (3.78, 4.35, 4.90%) at 1, 2 and 3 MAS respectively and it was on par with T₆, T₇, T₈, and T₉ at 1 month after storage. treatment T₈ (4.28, 4.70 %) at 2 and 3 MAS.

The minimum reducing sugar content was observed in treatment T₁ (2.90, 3.18 and 3.50) at 1, 2 and 3 MAS respectively and was on par with T₁, T₂, and T₃ at 1 months after storage, the treatment T₂ (3.23 and 3.57%) at 2 and 3 MAS.

4.3.5 Non-reducing sugar (%)

The glance of data on non-reducing sugar content indicated non-significant differences among the treatments.

4.3.6 Total sugar (%)

The data revealed significant differences among the treatments and also at different months of storage. Maximum total sugar was recorded in treatment T₉ (3.67, 4.15, 4.69 and 5.20 %) respectively and it was on par with T₇ and T₈ at 0, 1, 2 and 3 months after storage. However, the minimum total sugar content was observed in treatment T₁ (2.90, 3.07, 3.34 and 3.64%) respectively at 0, 1, 2 and 3 months after storage respectively.

4.3.7 Colour analysis

Colour of custard apple RTS was measured by colour meter in terms of L^* (dark-light), a^* (red-green) and b^* (blue- yellow) and the data is presented in Table 13.

The significantly maximum L^* was observed in treatment T₇ (37.42, 37.63, 37.55 and 37.51) at initial, 1, 2 and 3 months after storage respectively and it was on par with T₃, T₄, and T₈. The minimum L^* value was observed in T₁ (27.94, 27.82, 27.80 and 27.76) at initial, 1, 2 and 3 months after storage respectively.

The significantly maximum a^* value was observed in treatment T₄ (1.50, 1.67, 1.80 and 1.87) at initial, 1, 2, and 3 MAS respectively. The significantly minimum a^* value was observed in treatment T₈ (1.01) at initial DAS and T₆ (1.05, 1.25 and 1.35) at 1, 2 and 3 MAS.

Significantly higher b^* value was observed in treatment T₃ containing 10 per cent pulp + 16 per cent TSS (5.31, 5.54, 5.46 and 5.42) at initial, 1, 2 and 3 MAS respectively. It was on par with T₂, T₄, T₅ and T₆. Significantly minimum value was observed in T₈ (4.16, 4.13, 4.11 and 4.10) at initial, 1, 2 and 3 MAS respectively.

4.3.8 Non enzymatic browning (OD at 440 nm)

The data on non enzymatic browning of custard apple RTS was measured by optical density at 440 nm and is presented in Table 14. The data showed the continuation of non significant differences among the treatments at all the storage period.

4.3.9 Microbial analysis (CFU/ml)

Indicates that microbial load of custard apple RTS varied significantly among the treatments as influenced by treatments and storage period. As marked from the mean values, microbial population showed an increasing trend in custard apple RTS from fresh (22.70 CFU/ml) to (54.26 CFU/ml) at 3 months after storage.

Table 12: Effect of treatments on reducing sugar, non-reducing sugar and total sugar of custard apple RTS during storage

Treatments	Reducing sugar (%)				Non-reducing sugar (%)				Total sugar (%)			
	Months after storage											
	Initial	1	2	3	Initial	1	2	3	Initial	1	2	3
T ₁ - Pulp (10%) + TSS (14°B)	2.71	2.90	3.18	3.50	0.18	0.16	0.15	0.13	2.90	3.07	3.34	3.64
T ₂ - Pulp (10%) + TSS (15°B)	2.75	3.10	3.23	3.57	0.22	0.20	0.18	0.17	2.98	3.31	3.42	3.75
T ₃ - Pulp (10%) + TSS (16°B)	2.80	3.18	3.51	3.78	0.24	0.23	0.16	0.14	3.05	3.43	3.68	3.93
T ₄ - Pulp (12%) + TSS (14°B)	2.84	3.32	3.59	3.95	0.29	0.22	0.21	0.19	3.14	3.55	3.82	4.15
T ₅ - Pulp (12%) + TSS (15°B)	2.89	3.47	3.81	4.15	0.30	0.15	0.11	0.10	3.21	3.63	3.93	4.25
T ₆ - Pulp (12%) + TSS (16°B)	2.91	3.52	3.97	4.44	0.37	0.21	0.18	0.14	3.30	3.74	4.16	4.59
T ₇ - Pulp (14%) + TSS (14°B)	2.96	3.57	4.13	4.64	0.42	0.23	0.18	0.17	3.40	3.81	4.32	4.82
T ₈ - Pulp (14%) + TSS (15°B)	3.02	3.56	4.28	4.70	0.49	0.34	0.28	0.25	3.53	3.92	4.57	4.96
T ₉ - Pulp (14%) + TSS (16°B)	3.12	3.78	4.35	4.90	0.52	0.35	0.32	0.29	3.67	4.15	4.69	5.20
Mean	2.89	3.38	3.78	4.18	0.34	0.23	0.20	0.18	3.24	3.62	3.99	4.37
S.Em±	0.21	0.08	0.05	0.06	0.11	0.06	0.04	0.04	0.05	0.05	0.10	0.07
C.D.at 1%	NS	0.35	0.21	0.25	NS	NS	NS	NS	0.15	0.15	0.39	0.32

NS- Non significant

Table 13: Effect of treatments on colour (L^* a^* b^*) values of custard apple RTS during storage

Treatments	L^* value				a^* value				b^* value			
	Months after storage											
	Initial	1	2	3	Initial	1	2	3	Initial	1	2	3
T ₁ - Pulp (10%) + TSS (14°B)	27.94	27.82	27.80	27.76	1.08	1.14	1.34	1.44	4.42	4.40	4.38	4.37
T ₂ - Pulp (10%) + TSS (15°B)	33.04	33.01	32.87	32.77	1.09	1.26	1.44	1.54	4.82	4.79	4.77	4.76
T ₃ - Pulp (10%) + TSS (16°B)	35.89	35.86	35.83	35.49	1.21	1.51	1.71	1.81	5.31	5.54	5.46	5.42
T ₄ - Pulp (12%) + TSS (14°B)	35.71	35.94	35.85	35.81	1.50	1.67	1.80	1.87	4.74	4.71	4.69	4.68
T ₅ - Pulp (12%) + TSS (15°B)	28.85	28.82	28.81	28.74	1.02	1.21	1.41	1.51	4.98	4.87	4.80	4.76
T ₆ - Pulp (12%) + TSS (16°B)	34.68	34.56	34.54	34.53	1.03	1.05	1.25	1.35	4.85	4.73	4.65	4.61
T ₇ - Pulp (14%) + TSS (14°B)	37.42	37.63	37.55	37.51	1.12	1.42	1.62	1.72	4.39	4.36	4.34	4.33
T ₈ - Pulp (14%) + TSS (15°B)	35.96	35.93	35.91	35.81	1.01	1.15	1.35	1.45	4.16	4.13	4.11	4.10
T ₉ - Pulp (14%) + TSS (16°B)	32.18	32.15	31.81	31.81	1.07	1.34	1.57	1.67	4.46	4.44	4.43	4.42
Mean	33.52	33.52	33.44	33.36	1.13	1.31	1.50	1.59	4.68	4.66	4.63	4.61
S.Em±	0.56	0.52	0.54	0.55	0.10	0.08	0.08	0.08	0.20	0.21	0.22	0.22
C.D.at 1%	2.33	2.14	2.24	2.27	0.40	0.32	0.33	0.31	0.84	0.88	0.90	0.91

L^* = Dark - Light, a^* = Green – Red, b^* = Blue –yellow

Table 14: Effect of treatments on non enzymatic browning, total bacterial count, colour and appearance of custard apple RTS during storage

Treatments	Non enzymatic browning (OD value)				Total bacterial count (CFU/ml)				Colour and appearance (Score out of 5.0)			
	Months after storage											
	Initial	1	2	3	Initial	1	2	3	Initial	1	2	3
T ₁ - Pulp (10%) + TSS (14°B)	0.13	0.14	0.16	0.17	34.33	54.67	63.67	71.33	4.17	3.83	3.43	*
T ₂ - Pulp (10%) + TSS (15°B)	0.13	0.14	0.16	0.17	30.67	49.67	61.67	68.00	4.17	4.08	3.50	3.17
T ₃ - Pulp (10%) + TSS (16°B)	0.13	0.14	0.16	0.17	27.67	46.33	55.67	60.00	4.16	3.86	*	*
T ₄ - Pulp (12%) + TSS (14°B)	0.14	0.15	0.16	0.17	25.67	43.00	54.00	57.33	3.88	3.83	3.45	3.00
T ₅ - Pulp (12%) + TSS (15°B)	0.13	0.14	0.16	0.16	21.33	43.00	49.33	53.00	3.75	3.50	*	*
T ₆ - Pulp (12%) + TSS (16°B)	0.14	0.15	0.16	0.17	19.67	37.67	46.67	51.67	2.83	2.75	2.00	1.33
T ₇ - Pulp (14%) + TSS (14°B)	0.14	0.15	0.16	0.17	17.00	37.33	46.67	50.67	3.50	3.17	2.92	2.17
T ₈ - Pulp (14%) + TSS (15°B)	0.14	0.15	0.16	0.17	15.33	29.33	43.67	45.00	3.45	3.17	2.83	2.50
T ₉ - Pulp (14%) + TSS (16°B)	0.13	0.15	0.15	0.16	12.67	26.33	29.33	31.33	3.33	2.50	2.27	1.92
Mean	0.13	0.15	0.16	0.17	22.70	40.52	50.08	54.26	3.69	3.41	2.27	1.57
S.Em±	0.79	0.79	0.53	0.79	1.15	2.93	3.46	3.39	0.19	0.02	0.02	0.01
C.D.at 1%	NS	NS	NS	NS	4.68	11.92	14.07	13.80	NS	0.23	0.22	0.22

CFU = Colony forming unit, * Product spoiled, NS- Non significant, OD- Optical density

Significantly minimum microbial load was noticed in T₉ (14% pulp + 16% TSS) with colonies of 12.67, 26.33, 29.33 and 31.33 CFU/ml at initial, 1, 2 and 3 months after storage respectively, which was on par with T₇ and T₈ at initial; with T₆, T₇ and T₈ at 1 MAS. The maximum microbial population was observed in T₁ (34.33, 54.67, 63.67 and 71.33 CFU/ml) at initial, 1, 2 and 3 MAS respectively.

4.3.10 Organoleptic evaluation (Score out of 5.00)

Organoleptic evaluation of custard apple RTS was carried out by a panel of judges at the all stages of storage periods. Each treatment was evaluated for colour and appearance, taste and flavour, mouthfeel and overall acceptability on a 5 point scale.

4.3.10.1 Colour and appearance

Colour and appearance influenced by treatments and storage period are presented in Table 14.

The score with respect to colour and appearance was recorded to be highest in treatment T₂ (4.17, 4.08, 3.50 and 3.17) at initial, 1, 2 and 3 months after storage respectively. Fresh custard apple RTS observed non significant difference and it was on par with T₁ at 1 MAS; T₄ at 2 and 3 MAS.

The minimum score for colour and appearance was observed in T₉ at initial and 1 MAS and it was followed by T₆ at 1 MAS, T₆ at 2 and 3 MAS lowest score was observed and was followed T₉. However, T₁ was spoiled at 1 MAS and T₃, T₄ were spoiled at 2 MAS.

4.3.10.2 Mouthfeel

The score for mouth feel of RTS decreased from 3.61 at initial stage to 1.58 at 3 months after storage (Table 15).

The maximum score was recorded in treatment T₂ (4.00, 3.92, 3.33 and 3.17) at initial, 1, 2 and 3 MAS respectively and it was on par with T₃ at initial; followed by T₃ at 1 MAS; followed by T₇ at 2 and 3 MAS. And lowest was observed in T₈ followed by T₆, and T₅ at initial and 1 month after storage and it was followed by T₆; with T₁ and T₉ at 2 and 3 MAS and was followed by T₉ and T₈.

4.3.10.3 Taste and flavour

The score for taste and flavour of custard apple RTS indicates their decrease linearly from 3.57 at initial stage to 1.53 at 3 months after storage.

In fresh RTS as well as at 1, 2 and 3 months after storage, the treatment T₂ (10% pulp + 15% TSS) recorded maximum score (4.00, 3.85, 3.17 and 3.08) at initial, 1, 2 and 3 MAS respectively and it was followed by T₅ at initial; T₈ at 1 MAS; T₇ at 2 and 3 MAS. The minimum score was observed in T₁ (3.42, 1.43 and 0.67) at initial, 1 and 2 MAS respectively and it was on par with T₄ at initial; followed by T₃ at 1 MAS; T₉ at 2 MAS; while T₉ observed lowest score at 3 MAS and it was on par with T₈.

4.3.10.4 Overall acceptability

The mean for overall acceptability showed decrease in score (3.62 to 1.44) with advancement in storage period (Table 15). In fresh RTS as well as in RTS after storing for 1, 2 and 3 month, the maximum overall acceptability was recorded in T₂ (4.03, 3.97, 3.25 and 2.87) at initial, 1, 2 and 3 MAS respectively and was followed by T₅ at initial; T₃ at 1 MAS; T₇ at 2 MAS; T₄ at 3 MAS.

The lowest score in T_8 and was followed by T_6 at initial and was on par with T_6 ; at 1 MAS treatment T_5 scored lowest and was on par with T_1 ; at 2 MAS T_1 observed lowest score

Table 15: Effect of treatments on mouthfeel, taste and flavour and overall acceptability of custard apple RTS during storage

Treatments	Mouth feel (Score out of 5.0)				Taste and flavour (Score out of 5.00)				Overall acceptability (Score out of 5.00)			
	Months after storage											
	Initial	1	2	3	Initial	1	2	3	Initial	1	2	3
T ₁ - Pulp (10%) + TSS (14°B)	3.58	3.27	0.33	*	3.42	1.43	0.67	*	3.52	2.25	0.67	*
T ₂ - Pulp (10%) + TSS (15°B)	4.00	3.92	3.33	3.17	4.00	3.85	3.17	3.08	4.03	3.97	3.25	2.87
T ₃ - Pulp (10%) + TSS (16°B)	3.83	3.58	*	*	3.43	1.83	*	*	3.73	3.60	*	*
T ₄ - Pulp (12%) + TSS (14°B)	3.67	3.08	2.50	2.45	3.58	3.08	2.50	2.25	3.68	3.27	2.43	2.40
T ₅ - Pulp (12%) + TSS (15°B)	3.75	2.17	*	*	3.75	3.17	*	*	3.78	2.23	*	*
T ₆ - Pulp (12%) + TSS (16°B)	3.42	3.00	2.67	2.50	3.50	3.17	3.08	2.50	3.50	3.07	2.17	2.11
T ₇ - Pulp (14%) + TSS (14°B)	3.50	3.33	2.83	2.58	3.50	3.33	3.14	2.58	3.52	3.42	3.00	2.27
T ₈ - Pulp (14%) + TSS (15°B)	3.17	3.10	2.75	1.83	3.43	3.40	2.90	1.67	3.27	3.13	2.83	1.82
T ₉ - Pulp (14%) + TSS (16°B)	3.58	3.33	1.75	1.67	3.50	3.00	1.83	1.67	3.58	3.18	1.62	1.50
Mean	3.61	3.20	1.80	1.58	3.57	2.92	1.92	1.53	3.62	3.12	1.77	1.44
S.Em±	0.03	0.01	0.04	0.03	0.03	0.01	0.05	0.09	0.02	0.02	0.03	0.03
C.D.at 1%	0.24	0.14	0.28	0.10	0.24	0.10	0.22	0.23	0.20	0.11	0.10	0.22

*Product spoiled

and it was followed by T₉; at 3 MAS the lowest score was observed T₉ and was followed by T₈ during the investigation.

4.4 Experiment IV – Preparation and preservation of custard apple squash

In the present study, different recipes containing six level (40, 42, 44, 46, 48 and 50%) TSS and 25% pulp were used to develop custard apple squash. The results of the study are presented hereunder.

4.4.1 Total soluble solids (%)

The data on total soluble solids (TSS) of custard apple squash as influenced by treatments and storage periods are presented in Table 16. The treatments found significant differences with respect to TSS content throughout the study. There was a general increase in the TSS content in all the treatments as the storage period prolonged.

The maximum TSS was observed in treatments T₆ (25% pulp +50% TSS) recorded 50.72, 50.79 and 50.87 % and followed by T₅ (48.73, 48.77 and 48.83%) at 1, 2 and 3 MAS respectively. The minimum TSS was recorded in treatment T₁ (40.79, 40.88 and 41.23%) and followed by T₂ (42.78, 42.91, 43.65%) at 1, 2 and 3 months after storage respectively.

4.4.2 Titratable acidity (%)

The results showed significant differences among the treatments and storage periods (Table 16). The titratable acidity content of the fresh custard apple squash was initially adjusted to 1 per cent in all the treatments. During storage, the mean titratable acidity content was decreased, it was found to be 0.95, 0.92 and 0.90 per cent, at 1, 2 and 3 MAS respectively.

The treatment T₆ recorded significantly maximum titratable acidity in squash after 1, 2 and 3 months of storage (0.98, 0.96 and 0.95%) respectively and it was found to be on par with the treatments T₃, T₄ and T₅. The significantly minimum score was recorded in T₁ (0.92, 0.87 and 0.82%) at 1, 2 and 3 MAS respectively and it was at on par with treatment T₂, T₃, and T₄ at 1 MAS; with T₂ and T₃ at 2 MAS; with T₂ at 3 MAS.

4.4.3 Ascorbic acid (mg/100g)

The record on ascorbic acid content over the different periods of observation showed non-significant among themselves at different periods of storage (Table 16).

4.4.4 Reducing sugar (%)

The data on reducing sugar as influenced by treatments and storage periods are presented in Table 17.

In custard apple squash, significantly maximum reducing sugar level was existent in treatment T₆ (13.31%) at initial days of storage and treatment T₅ (15.28, 15.38 and 15.97%) at 1, 2 and 3 months after storage respectively. The minimum reducing sugar content was observed in treatment T₁ (12.07, 14.37, 14.67 and 15.16 %) at initial, 1, 2 and 3 months after storage respectively.

4.4.5 Non-reducing sugar (%)

The perusal of data on non-reducing sugar content indicated significant differences among the treatments and this biochemical parameter decreased linearly as the storage period increased.

Table 16: Effect of treatments on total soluble solids, titratable acidity and ascorbic acid of custard apple squash during storage

Treatments	Total soluble solids (%)				Titratable acidity (%)				Ascorbic acid (mg/100g)			
	Months after storage											
	Initial	1	2	3	Initial	1	2	3	Initial	1	2	3
T ₁ - Pulp (25%) + TSS (40°B)	40.00	40.79	40.88	41.23		0.92	0.87	0.82	2.59	2.47	2.15	2.16
T ₂ - Pulp (25%) + TSS (42°B)	42.00	42.78	42.91	43.65		0.93	0.88	0.86	2.63	2.49	2.41	2.28
T ₃ - Pulp (25%) + TSS (44°B)	44.00	44.84	44.91	45.09	1.00	0.95	0.91	0.89	2.54	2.31	2.18	2.10
T ₄ - Pulp (25%) + TSS (46°B)	46.00	46.62	46.74	47.77		0.96	0.93	0.91	2.52	2.59	2.51	2.39
T ₅ - Pulp (25%) + TSS (48°B)	48.00	48.73	48.77	48.83		0.97	0.95	0.94	2.58	2.49	2.37	2.23
T ₆ - Pulp (25%) + TSS (50°B)	50.00	50.72	50.79	50.87		0.98	0.96	0.95	2.74	2.59	2.53	2.39
Mean	---	45.75	45.83	46.24	1.00	0.95	0.92	0.90	2.60	2.49	2.36	2.26
S.Em±	---	0.09	0.10	0.10		0.02	0.03	0.03	0.11	0.09	0.16	0.10
C.D.at 1%		0.38	0.44	0.45		0.04	0.05	0.05	NS	NS	NS	NS

NS- Non significant

Table 17: Effect of treatments on reducing sugar, non-reducing sugar and total sugar of custard apple squash during storage

Treatments	Reducing sugar (%)				Non –reducing sugar (%)				Total sugar (%)			
	Months after storage											
	Initial	1	2	3	Initial	1	2	3	Initial	1	2	3
T ₁ - Pulp (25%) + TSS (40°B)	12.07	14.37	14.67	15.16	4.81	3.55	3.42	3.35	17.13	18.11	18.59	19.32
T ₂ - Pulp (25%) + TSS (42°B)	12.50	14.43	14.79	15.33	5.70	4.23	4.02	3.80	18.50	18.88	19.02	19.33
T ₃ - Pulp (25%) + TSS (44°B)	12.60	14.53	14.89	15.45	6.25	4.65	4.60	4.50	19.18	19.42	19.83	20.19
T ₄ - Pulp (25%) + TSS (46°B)	12.71	14.69	14.99	15.59	6.38	4.66	4.53	4.50	19.42	19.59	19.99	20.38
T ₅ - Pulp (25%) + TSS (48°B)	12.93	15.28	15.38	15.97	6.33	4.29	4.19	4.13	19.59	19.79	20.11	20.53
T ₆ - Pulp (25%) + TSS (50°B)	13.31	14.89	15.14	15.78	6.14	4.86	4.80	4.78	19.77	20.01	20.33	20.81
Mean	12.69	14.53	14.98	15.55	5.94	4.37	4.26	4.18	18.93	19.30	19.65	20.09
S.Em±	0.07	0.08	0.10	0.05	0.15	0.03	0.04	0.03	0.13	0.14	0.09	0.08
C.D.at 1%	0.21	0.35	0.40	0.24	0.60	0.09	0.12	0.10	0.56	0.55	0.40	0.35

In the fresh custard apple squash, the treatment T₄ (25% pulp + 46 % TSS) showed the maximum value of 6.38 and at 1, 2 and 3 MAS treatment T₆ (4.86, 4.80, 4.78%) respectively, showed maximum reducing sugar. The significantly minimum value in treatment T₁ (4.81, 3.55, 3.42 and 3.35%) respectively and followed by T₂ (5.70, 4.23, 4.02 and 3.80) respectively at initial, 1, 2 and 3 months after storage.

4.4.6 Total sugar (%)

The data revealed significant differences among the treatments and also at different months of storage. Maximum total sugar were recorded in treatment T₆ (19.77, 20.01, 20.33 and 20.81 %) respectively and it was on par with T₄ and T₅ at 0, 1, 2 and 3 months after storage.

The minimum total sugar content was observed in treatment T₁ (17.13, 18.11, 18.59 and 19.32%) respectively and followed by T₂ at 0, 1 and 2 months after storage and it was on par with treatment T₂ at 3 MAS (Table 17).

4.4.7 Colour analysis

Colour of custard apple squash was measured by colour meter in terms of L*(dark-light), a* (red-green) and b* (blue- yellow) and the data is presented in Table 18.

The significantly maximum L* value was observed in treatment T₁ (21.79, 21.76, 21.66 and 21.56) and followed by T₂ (20.38, 20.22, 20.14 and 20.06) at initial, 1, 2 and 3 months after storage respectively. The minimum L* value was observed in T₆ (14.81, 14.54, 14.37 and 14.24) respectively and followed by treatment T₅ (17.61, 17.42, 17.32 and 17.22) at initial, 1, 2 and 3 months after storage respectively.

In custard apple pulp, the significantly maximum a* value was observed in treatment T₂ (1.71, 1.81, 1.97 and 2.23) at initial, 1, 2 and 3 MAS respectively. The minimum a* value was observed in treatment T₆ (1.08, 1.18, 1.33 and 1.43) respectively at initial, 1, 2 and 3 MAS respectively.

Significantly higher b* value was observed in treatment T₁ (25 per cent pulp + 40 % TSS) and recorded (3.40, 3.37, 3.34 and 3.03) respectively. It was on par with T₂ and T₄ at initial; with T₃ at 1 and 2 MAS; followed by T₃ at 3 MAS. Significantly minimum value was observed in T₆ (1.96, 1.91, 1.85 and 1.76) respectively and it was on par with T₄ and T₅ at initial, 1, 2 and 3 MAS.

4.4.8 Non enzymatic browning (OD at 440 nm)

The data on non enzymatic browning of custard apple squash was measured by optical density at 440 nm (Table 19). The results showed the prolongation of non significant differences among the treatments.

4.4.9 Microbial analysis (CFU/ml)

The data presented in Table 19 indicate the microbial load of custard apple squash as influenced by treatments and storage period.

The significantly minimum bacterial load was observed in treatment T₆ (2.25, 4.75, 9.50, 11.75 CFU/ml) at initial, 1, 2 and 3 MAS respectively. The maximum bacterial population was observed in T₁ (7.63, 15.50, 18.75 and 21.00 CFU/ml) at initial, 1, 2 and 3 MAS respectively.

Table 18: Effect of treatments on colour (L^* a^* b^*) values of custard apple Squash during storage

Treatments	L^* value				a^* value				b^* value			
	Months after storage											
	Initial	1	2	3	Initial	1	2	3	Initial	1	2	3
T ₁ - Pulp (25%) + TSS (40°B)	21.79	21.76	21.66	21.56	1.67	1.77	1.96	1.98	3.40	3.37	3.34	3.03
T ₂ - Pulp (25%) + TSS (42°B)	20.38	20.22	20.14	20.06	1.71	1.81	1.97	2.23	2.85	2.78	2.73	2.43
T ₃ - Pulp (25%) + TSS (44°B)	19.91	19.88	19.83	19.73	1.69	1.79	1.97	1.98	2.95	2.94	2.88	2.65
T ₄ - Pulp (25%) + TSS (46°B)	17.74	17.49	17.39	17.29	1.28	1.38	1.58	1.88	2.26	2.22	2.15	2.06
T ₅ - Pulp (25%) + TSS (48°B)	17.61	17.42	17.32	17.22	1.42	1.52	1.72	1.95	2.36	2.30	2.24	2.08
T ₆ - Pulp (25%) + TSS (50°B)	14.81	14.54	14.34	14.24	1.08	1.18	1.33	1.43	1.96	1.91	1.85	1.76
Mean	18.71	18.55	18.45	18.35	1.48	1.58	1.76	1.91	2.63	2.59	2.53	2.34
S.Em±	0.16	0.12	0.12	0.11	0.01	0.01	0.03	0.11	0.16	0.13	0.14	0.08
C.D.at 1%	0.47	0.36	0.34	0.34	0.03	0.03	0.08	0.33	0.63	0.56	0.55	0.34

L^* = Dark - Light, a^* = Green – Red, b^* = Blue –yellow

Table 19: Effect of treatments on non enzymatic browning, total bacterial count and colour and appearance of custard apple squash during storage

Treatments	Non enzymatic browning (OD value)				Total bacterial count (CFU/ml)				Colour and appearances (Score out of 5.00)			
	Months after storage											
	Initial	1	2	3	Initial	1	2	3	Initial	1	2	3
T ₁ - Pulp (25%) + TSS (40°B)	0.05	0.09	0.11	0.13	7.63	15.50	18.75	21.00	4.30	3.75	3.75	3.13
T ₂ - Pulp (25%) + TSS (42°B)	0.06	0.09	0.11	0.13	6.38	13.50	17.00	20.50	4.33	4.13	3.88	3.50
T ₃ - Pulp (25%) + TSS (44°B)	0.06	0.09	0.12	0.13	6.00	12.00	14.50	18.00	3.93	3.63	3.54	3.50
T ₄ - Pulp (25%) + TSS (46°B)	0.06	0.08	0.11	0.13	4.38	8.75	12.25	15.25	4.07	3.82	3.57	3.32
T ₅ - Pulp (25%) + TSS (48°B)	0.05	0.09	0.12	0.13	3.25	6.75	11.00	13.25	4.09	4.09	3.50	3.38
T ₆ - Pulp (25%) + TSS (50°B)	0.07	0.09	0.11	0.12	2.25	4.75	9.50	11.75	4.07	4.07	3.75	3.44
Mean	0.06	0.09	0.11	0.13	4.98	10.21	13.83	16.64	4.14	3.92	3.67	3.38
S.Em±	0.87	1.26	0.57	0.75	0.86	1.75	2.84	2.98	0.13	0.12	0.15	0.02
C.D.at 1%	NS	NS	NS	NS	3.49	7.12	NS	NS	0.96	0.85	0.03	0.14

CFU = Colony forming units, NS- Non significant, OD-optical density

4.4.10 Organoleptic evaluation (Score out of 5.00)

Organoleptic evaluation of custard apple squash was carried out by a panel of judges at the all stages of storage periods. Each treatment was evaluated for colour and appearance, taste and flavour, mouthfeel and overall acceptability on a 5 point scale.

4.4.10.1 Colour and appearance

Colour and appearance influenced by treatments and storage period are presented in Table 19. The score with respect to colour and appearance was recorded to be the highest in treatment T₂ (4.33, 4.13, 3.88 and 3.50) at initial, 1, 2 and 3 MAS and was on par with T₁ at initial and 2 MAS; T₅ at 1 MAS; T₃ at 3 MAS. The lowest score was recorded in T₃ (3.93 and 3.63) at initial, 1 month after storage and was followed T₄ at initial; T₁ at 1 MAS. T₅ (3.50) at 2 MAS and was on par with T₃; T₁ (3.13) at 3 MAS followed T₄.

4.4.10.2 Mouthfeel

The score for mouth feel linearly decreased from 4.01 at initial stage to 3.31 at 3 months after storage (Table 20). The maximum score was recorded in treatment T₂ (4.13, 4.00, 3.83 and 3.82) and was on par with T₁ and T₃ at 3 MAS. And lowest was observed with T₃ at initial and was T₄, T₆ at 1 and 2 month after storage and was on par with T₄, T₁ at 3 MAS followed by T₆.

4.4.10.3 Taste and flavour

The score for taste and flavour of custard apple squash indicates their decrease linearly from 3.96 at initial stage to 3.62 at 3 months after storage. The maximum score was recorded in treatment T₂ (25% pulp + 42% TSS) (4.22, 4.00, 3.75 and 3.70) at initial and was followed by T₅, at 1 MAS followed by T₁, at 2 MAS on par with T₃ and 3 MAS on par with T₃ respectively and minimum score was observed in T₁ (3.88) at initial and was on par with T₄, T₆ (3.63 and 3.44) at 1 and 2 MAS and was on par with T₄ and T₁; T₄ (2.24) at 3 MAS and was followed T₆.

4.4.10.4 Overall acceptability

The mean for overall acceptability showed decrease in score (4.16 to 3.36) with advancement in storage period (Table 20). The maximum overall acceptability was recorded in T₂ (4.30, 4.13, 3.80 and 3.69) respectively and was followed T₄ at 1 MAS; on par with T₅ at 2 MAS; T₁ at 3 MAS. The lowest score was observed in T₆ at 1 MAS and was followed by T₁; T₄ at 2 MAS and T₆ at 3 months after storage.

Table 20: Effect of treatments on mouth feel, taste and flavour and overall acceptability of custard apple squash during storage

Treatments	Mouth feel (Score out of 5.00)				Taste and flavour (Score out of 5.00)				Overall acceptability (Score out of 5.00)			
	Months after storage											
	Initial	1	2	3	Initial	1	2	3	Initial	1	2	3
T ₁ - Pulp (25%) + TSS (40°B)	4.12	3.88	3.77	2.00	3.88	3.82	3.57	3.44	4.20	3.78	3.72	3.64
T ₂ - Pulp (25%) + TSS (42°B)	4.13	4.00	3.83	3.82	4.22	4.00	3.75	3.70	4.30	4.13	3.80	3.69
T ₃ - Pulp (25%) + TSS (44°B)	3.84	3.80	3.72	3.69	3.94	3.74	3.71	3.69	3.83	3.80	3.67	3.57
T ₄ - Pulp (25%) + TSS (46°B)	3.93	3.75	3.64	3.44	3.90	3.64	3.60	2.24	4.10	3.90	3.67	2.58
T ₅ - Pulp (25%) + TSS (48°B)	4.05	3.82	3.82	3.52	4.09	3.64	3.63	3.52	4.28	3.86	3.73	3.42
T ₆ - Pulp (25%) + TSS (50°B)	3.97	3.63	3.63	3.39	3.93	3.63	3.44	3.08	4.24	3.50	3.50	3.25
Mean	4.01	3.81	3.74	3.31	3.96	3.75	3.62	3.28	4.16	3.83	3.68	3.36
S.Em±	0.17	0.48	0.46	0.24	0.02	0.12	0.01	0.17	0.12	0.02	0.17	0.14
C.D.at 1%	NS	NS	1.52	1.70	0.21	NS	0.15	1.21	NS	0.13	1.20	0.99

NS- Non significant

5. DISCUSSION

Custard apple is a typical fruit characterized by very short shelf life and highly perishable under ambient condition. The fruit ripens on third day retain edible status up to 4th day and rapidly shows symptom of deterioration after fourth day and becomes unfit for consumption on fifth day of storage. In this context experiment was carried out to identify suitable technique to increase the availability of processed pulp and products all round the year.

It is evident from reviewed literature that little attention has been given to develop the processing technologies for custard apple fruits. Based on the available technology for other fruits, few products such as ready-to-serve beverage, squash, nectar and other soft drinks can be tried for the domestic as well as international markets developing protocols for preservation of pulp will help for further preparation of value added products during unseasonal period. Further, efforts are needed to standardize the processing techniques and processed products. Out of the several products that can be prepared from a fruit, juice based beverages are more popular in India as well as in the world (Chakraborty *et al.*, 1993). Therefore, the present investigation was carried out to study the preparation and preservation of custard apple pulp by two methods of preservation technique, preparation of ready-to-serve beverage and squash. The results obtained in the study are discussed hereunder.

5.1 Preservation of custard apple pulp by chemical preservatives

Preservation of fruit pulp is very important so that the preserved pulp can be further used for preparation of juice based beverages. But preservation of fruit juices at ambient temperature without addition of any chemical preservatives or pasteurisation is not possible due to high nutritional composition of fruit juices. Fruit pulp is rich source of sugars, minerals, vitamins, organic acids, *etc.*, which act as a good source of food for spoilage microorganisms. The enzymes present in pulp are also responsible for deterioration of the quality. Thus, any of the preservation method either alone or in combination is a prerequisite for extending the shelf life of fruit pulp at refrigeration temperature. Therefore, an attempt was made to preserve the custard apple pulp at ambient temperature.

Pasteurisation and use of chemical preservatives are two well known methods of preservation of pulp and juices. However, correct pasteurisation temperature, duration and suitable chemical preservatives and their concentrations need to be worked out for specific fruits as their composition and pH vary. Hence, in the present investigation, two methods of preservation of custard apple pulp separately were employed in order to know their effect on the physico-chemical characteristics of the pulp, organoleptic qualities affected by treatments.

5.1.1 TSS, sugars and non enzymatic browning

Increase in total soluble solids content of pulp during storage is desirable for the preservation of good quality pulp. The total soluble solids content in the pulp increased apparently during storage (Table 1, 2 and 4).

Chemical composition of pulp in different treatments was affected by the chemical preservative. TSS and total sugar in custard apple pulp was significantly maximum in T₂ (potassium metabisulphite at 1500 ppm) at initial and during storage, This might be due to slow hydrolysis of polysaccharides, acids and pectic substances to simpler substances like sugar in presence of acid present in juice. Significantly minimum TSS and total sugar was recorded in T₈ (control) where no preservative was added. Similar results of increase in TSS and total sugar of stored pulp was reported by several workers *viz.*, Urmil and satinder (1988) in citrus juice, Ranote *et al.* (1993) in kinnow orange juice, Devaraju (2001) in ber juice and Jayalaxmi (2006) in sapota juice, Amin *et al.* (2008) and Muhammad *et al.* (2011) in apple pulp.

The pulp in treatment T₂ (15.90, 15.92, 16.00 and 16.01 %) recorded highest reducing sugar at initial, 5, 10 and 15 days after storage respectively. The minimum was recorded in

control. The increase in reducing sugar may be attributed to the conversion of non-reducing sugar to reducing sugar, Non-reducing sugar recorded decreased trend over storage period and non enzymatic browning exhibited minimum value for all these parameters throughout the study period. However, the treatments had showed non significant differences with respect to non enzymatic browning. Similar result of increase in the level of reducing sugar and total sugar during storage have been reported by Devaraju (2001) in ber juice, Jayalaxmi (2006) in sapota juice, Amin *et al.*(2008) in mango pulp, Ayub *et al.* (2010) in strawberry juice, Akhtar *et al.*(2009) in mango pulp.

5.1.2 Titratable acidity, ascorbic acid and total bacterial count

In the present investigation, the level of titratable acidity decrease might be due to chemical reaction between the organic constituents of the pulp and influenced further by temperature and enzymatic action. (Table 1 and 4). Further ascorbic acid content decreased during storage period. This behaviour may be due to its oxidation by trapped oxygen in the glass bottles which results in formation of dehydroascorbic acid in the juice. It is evident that pulp preserved without any chemical preservative (T₈) showed substantial increase in microbial load with correspondent increase in storage period. Chemical preservatives significantly decreased the microbial load in the pulp. Custard apple pulp samples containing potassium metabisulphite 1500 ppm performed superior up to 15 days of storage. Similar results have been reported by Hashmi *et al.* (2007) in mango pulp, Amin *et al.* (2008) in mango pulp, Hussain *et al.* (2008), Mouhammad *et al.* (2011).

5.1.3 Colour analysis

Colour in food is usually due to the presence of natural pigments like anthocyanins, carotenoids or chlorophyll (Table 3). The variation in the colour of a system varies with changes in concentration of some of the components that forms the basis of colorimetric analysis. Ludneava and Yankov, (1994) determined changes in colour (L^* , a^* , b^* values) during storage of mixed nectars prepared from apple and citrus fruits.

The mean values of lightness (L^*) and yellowness (b^*) decreased with increasing storage period and whereas redness (a^*) showed increasing trend in custard apple pulp. Significantly maximum L^* (lightness) value was observed in treatment T₄ (48.47, 48.37, 48.31 and 48.31) respectively at 0, 5, 10 and 15 days after storage respectively, which was treated with sodium benzoate at 1500 ppm. However, minimum L^* value was observed in T₈ (34.55, 34.45, 34.25 and 33.81) at 0, 5, 10 and 15 days after storage respectively. Lower L^* values indicate the darkness.

Significantly maximum a^* value was observed in treatment T₂ (2.82, 2.96, 2.98 and 3.00) at 0, 5, 10 and 15 days after storage, which was treated with sodium benzoate at 1500 ppm. Maximum results in pulp treated with sodium benzoate with increasing storage period may be a due to effective control of browning helps in retaining original color during storage.

Significantly maximum b^* value was observed in treatment T₁ (4.27, 3.98) in freshly prepared and 5 days after storage and treatment T₆ (3.89) at 5 and 10 days after storage. However, minimum b^* value was observed in T₈. Highest value of b^* indicate that yellowness, contrary lowest means towards blue.

5.1.4 Organoleptic evaluation

Evaluation of sensory qualities of products is an important tool for deciding the consumer acceptability (Table 4 and 5). A human element plays an important role in evaluation of organoleptic characters of a product. For any new product, the consumer acceptability needs be evaluated first at the laboratory level. Hence, in the present investigation, 10 semi-trained panellists comprising teachers and post graduate students of Kittur Rani Channamma College of Horticulture, Arabhavi were involved in the evaluation process.

Quality aspects of food products such as colour, flavour and nutritive value generally reduce with the increase in storage period. In the present study also, organoleptic scores for colour and appearance, mouth-feel, taste and flavour and overall acceptability of pulp decreased in all the treatments as the storage time progressed. Similar decrease in sensory quality during storage of pulp has been reported by Gamage *et al.* (1997) in custard apple, Sonia *et al.* (2003) in sand pear, Hashmi *et al.* (2007) in mango pulp, Akhtar *et al.* (2009) in mango, Durrani *et al.* (2010) in apple pulp, Kamble and Soni (2010) in custard apple pulp, Pawar *et al.* (2010) in custard apple, Muhammad *et al.* (2011) apple pulp, Hiremath and Rokhade (2012) in sapota.

The treatments which contain potassium metabisulphite at 1500 ppm had highest score for all sensory qualities due to effective control of browning their by retaining original colour, whereas superimposition of intermediate colour developed due to maillard reaction accelerated between reducing sugars and amino acids during storage.

5.2 Preservation of custard apple pulp by pasteurization

5.2.1 TSS, sugars and non enzymatic browning

The total soluble solids, total sugar and non enzymatic browning of pasteurized pulp were found to increase with increase in storage period (Table 6, 7 and 9).

The treatment T₃ (pasteurization temperature at 85°C for 30 min) was found to have high reducing sugar content initially as well as during storage. The increase in total sugar corresponding to decrease in non-reducing sugar, which might be due to hydrolysis of polysaccharides into reducing sugar. The result on TSS, total sugar and non enzymatic browning of pulp indicated non significant differences among the treatments during storage and increase in reducing sugars was correlated with decrease in non-reducing sugar. It is supported by Kamble and Soni (2010), Hiremath and Rokhade (2012), Pawar *et al.* (2010).

5.2.2 Titratable acidity, ascorbic acid and total bacterial count

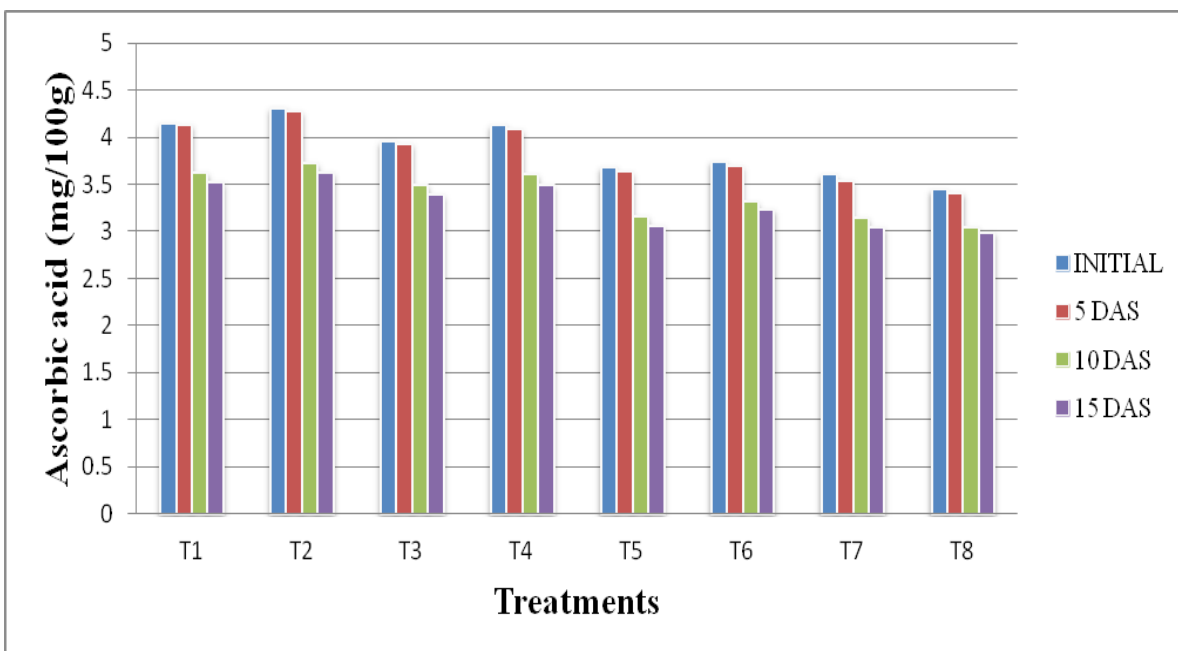
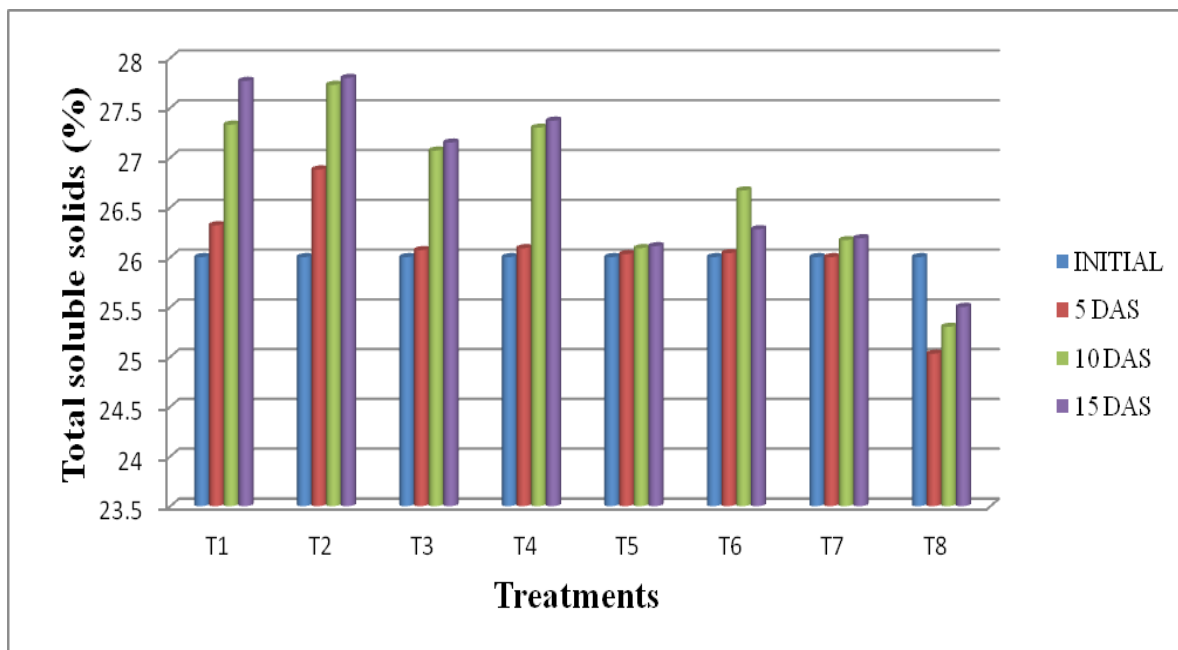
The titratable acidity decreased with the progress in storage period (Table 6 and 9). Significantly maximum value was recorded in T₂ (pasteurization temperature at 85 °C for 25 min) in freshly prepared pulp and at 5, 10, 15 days after storage. The treatments showed non significant differences among treatments.

Ascorbic acid is one of the important parameters from the nutritional point of view. So, conservation of ascorbic acid is very important during storage period. The ascorbic acid content decreased as the storage period increased. In the present investigation data indicated non significant difference among the treatments.

The treatment T₂ recorded significantly minimum microbial load of 17, 30, 39.33, and 41.67 CFU/ml at initial, 5, 10 and 15 days after storage respectively. The significantly maximum value was observed in T₇ (60, 71.67, 74.33 and 75.67). The results corroborates with Umme *et al.* (1997), Pawar *et al.* (2010), Hiremath and Rokhade (2012), Nwachukwu and Ezeigbo (2013).

5.2.3 Colour analysis

The variation in the colour of a system varies with changes in concentration of some of the components that form the basis of colorimetric analysis. Ludneava and Yankov, (1994) determined changes in colour (*L**, *a**, *b** values) during storage. The maximum *L** value was observed in T₁ (pasteurization temperature-85 °C for 20 min) throughout the storage period. In this study the duration of pasteurization was show more lightness compared to other treatments. The minimum value was observed in treatment T₇ (control) at initial, 5, 10 and 15 days after storage.



T₁- Potassium metabisulphite at 1000 ppm
1000 ppm

T₂ -Potassium metabisulphite at 1500 ppm
1500 ppm

T₃- Sodium benzoate 1000 ppm
ppm

T₄- Sodium benzoate 1500 ppm

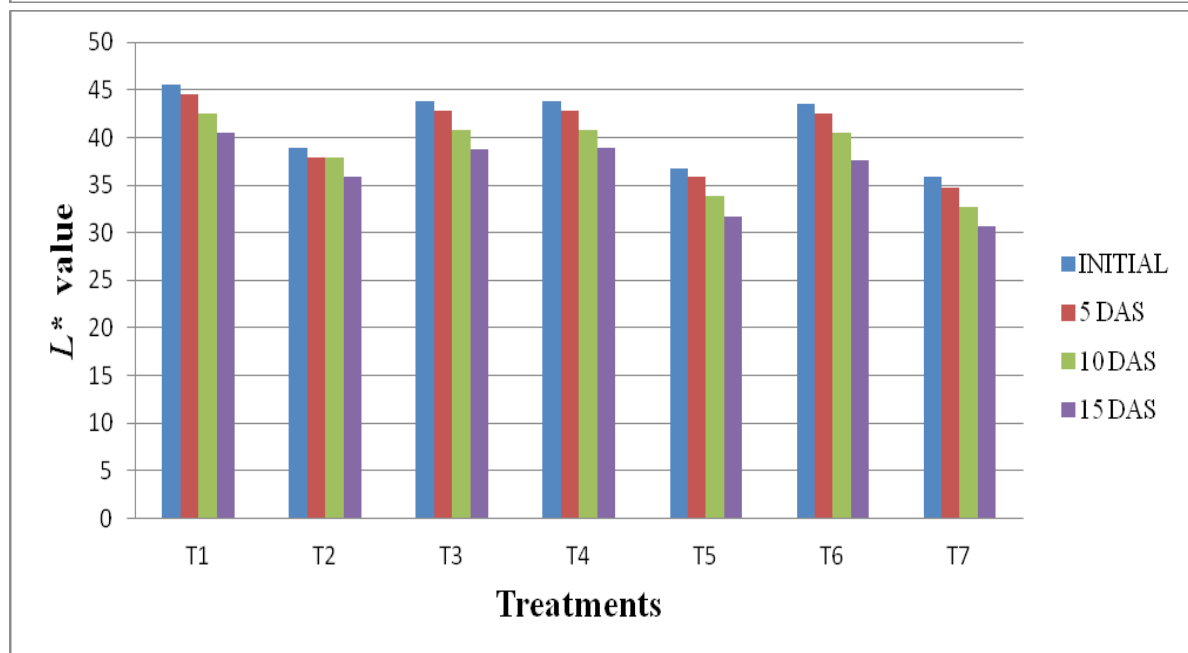
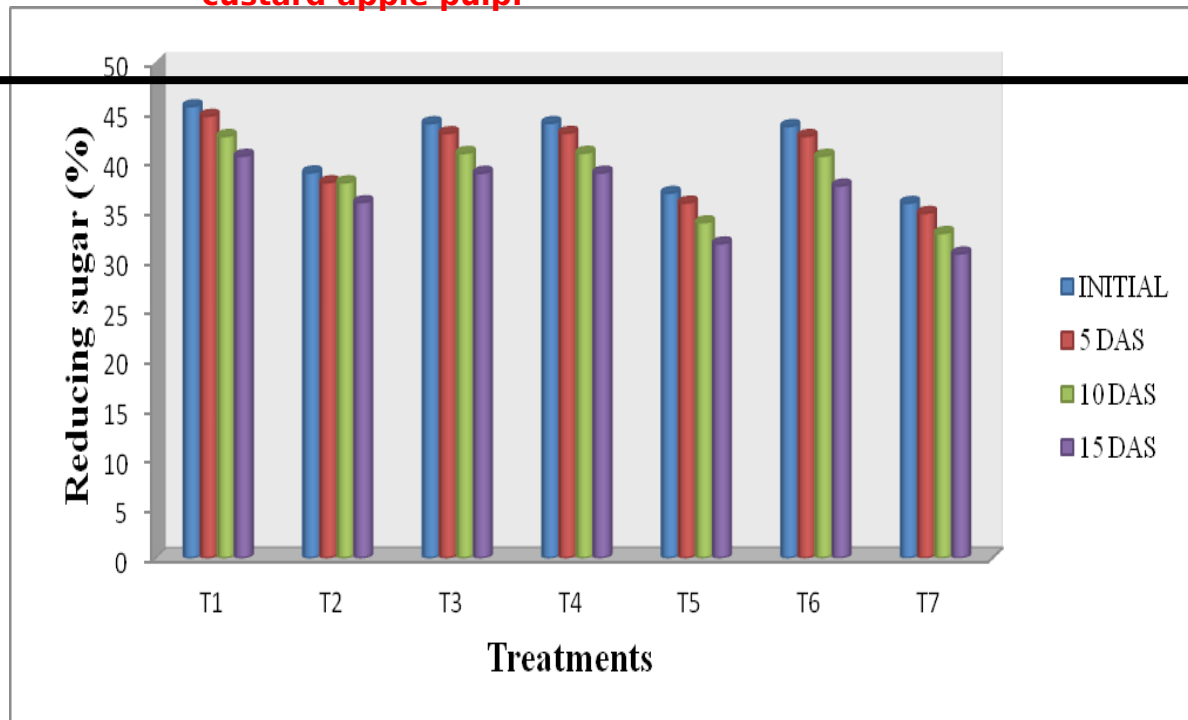
T₅- Potassium sorbate

T₆-Potassium sorbate

T₇-Citric acid 1000

T₈-Control

Fig 1: Effect of different treatments on changes in total soluble solids and ascorbic acid content of chemical treated custard apple pulp.



T₁- Pasteurization temperature at 85 °C for 20 min

T₅- Pasteurization

T₂ -Pasteurization temperature at 85 °C for 25 min

T₆- Pasteurization

T₃- Pasteurization temperature at 85 °C for 30 min

T₇- Control

T₄- Pasteurization temperature at 90 °C for 20 min

Fig. 2: Effect of different treatments on changes in reducing sugar and L^* value of pasteurized custard apple pulp.

The maximum a^* value was observed in the treatment T_3 at 0 and 5 DAS. At 10 and 15 DAS treatment T_4 was observed maximum value. This might be due to possible browning reaction during storage. On other hand minimum a^* value was observed in treatment T_6 and T_7 at initial days of storage. T_7 at 5, 10 and 15 DAS. Lower a^* value indicates towards greenness of the sample due to microbial growth observed in the sample.

The maximum b^* value was observed in treatment T_3 (5.89, 5.78, 5.71 and 5.67) at 0, 5, 10 and 15 days after storage respectively, this may be due to moderate temperature and timing fixed for pasteurization of sample. However, minimum was observed in T_7 (4.65, 4.55, 4.54 and 4.54) at 0, 5, 10 and 15 days after storage respectively.

5.2.4 Organoleptic evaluation

Evaluation of sensory qualities of product is an important tool for deciding the consumer acceptability. Human element plays an important role in the evaluation of organoleptic characters of a product. This evaluation serves as a guide to consumer acceptability. In fresh pulp and during storage, the highest score for all sensory qualities was observed in treatment T_5 (pasteurization temperature-90°C for 25 min). This may be attributed to the inactivation of enzymes like Polyphenol oxidase responsible for browning reaction which prevented discoloration of pulp their by getting higher scores. This observation is in agreement with Masoodi *et al.* (1992), Ranote *et al.* (1993) and Panesar *et al.* (2000). The lowest score was observed in treatment T_7 and in control where there was no pasteurization done during processing. Similar results were reported by Umme *et al.* (1997), Kamble and soni (2010), Nwachukwu and Ezeigbo (2013).

5.3 Preparation and preservation of custard apple RTS

In case of processed products, yield is not the one and only criteria for evaluating the efficiency of a treatment. The chemical composition also determines the quality of the product. Therefore, the RTS beverage developed from custard apple in the present investigation was analysed for physico-chemical composition.

5.3.1 TSS, sugars and non enzymatic browning

The TSS content of 14, 15 and 16 per cent with pulp concentration of 10, 12 and 14 per cent was adjusted (Table 11, 12 and 14). Significantly maximum TSS was observed in treatment T_9 containing pulp 14 per cent + TSS 16 per cent. The increase in total soluble solids throughout storage period might be due to conversion of polysaccharides into sugars by hydrolysis. The minimum TSS was observed in treatment T_1 (pulp 10%+TSS 14%) Corroborative findings to the present study are reported by Kotecha *et al.* (1995) in custard apple juice, Tripathi *et al.* (1988) in aonla, Ramajayam *et al.* (2002) in simarouba, Sorolia and Mukharjee (2002) in lime, Kannan *et al.* (2004) in jamun fruit products, Saravanan *et al.* (2004) in papaya beverage, Bharadwaj and Mukherjee (2011) in kinnow RTS blend.

Concomitant with the change in TSS, sugar content of RTS increased during the storage period. Both total sugars and reducing sugar increased significantly, whereas non-reducing sugar decreased and treatment showed non significant differences during storage period. Total and reducing sugar varied in the same way as TSS in the RTS treatments for the similar reason. The findings of the present study are well supported by Attri *et al.* (1998) in pear blended juice, Tiwari (2000) in guava and papaya blended RTS, Deka (2000) in mixed fruit juice, Vijayalakshmi (2012) in blended RTS. The data on browning of custard apple RTS showed non significant differences among the treatments at all the storage period.

5.3.2 Titratable acidity, ascorbic acid and total bacterial count

In the present investigation, the level of titratable acidity decreased as the storage period increased. The data showed non significant difference between the treatments (Table 11).

Ascorbic acid is one of the major nutritional components. In this experiment mean ascorbic acid content of RTS was found to decrease from 2.37 mg/100 g in the fresh RTS to 2.22 mg/100 g at 3 MAS. Significantly maximum ascorbic acid content throughout the study period was observed in T₉. On the contrary, the treatment T₁ showed significantly minimum ascorbic acid content at the end of 3 MAS this could be attributed to light and heat labile nature of the vitamin-C which was affected by temperature during pasteurization. Most researchers agree that the ascorbic acid can be easily destroyed by heat and oxidation similar results were reported by Gowda and Ramanjaneya (1995), Pandey and Singh (1998) in guava squash, Jain *et al.* (1996), Dobhal, (2000) in phalsa beverage and Mandal, (2003) in pineapple and phalsa blended everage.

The quality of the products may deteriorate during storage. It might be influenced by various treatments employed in the preparation of products and conditions of storage environment. The microbial population showed a slight increase in their number during the storage period of 3 months (Table 14). However, such marginal increase did not affect the wholesomeness of the products. Potassium metabisulphite used for preservation of RTS in the present study. Pasteurization of custard apple RTS prior to filling in to bottles combined with addition of these chemical preservative might have helped in controlling and limiting the bacterial population to a safe level. significantly minimum bacterial population was recorded in T₉ (potassium metabisulphite at 1500 ppm), similar results were reported by Giridharilal *et al.* (1986), Ejechi *et al.* (1998) in mango juice, Attri *et al.* (1998) in pear juice blended with temperate fruit, Deka (2000) in mixed fruit juice, Abbo *et al.* (2006) in soursop juice, Markam and Singh, (2012) in custard apple RTS.

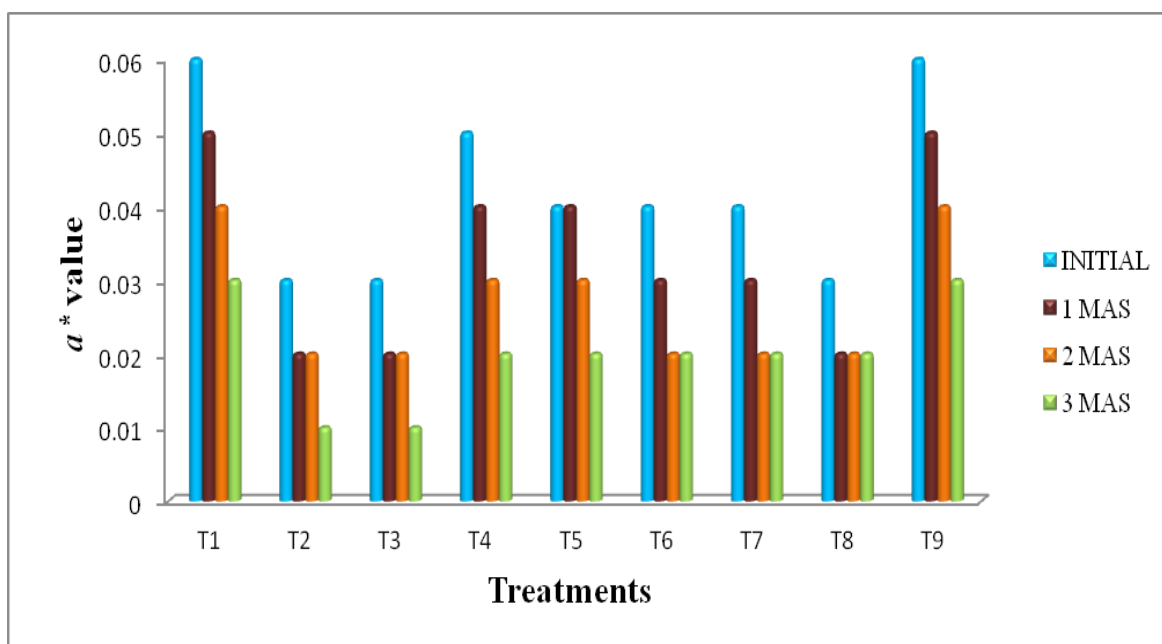
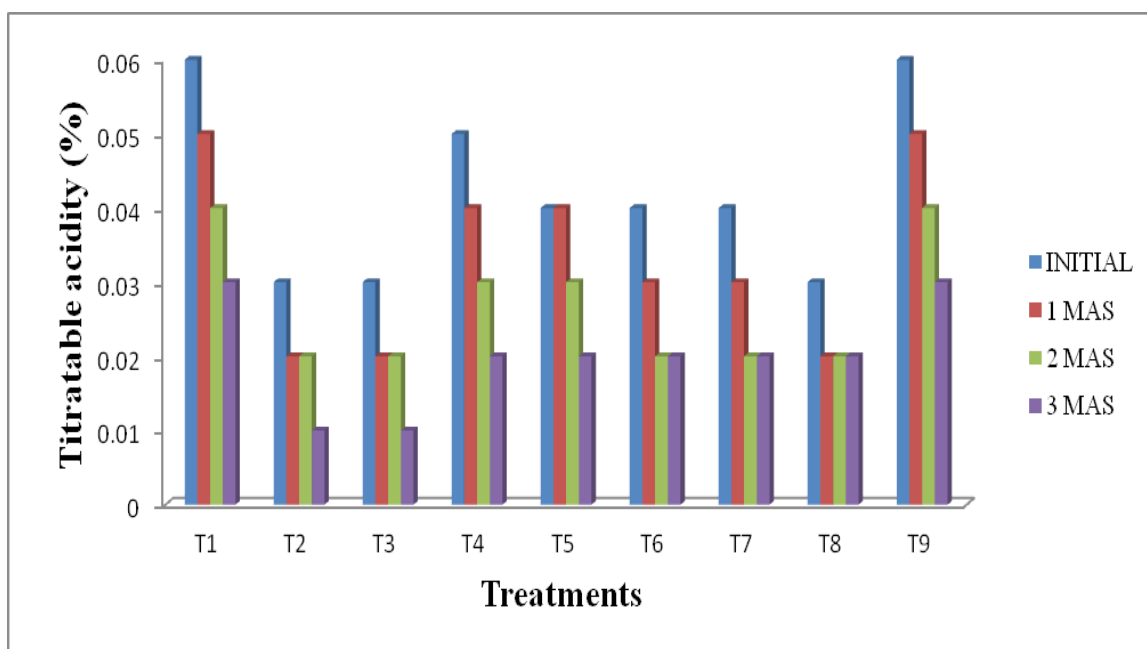
5.3.3 Colour analysis

The variation in the colour of a system varies with changes in concentration of some of the components that form the basis of colorimetric analysis. Ludneava and Yankov, (1994) determined changes in colour (L^* , a^* , b^* values) during storage. The maximum L^* value was observed in T₇ (15 per cent pulp + 14 per cent TSS) throughout the storage period and minimum value was observed in T₁, lower L^* value indicate the darkness. The maximum a^* value was observed in the treatment T₄ (1.50, 1.67, 1.80 and 1.87) containing 12 per cent pulp+14%TSS at 0, 1, 2 and 3 months after storage respectively and minimum value was observed in T₆. In present study a^* values was increased with increasing storage period. It might be due to browning reaction observed during storage. The maximum b^* value was observed in treatment T₃ (1.98, 1.35, 1.07 and 0.87) containing 10 per cent pulp+16%TSS at 0, 1, 2 and 3 months after storage respectively. Highest value of b^* indicates yellowness, contrary lowest means towards blue (Table13).

5.3.4 Organoleptic evaluation

Quality is the ultimate criteria of the desirability of any food product to the consumer, whereas, sensory quality is a combination of different senses of perception coming in to play in choosing a product.

Quality aspects of food products such as colour, flavour and nutritive value generally reduce with the increase in storage period. In the present study also, organoleptic score for colour and appearance, mouth-feel, taste and flavour and overall acceptability of RTS decreased in all the treatments as the storage time progressed. The treatment with 10 per cent pulp + 15 per cent TSS (T₂) scored better for all the four sensory parameters than the remaining treatments. Similar decrease in sensory quality during storage of beverages has been reported by Rao *et al.* (1979) in rangpur lime beverage, Jain and Khurdiya (2004) in blended Indian gooseberry RTS, Markam and Singh, (2012).



T₁- Pulp (10%) + TSS (14°B)

T₂ - Pulp (10%) + TSS (15°B)

T₃- Pulp (10%) + TSS (16°B)

T₄- Pulp (12%) + TSS (14°B)

T₅- Pulp (12%) + TSS (15°B)

T₆- Pulp (12%) + TSS (16°B)

T₇- Pulp (14%) + TSS (14°B)

T₈- Pulp (14%) + TSS (15°B)

T₉- Pulp (14%) + TSS (16°B)

Fig. 3: Effect of different treatments on changes in titratable acidity and a* value of custard apple RTS

5.4 Preparation and preservation of custard apple squash

5.4.1 TSS, sugars and non enzymatic browning

The TSS of custard apple squash recorded an increase in total soluble solids with the advancement of storage period. This might be due to increase in total sugars caused by inversion of polysaccharides like starch and cellulose substances in the presence of organic acids into simpler soluble molecules and also inversion of added sucrose into simpler soluble substance in the course of time. This indicates that, during storage there was change in the composition of juice extracts or other ingredients used in the product causing change in TSS. Similar results were observed by Kannan and Thirumaran (2004) in jamun syrup, Surender *et al.* (2005) in bael or blended bael ready to serve beverage, Madanlal *et al.* (2006) in guava ready to serve beverage and Vijay *et al.* (2006) in aonla squash.

The treatment T₆ (25% pulp + 50% TSS) was found to have high total soluble solids, reducing sugar and total sugar content initially as well as during storage (Table 16 and 17). On the contrary, the treatment T₁ (25% pulp + 40% TSS) exhibited minimum value for all these parameters throughout the study period. However, for the non enzymatic browning treatments did not show any significant differences for all these parameters (Table 19).

The increase in reducing and total sugars corresponding to the increase in total soluble solids and ultimate decrease in non-reducing sugars, which might be due to hydrolysis of polysaccharides into reducing sugar. As increase in reducing sugar was correlated with decrease in non-reducing sugar. This view was corroborated by Jain *et al.* (1984) in orange, lemon and bael squash, Vijay *et al.* (2006) in aonla squash and Gajanana (2002) in aonla juice.

5.4.2 Titratable acidity, ascorbic acid and total microbial count

Mean values of titratable acidity at different months of storage of custard apple squash (1.00, 0.95, 0.92 and 0.90%) at 0, 1, 2 and 3 months after storage respectively indicate that titratable acidity decreased with the progress in storage period (Table 16). The decrease in acidity might be due to hydrolysis of polysaccharide into simple sugars and non-reducing into reducing sugars, where acid is utilized for converting them into reducing sugars. Similar results were reported by Gajanana (2002) in aonla juice, Ramajayam *et al.* (2002) in simarouba, and Surender *et al.* (2005) in blended bael RTS.

The treatment T₆ recorded significantly maximum titratable acidity after 1, 2 and 3 months of storage and the significantly lowest titratable acidity were found in T₁ throughout the storage period. Reduction in acidity level in fruit beverages owes to chemical interaction between the organic constituents of the juice induced by temperature and actions of enzymes as reported by Nath *et al.* (2005). The decrease in acidity during storage was also observed in kinnow mandarin juice by Sarmah *et al.* (1981); similar result was reported by Mehta and Bajaj (1983). With respect to ascorbic acid content showed non-significant difference among themselves at different periods of storage (Table 16).

Microbial spoilage is a major constraint in improving storability of squash. They multiply and infect the product when the congenial condition prevails. The data on total bacterial count indicates that microbial population showed an increase in their number during the storage period of three months (Table 19). But it did not affect the integrity of the product. Use of potassium metabisulphite has been reported to be very effective in preventing the spoilage of the products during storage (Giridharilal *et al.*, 1986). In the current experiment preservative employed for safeguarding squash beverages from microbial spoilage. Pasteurization of squash prior to filling into bottles and addition of these chemical preservative might have played a notable task in controlling and limiting the bacterial population to a safer level. However, minimum microbial population was recorded in treatments containing pulp 25 per cent + 50 per cent TSS (T₆) and maximum was recorded in T₁ and it has been documented in some studies Deka, (2000), Ejechi *et al.* (1998), Attri *et al.* (1998),

Bharadwaj and Mukherjee, (2011). After 2 months of storage results showed non significant difference among the treatments.

5.4.3 Colour analysis

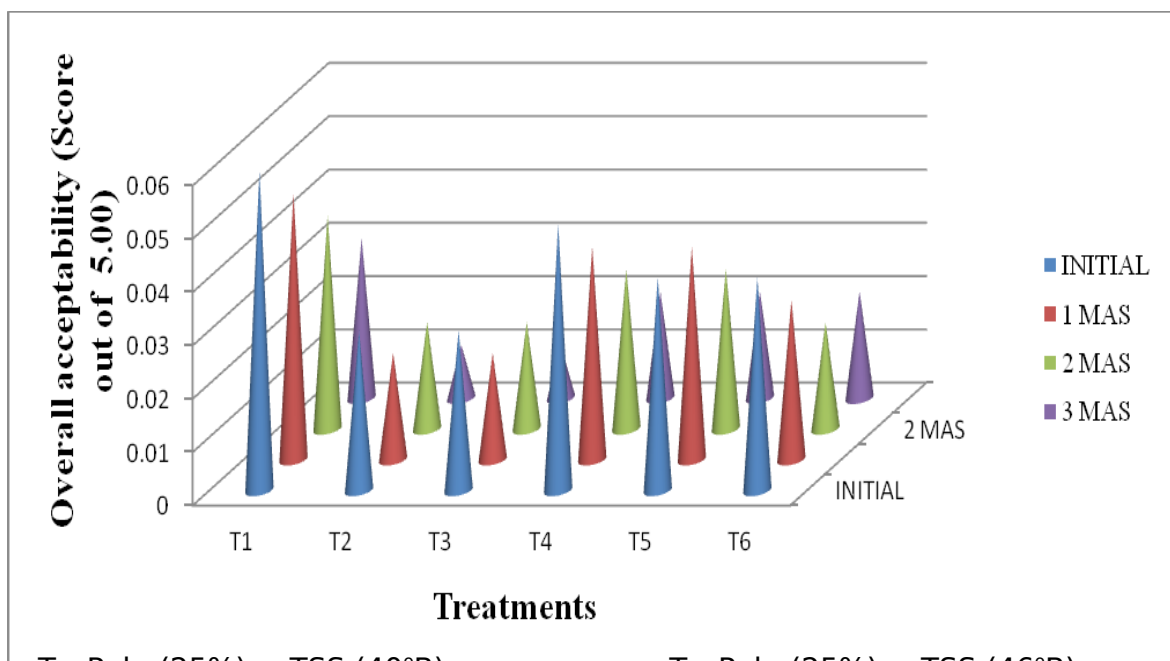
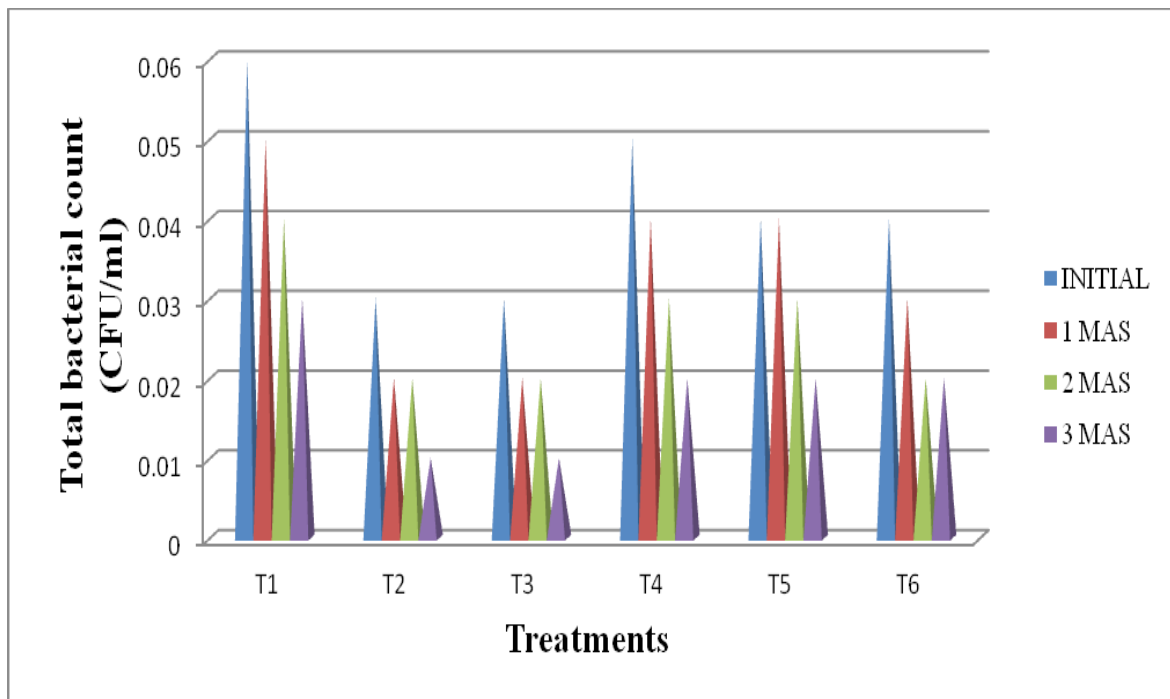
The variation in the colour of a system varies with changes in concentration of some of the components that form the basis of colorimetric analysis. Ludneava and Yankov, (1994) determined changes in colour (L^* , a^* , b^* values) during storage. The maximum L^* value was observed in T_1 throughout the storage period which containing pulp 25 per cent+ 40% TSS whereas minimum value was recorded in T_6 at initial, 1, 2 and 3 months after storage (Table 18).

The maximum a^* value was observed in the treatment T_2 (1.71, 1.81, 1.97 and 2.33) at 0, 1, 2 and 3 months after storage respectively. It might be due to maillard reaction during storage. On other hand minimum a^* value was observed in treatment T_6 (1.08, 1.18, 1.33 and 1.43) respectively. Lower a^* value indicates that towards the greenness of the sample and juice was light in colour.

The maximum b^* value was observed in treatment T_1 . However, minimum was observed in T_6 (1.96, 1.91. 1.85 and 1.76) at 0, 1, 2 and 3 months after storage respectively.

5.4.4 Organoleptic evaluation

The merit of any product for consumer acceptability depends on the consumer preference. Hence, organoleptic evaluation is an important tool to know the consumer acceptability. In fresh custard apple squash (Table 19 and 20), the highest score for colour and appearance (4.33) was observed in treatment T_2 (pulp 25 per cent + 42 per cent TSS), the lowest score was observed in treatment T_3 . However, considering the performance with respect to colour and appearance, taste and flavour as well as overall acceptability, the treatment T_2 stands better and recorded maximum score during storage. Similar results were reported by Waskar and Khurdiya (1987) in phalsa beverage, Kaur *et al.* (1995) in seabuckthorn berries, Chauhan *et al.* (1997) in aloe-vera leaves, Jadhav *et al.* (2004) in tamarind juice, Singh *et al.* (2007).



T₁- Pulp (25%) + TSS (40°B)

T₄- Pulp (25%) + TSS (46°B)

T₂ - Pulp (25%) + TSS (42°B)

T₅- Pulp (25%) + TSS (48°B)

T₃- Pulp (25%) + TSS (44°B)

T₆- Pulp (25%) + TSS (50°B)

Fig. 4: Effect of different treatments on changes in titratable acidity and a* value of custard apple squash

SUMMARY AND CONCLUSIONS

Investigation on “Studies on processing and preservation of custard apple pulp, squash and ready-to-serve beverages” was conducted during 2013-14 in the Department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi (UHS, Bagalkot) Karnataka. The present study was carried out to standardize the methods of preservation of pulp and to evaluate storage stability of processed products such as RTS, squash.

6.1 Effect of chemical preservatives on storage of custard apple pulp

The chemical constituents of the pulp *viz.*, total soluble solids, reducing sugar, total sugar, a^* value and non enzymatic browning were found to increased marginally from 26 to 26.82 per cent, 15.36 to 15.72 per cent, 18.66 to 18.84 and 2.54 to 2.84 and 0.18 to 0.21 respectively, whereas ascorbic acid, titratable acidity, non-reducing sugar, L^* value and b^* value decreased from 3.87 to 3.29 mg per 100g, 0.61 to 0.44 per cent, 3.21 to 2.94 per cent, 39.83 to 39.30 and 3.19 to 2.71 respectively, during the storage period of 15 days. However, non significant differences were noticed in total sugar and non enzymatic browning at 5, 10 and 15 days after storage.

During storage period of 15 days, the mean organoleptic scores decreased from an initial value of 3.57 to 1.95 for colour and appearance, 3.71 to 2.93 for mouth feel, 3.81 to 2.36 for taste and flavor and 3.40 to 2.57 for overall acceptability. The results of organoleptic evaluation particularly indicated that the treatment T_2 (pulp treated with potassium metabisulphite at 1500 ppm) was found superior in their acceptability than other treatments for all the four organoleptic parameters throughout the course of investigation. There was marginal increase in microbial load (TBC) in custard apple pulp during storage, but it did not affect the wholesomeness of the product up to 15 days of storage.

6.2 Effect of pasteurization temperature for preservation of custard apple pulp

The results of pasteurization of pulp revealed that the chemical constituents, *viz.*, total soluble solids, reducing sugar, total sugar, a^* value and non enzymatic browning were found to increase from 26 to 26.11 per cent, 15.79 to 15.99 per cent, 19.06 to 19.40 per cent, 1.18 to 1.63, and 0.24 to 0.35 respectively. There was non significant change in TSS, titratable acidity, ascorbic acid, total sugar, non reducing sugar at 10th day of storage. Whereas titratable acidity, ascorbic acid, non-reducing sugar, L^* value and b^* value decreased from 0.69 to 0.50 per cent, 5.38 to 4.18 mg per 100 g, 3.11 to 3.02 per cent, 41.17 to 36.32 lightness and 5.35 to 5.04 yellowness respectively at 15 days after storage.

At 15 days of storage, the mean scores decreased from an initial value of 4.48 to 3.00 for colour and appearance, 4.40 to 2.58 for mouth feel, 3.41 to 2.36 for taste and flavor and 3.57 to 2.22 for overall acceptability. Considering the performance with respect to all the sensory parameters, the treatment T_5 (Pasteurization temperature at 90 °C for 25 min) was found superior in comparison to all other treatments. There was marginal increase in microbial load of pulp during storage period but did not affect the wholesomeness of the product upto 15 days of storage.

6.3 Preparation and preservation of custard apple RTS

Custard apple RTS with different recipes containing three (10, 12, 14%) levels of pulp with 14, 15, 16% of TSS were used to develop RTS. However, titratable acidity (0.1%) was kept constant in all the treatments. At initial titratable acidity, non reducing sugar and non enzymatic browning showed non significant difference among the treatments.

The highest total soluble solids, reducing sugar, total sugar and non-reducing sugar was observed in treatment T₉ with 14 per cent pulp + 16 per cent TSS and highest a* value was observed in treatment with T₄ 12 per cent pulp + 14 per cent TSS. However, the mean titratable acidity, ascorbic acid, L* and b* values decreased in general from 0.04 to 0.02 per cent, 2.37 to 2.22 mg/100 g, 33.52 to 33.36 and 4.68 to 4.61 respectively during the storage of 3 months.

The organoleptic evaluation of RTS revealed that the treatments T₂ (pulp 10%+15% TSS) observed maximum acceptability based on organoleptic scores for all the parameters.

The total bacterial count was found to increase in custard apple RTS during storage period. However, it did not affect the quality of the product during three months of storage.

6.4 Preparation and preservation of custard apple squash

In custard apple squash, different recipes containing six levels of TSS (40, 42, 44, 46, 48 and 50%) and 25 per cent pulp were used as constant to develop product. However, titratable acidity (1%) was kept constant in all the treatments. During storage studies the parameters like ascorbic acid, non enzymatic browning and total bacterial count showed non significant difference except initial and 1 MAS.

Analyzing the squash for specific chemical parameters indicated significant differences among the treatments. The chemical constituents, viz., total soluble solids, reducing sugar, total sugar and a* value were found to increase from 45.75 to 46.24 per cent, 12.69 to 15.55 per cent, 18.93 to 20.09 per cent and 1.48 to 1.91 respectively. Whereas titratable acidity, ascorbic acid, non-reducing sugar, L* value, and b* value decreased from 1.00 to 0.90 per cent, 2.60 to 2.26 mg/100 g, 5.94 to 4.18 per cent, 18.71 to 18.35 lightness and 2.63 to 2.34 yellowness respectively at initial, 1, 2 and 3 MAS.

During three months of storage, the mean scores decreased significantly from an initial value of 4.14 to 3.38 for colour and appearance, 4.01 to 3.31 for mouth feel, 3.96 to 3.28 for taste and aroma and 4.16 to 3.36 for overall acceptability. It indicates eventual decrease in preference due to changes in the chemical constituents of juice during storage. Considering the performance with respect to all the sensory parameters, the treatment T₂ (pulp 25% + 42 % TSS) stands superior in comparison to all other treatments. There was marginal increase in microbial load of custard apple squash beverage during storage period but did not affect the wholesomeness of the product during three months of storage.

Conclusion

1. Custard apple pulp treated with potassium metabisulphite at 1500 ppm had scored better result with respect to physico-chemical characters and organoleptic traits.
2. Pulp pasteurized at 90°C for 25 min stands superior in maintaining physico-chemical and organoleptic parameters.
3. Ready to serve beverage prepared with treatment T₂ (pulp 10%+15% TSS) observed to have maximum acceptability based on organoleptic and physico-chemical characteristics.
4. Performance of squash with respect to all the sensory parameters and physico-chemical, the treatment T₂ (pulp 25% + 42 % TSS) stands superior.

Future line of work

1. Methods and protocols for long term storage products of custard apple through freeze drying should be developed.
2. Addition of antioxidants helps to avoid browning.
3. Efforts may be made to accomplish supplementary increase in nutritional and functional quality of highly acceptable recipes of custard apple RTS, squash and syrup. Other products such as jam, ice-cream may be tried to add more food value to custard apple.

REFERENCES

- Abbo, E. S, Olurin, T. O. and Odeyemi, G., 2006, Studies on the storage stability of soursop (*Annona muricata* L.) juice. African J. Biotechnol. 5(19): 1808-1812.
- Akhtar, S., S. Mahmood, S. Naz, M. Nasir and M.T. Sultan, 2009, Sensory evaluation of mangoes (*Mangifera indica*.L) grown in different regions of Pakistan. Pak. J. of Bot. 41(6): 2821-2829.
- Alexander, D., Scholefield, P. B. and Frodsham, A., 1982, Sweetsop (*Annona squamosa* L.). Some tree fruits for tropical Australia. Common wealth scientific and industrial research organisation.
- Amin, M., Aman, U. M., Mazhar, M. S., Islam, U. D., Khalid, M. S. and Saeed, A., 2008, Mango fruit de-sapping in relation to time of harvesting. Pak. J. of Bot. 40(4): 1587-1593.
- Anonymous, 1984, Official Methods of Analysis. Ed. Sidney Williams, Association official Analytical Virginia. 14th edition, pp. 424- 462.
- Attri, B. L., Lal, B. B. and Joshi, V. K., 1998, Physico-chemical characteristics, sensory quality and storage behaviour of sand pear juice blended with temperate fruit juice. Indian Food Packer. 52: 36-38.
- Ayub, M., Ullah, J., Muhammad, A. and Zeb, A., 2010, Evaluation of strawberry juice preserved with chemical preservatives at refrigeration temperature. Int. J. Nutr. Metab. 2(2):27-32.
- Aziz, P. A. and Yusof, S., 1994, Physico chemical characteristics of soursop fruit (*Annona muricata*) during growth and development. Asian Food J. 9(4):147-150.
- Bhardwaj, R. L. and Mukherjee S., 2011, Effect of fruit juice blending ratios on kinnow juice preservation at ambient storage condition. African J. Food Sci. Vol. 5(5): 281-286.
- Bhosale , V. I., Kute, L. S. and Kadam, S. S., 2000, Studies on preparation of Ready- to-Serve beverage from Aonla: Mango juice blend. Bev. Food World, 27(2): 24-27.
- Bobby, B. and Radhaisri, S., 2003, Processing and quality evaluation of citrus (*citrus reticulata* and *citrus sinensis*) squashes. Proc.5th Inter. Food. Conv. Mysore, p. 82.
- Brenndor, B., Kennedy, L., Oswin, C. O., Trim, D. S., Mrema, G. C. And Werek, C., 1985, Bobby solar dryers. Their role in post harvest processing. Common Wealth Sci. Council, pp.91.
- Chakraborty, S., Agrawal, M. D. and Shukla, I. C., 1993, Studies on preparation of ready to serve beverages from watermelon juice. Bev. Food World, 20(1): 30.
- Chandan, K., 2004, Standardisation of protocol for preparation of dehydrated slices and RTS beverage from aonla fruits. *M.sc. (Hort.) Thesis*. Univ. Agric. Sci., Dharwad.
- Chauhan, V. K., Guat, T. and Varshney, A. K., 1997, Gel extraction from Aloe vera leaves. Post Production systems and Strategies- Food Safety and security, 175.
- Chikhalikar, N. V., Sahoo, A. K., Singhal, R. S. and Kulkarni, P. R., 2000, Studies on frozen pourable custard apple (*Annona squamosa* L.) pulp using cryoprotectants. J. Sci. Food Agri. 80:1339-1342.

- Chobe, R. S., 1999, Studies on extraction, clarification, preservation and storage of pomegranate (*Punica granatum* L.) juice. *M. Tech. (Agri.) Thesis*, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra.
- Choudhary, S. N., Dikshit and Sharma H.G., 2006, Studies on preparation and biochemical changes in guava RTS beverage during storage. *Indian J. Arid Hort.* 1(1): 78-79.
- Damame, S.V., Gaikwad, R. S., Patil, S. R. and Masalkar, S. D., 2002, Vitamin C content of various aonla products during storage. *Orissa J. Hort.*, 30 (1): 19-22.
- Deka, B. C., 2000, Preparation and storage of mixed fruit juice spiced beverage, *Ph.D. Thesis*, IARI, New Delhi,
- Devaraju, K. R., 2001, Processing of ber (*Ziziphus mauritiana* L.) fruits. *M.Sc (Hort). Thesis*, Univ. Agri. Sci., Dharwad (India).
- Deverajaiah, G., 1987, Investigation on the storage behaviour of processed products of jackfruit (*Artocarpus heterophyllus*). *M.Sc. Thesis*, Univ. Agri. Sci., Bangalore.
- Dobhal, P., 2000, Studies on preparation and preservation of phalsa (*Grewia subinaequilis* L.) beverages. *M.Sc. Thesis*, N. D. Univ. of Agril. & Tech., Faizabad (U.P), India.
- Durrani, Y., Zeb, A., Ayub, M., Ullah, W. and Muhammad, A., 2011, Sensory evaluation of mango (Chausa) pulp preserved with addition of selected chemical preservatives and antioxidant during storage. *Sarhad J. Agric.* 27(3):471-475.
- Durrani, Y., Ayub, M., Muhammad, A. and Ali, A., 2010, Physico chemical response of apple pulp to chemical preservatives and antioxidant during storage. *J. of Food Safety*, 12: 20-28.
- Dwivedi, N. S., Adsule, R. N. and Kotecha, P. M., 2004, Effect of different levels of sugar and skim milk powder on the chemical composition and sensory properties of custard apple toffee. *Indian Food Packer*, 23 (4):19-23.
- Ejechi, B. O., Sozey, J. A., and Akpomedaya, D. E., 1998, Microbial stability of mango juice preserved by combined application of mild heat and extracts of two tropical plants. *J. Food Prot.* 61: 725-728.
- Gajanana, K., 2002, Processing of aonla (*Embllica officinalis* Gaerth.) fruits, *M.Sc (Hort.). Thesis*, Univ. Agri. Sci., Dharwad.
- Gamage, T. V., Yuen, C. M. and Wills, R. B. H., 1997, Minimal processing of custard apple (*Annona atemoya*) pulp. *J. Process. and Preservation*, 21:289-301.
- Garande, V. K, Joshi, G. D. and Wasker, D.P., 1995, Storage of jamun (*Eugenia cumini*) fruit products. *Asian Food J.*, 10 (2): 54-56.
- Giridharilal, Siddappa, G. S. and Tandon K., 1986, In preservation of fruits and vegetables. Revised Ed. (ICAR Publication). New Delhi, India, pp 69.
- Gopalan, C., Kadam, S. S. and Sivasankar, B., 2004, Nutritive value of Indian Foods, National Institute of Nutrition, Indian council of medical research, Hyderabad.
- Gowda, I. N. D. and Ramanjaneya, 1995, Prevention of discolouration in guava beverage during storage. *J. Food Sci. Technol.*, 32 (4):323-325.
- Harrigan, W. F. and Mccance, M. E., 1966, Laboratory methods in Microbiology. Academic press, London, pp. 14-16.

- Hashmi, M. S., Alam, S., Riaz, A. and Shah, A. S., 2007, Studies on microbial and sensory quality of mango pulp storage with chemical preservatives. *Pak. J. Nutri.* 6 (1): 85-88.
- Hiremath, J. B. and Rokhade, A. K., 2012, Preparation and preservation of sapota juice. *Inter. J. Food, Agri. Veter. Sci.*, 2 (1): 87-91.
- Hsu, Y., Xu, J. and Hu, Q., 2008, Evaluation of antioxidant potential of aloe vera extracts. *J. Agric. Food Chem.*, 51: 7788-7791.
- Hussain, I., Zeb, A., Shakir, I. and Shah, A. S. 2008, Combined effect of potassium sorbate and sodium benzoate on individual and blended juices of apricot and apple fruits grown in Azad Jammu and Kashmir. *Pak. J. Nutr.* 7(1): 181-185.
- Hussain, S., Saleem-ur-Rehman, M., Randhawa A. and Iqbal, M., 2003, Studies on physico chemical, microbiological and sensory evaluation of mango pulp with chemical preservatives. *J. Res. Sci.* 14 (1), 01-09.
- Jadhav, H. M., Kotech, P. M and Kadam, S. S., 2004, Studies on preparation and storage of carbonated beverage from tamarind juice. *Bev. Food World*, 29(6): 22-24.
- Jain, N. L. and Borker, D.H., 1970, Preservation and storage stability of ready to serve beverages from guava (*Psidium guajava*). *Indian Food Packer*, 24(2): 29-33.
- Jain, S. G., Padmaja, P. and Sanjeev, M. S., 1996, Studies on watermelon products. *Indian Food Packer*, 50(3): 15-20.
- Jain, S. K. and Khurdiya, D. S., 2004, Vitamin C enrichment of fruit juice based ready-to-serve beverages through blending of Indian gooseberry (*Emblica officinalis* Gaertn.) juice. *Plant Foods for Human Nutri.* 59(2): 63-66.
- Jain, S. P., Tripathi, V. K. and Khurdhiya, S.T., 2003, Extraction of juice from Aonla. *Indian Food Packer.*, 50(4): 33-39.
- Jain, S. P., Tripathi, V. K. and Ram, H. B., 1984, Studies on storage behaviour of orange, lemon and bael squash. *Indian Food Packer*, 38(5): 38-39.
- Jasimahmed, 1996, Studies on juice extraction and quality of four varieties of banana for the preparation of banana based beverage. *Indian Food Packer* 50(4): 5-9.
- Jayalaxmi, B. H., 2006, Processing of sapota fruits. *MSc. (Hort.) Thesis*, Univ. Agric. Sci., Dharwad.
- Joshi, V. K., Chauhan, S.K., and Lal, B. B., 1993, Evaluation of enzymatically extracted plum juice and preparation of beverage. *J. Food Sci. Technol.* 30: 208-211.
- Kalpana, R., Khan, M. K. and Sahoo, N. R., 2008, Effect of storage on quality of stone apple ready-to-serve beverage. *J. Agri. Eng.*, 45(1): 62-68.
- Kalra, S. K., Tendon, D. K. and Singh, B. P., 1988, Simplified processing of aonla fruits for preserve making. *Rev. Food World*, 25(2): 35-36.
- Kamble, K. J. and Soni, S. B., 2010, Effect of steam blanching on quality of custard apple pulp. *J. Hort. For.* 2(5): 104-107.
- Kannan, S. and Thirumaran, A. S., 2004, Studies on the storage life of jamun (*Syzygium cuminii* Rom.) fruit products. *J. Food Sci. Technol.* 41(2): 186-188.

- Karuna, Y., Sreenivas, K. N., Vinayumar, R., Rajesh, A. M. and Yathindra, H. A., 2005, Standardization of tamarind blended litchi squash. *J. Ecobiol.* 29: 27-31.
- Kaur, M., Sharma, P. C., Kaushal, B. B. L. and Sharma, A. K., 1995, Standardization of methods for preparation of appetizer and ready-to-serve beverage from seabuckthorn (*Hippophae* sp.) berries. *J. Food Sci. Technol.* 45(2): 139-142.
- Kenghe, R. N., Unde, P. A. and Potdar, S. N., 2009, Processing of wild bael (*Aegle marmelos* corr.) fruit for value addition. *J. Maharashtra Agri. Univ.*, 34(1): 65-67.
- Khamuravi, S., Sharma, H. G. and Susheela, T. A., 2004, Studies on storage behaviour of kinnow juice. *Rev. Food World*, 29(3): 32-33.
- Khurdiya, D. S. and Anand, J. E., 1980, The colour stability of ber juice. *Indian Food Packer*, 36 (1): 44-49.
- Khurdiya, D. S. and Roy, K. S., 1985, Processing of Jamun (*Syzygium cuminii* L.) fruit into a ready to serve beverage. *J Food Sci. Tech.*, 22(1): 27-31.
- Kirtiraja, K., Gaikwad, Suman, S. and Shakya., B. R., 2013, Studies on the development and shelf life of low calorie herbal aonla ginger RTS beverage by using artificial sweeteners. *J. Food Process. Technol.* 4:1.
- Kotecha, P. M. and Kadam, S. S., 2003, Preparation of ready-to-serve beverage, syrup and concentrate from tamarind. *J. Food Sci. Technol. (Mysore)*, 40(1): 76-79.
- Kotecha, P. M., Adsule, R. N. and Kadam, S. S., 1995, Processing of custard apple. Preparation of ready to serve beverage and wine. *Indian Food Packer*, 24(1): 21-24.
- Krishnaveni, A. M., Animegalai, G. and Saravanakumar, R., 2001, Storage stability of jack fruit (*Artocarpus heterophyllus*) RTS beverage. *J. Food Sci. Technol.* 38(6): 601-602.
- Kumar, K., Abhay, M. and Jayant, S., 2005, Effect of storage period on quality characters of litchi beverages. *Prog. Hort.* 37(1): 89-91.
- Ludneava, H. S. and Yankov., 1994, Measurement of color changes due to browning in stored grapefruit juices. *Proc. Fla. State Hort. Soc.* 101:154-157.
- Madanlal, C., Dikshit, S. N. and Sharma, H. G., 2006, Studies on preparation and biochemical changes in guava RTS beverage during storage. *Indian J. Arid Horti.*, 1(1): 78-79.
- Madhukar, H. K., 2008, Standardisation of juice extraction process and recipe for juice based beverages from papaya fruits. *MSc. (Hort.) Thesis*, Univ. Agri. Sci., Dharwad.
- Mandal, P., 2003, Studies on preparation and preservation of blended beverage from pineapple (*Ananas comosus* L.) and phalsa (*Grewia subinequalis* L.). *M.Sc. Thesis*, N.D. Univ. of Ag. & Tech., Kumarganj, Faizabad (U.P.), India.
- Mangave, K. K., 1982, Seedling selection in custard apple (*Annona squamosa* L.), *MSc. (Agri.) Thesis*, submitted to M.P.K.V., Rahuri.
- Markam, R. and Singh, V., 2012, Studies on microbial and sensory quality of custard apple RTS beverage. *Asian J. Hort.* 7(2): 460-464.
- Masoodi, F. A., Bhupinder, K. and Harinder, K., 1992, Perlette grape juice extraction method, SO₂ concentration and storage on the physico-chemical composition. *Indian Food Packer*, 56(6): 5-13.

- Mehta, A. C. and Bajaj, M. R. D., 1983, Studies on preparation of ready to serve mandarin (*Citrus reticulata*) diet drink. Pak. J. Agri. Sci., 45 (4): 5-10.
- Miller, G. L., 1972, Use of Dinitro salicylic acid reagent for determination of reducing sugar. Ann. Chern., 31: 426-428.
- Mohamed, E. S., 1997, Preparation of carrot based ready-to serve drink fortified with some fruit flavors. Egyptian J. Food Sci., 25(1): 107-120.
- Muhammad, A., Ayub, M., Zeb, A., Durrani, Y., Ullah, J. and Afridi, S. U. R., 2011, Physicochemical analysis of apple pulp from mashday variety during storage. Agri. Biol. J. 2(2):192-196.
- Nath, A., Yadav, D. S., Pranabjyoti Sharma and Dey, B., 2005, Standardization of ginger-kinnow squash and its storage. J. Food Sci. Technol., 42(6): 520-522.
- Nilugin, S. E. and Mahendran, T., 2010, Preparation of ready-to-serve (RTS) beverage from palmyrah (*Borassus flabellifer* L.) fruit pulp. J. Agril. Sci., 5(2): 80-88.
- Nirmal, A. M., Lakshminarayana, S. and Siddappa, G. S., 2006, Preparation and preservation of wood apple juice. Indian Food Packer, 18(4): 13-41.
- Nwachukwu, E. and Ezeigbo, C. G., 2013, Changes in the microbial population of pasteurized soursop juice treated with benzoate and lime during storage. African J. Microbiol. Res. 7(31):3992-3995.
- Palaniswamy, K. P. Muthukrishnan, C. R. and Shanmugavelu, K. G., 1974, Studies on physico-chemical characters of lemon juice and squash during storage. Indian Food Packer, 28(4): 37-41.
- Pandey, A. K. and Singh, I. S., 1998, Studies on preparation and preservation of guava squash. Prog. Hort. 30(3-4): 190-193.
- Panesar, P. S., Sharma, H. K. and Rai, R., 2000, Preservation of kinnow juice. Indian Food Packer, 54(3): 79-81.
- Panse, V. S. and Sukhatme, P. V., 1967, Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi, pp. 152-174.
- Patil, A. L., Eblen, B. S. and Miller, A. J., 2011, Evidence of salmonella internalization into fresh mangoes during simulated post harvest insect disinfestations procedures. J. Food Prot. 67: 181-184.
- Paul, J. K., 1979, In Fruit and Vegetable Technology of Juice Processing. Naya Data Corporation, New Jersey, London, p. 90-142.
- Pawar, V. N., Kardile, W. G. and Hasmi, S. H., 2010, Studies on inactivation profile of polyphenol oxidase (PPO) from custard apple (*Annona squamosa* L.) pulp by heat treatment and its effects of sensorial quality. Food Sci. Res. J. 1(2):137-141.
- Prasanna, K. N., 2000, Effect of storage temperature on ripening and quality of custard apple (*Annona Squamosa* L.) fruits, J. Hort. Sci. Biotechnol. 75(5).
- Pruthi, J. S., Manan, J. K. and Teotia, M. S., 1984, Studies on the utilization of kinnow and malta oranges. J. Food Sci. Technol., 21(3): 123-127.
- Raghuramaih, B. and Ranganna, S., 1970, Citrus beverages manufacture and quality control. Indian Food Packer, 24(4): 25-27.

- Rajani, R., 1998, Development of value added products from custard apple fruit (*Annona squamosa* L.) *M.Sc (Agri.) thesis* submitted to UAS, Bangalore.
- Ramajayam, D., Jagannath, S., Syamasundar, J. and Sivakumar, K. C., 2002, Preparation of ready-to-serve and squashes from *simarouba* fruits. *Current Res.* 31(7/8): 111-113.
- Ranote, P. S. and Bains, G. S., 1982, Juice of kinnow fruit. *Indian Food Packer*, 36(5): 23-33.
- Ranote, P. S., Saini, P. S. and Bawa, A. S., 1993, Characteristics of kinnow mandarin juice and beverage. *Indian Food Packer*, 47 (1): 11-13.
- Rao, M. R., Rao, S.N. and Reddy, E. N., 1979, Utilization of Rangpur lime for the preparation of beverages. *Indian Food Packer*. 33: 33-34.
- Relekar, P. P., Naik, A. G. and Padhiar, B. V., 2013, Effect of recipe on qualitative changes in sapota squash during storage. *Int. J. Hort.* 3(6): 22-27.
- Rohit, B., Sharma, S. K. and Yadav, V. K., 2008, Studies on preparation and storage evaluation of seabuckthorn (*Hippophae salicifolia* D. Don.) squash beverage. *J. Hill Res.*, 21(2): 8-12.
- Roy, S. K. and Singh, R. N., 1979, Bael fruit (*Aegle marmelous*) a potential fruit for processing. *Eco. Bot.* 33(2): 203-212.
- Rupantar, P. S, Chavan, K. D., Pawar, B. K. and Bhosale, D. N, 2009, Utilization of kokum juice for preparation of paneer whey beverage . *J. Dairy. Foods.* 28(2): 111-114.
- Saini, S. P. S., Bawa, A. S. and Dharmpal, 2001, Storage stability of mango RTS. *Bev. Food World*, 24(1): 25-38.
- Sakhale, B. K., Pawar, V. and Ranveer, R. C., 2012, Studies on effect of chemical preservatives on keeping quality of kesar mango pulp. 1-184.
- Sameer, A.S, 2006, Processing of jamun fruits for value addition. *M. Sc. (Hort.) Thesis* Univ. Agri. Sci. Dharwad.
- Sanjeev Kumar and Singh, I. S. 1998, Studies on processing of papaya (*Carica papaya* L.) fruits. *Prog. Hort.* 30(3/4): 139-147.
- Saravanan, K., Godara, R. K., Goyal, R. K. and Sharma, R. K. 2004, Processing of papaya fruit for the preparation of ready-to-serve beverage and its quality. *Indian J. Hill Farm.* 17(1/2): 49-55.
- Sarmah, A., Premalatha, M.R., Malathi, D. and Govindaraju, P, 1981, Preparation of *Aloe vera* based fruit squashes. *National seminar on post production systems and strategies – Food Safety and Security*, Sept. 22-23. pp. 220.
- Saxena, A.K., Teotia, M.S. and Berry, S.K, 1996, Studies on the development of grape-mango and grape-pineapple beverage blends. *Indian Food Packer*, 41(4): 43-59.
- Singh, I. J., Singh, H. K and Chopra, C. S, 2001, Studies on processing of mango and papaya pulp squash. *Beverage and food world*, 28(9): 34-35.
- Singh, I. J., Singh, H. K and Chopra, C. S, 2005, Studies on processing of bael fruits. *Beverage and food world*, 32(9): 35-36.

- Singh, I. S. and Sanjeeva Kumar, 1995, Studies on processing of aonla fruits. Prog. Horti., 27(1-2): 39-47.
- Singh, R., Nidhi, R. G and Rana, M. K., 2007, Changes in chemical components of RTS bael-guava blended beverages during storage. J. Food. Sci. Technol., 45(4): 378-380.
- Sonia, S., Sogi, D. S. and Bawa, A. S. 2003, Shelf-life studies on chemically preserved sand pear (*Pyrus pyrifolia* cv Patharnakh) pulp. J. Food Sci. Technol., 40: 230-232.
- Sorolia, D. K. and Mukharjee, S., 2002, Comparative efficacy of different preservation methods in keeping quality of lime (*Citrus aurantifolia* Swingle L.) juice during storage. Haryana J. Hort. Sci., 31(3-4): 185-188.
- Srinivas, D. K., Sanjey, K., Abhay, D., Yadav, R.C. and Sood, S, 2007, Processing potential of sapota. Nat. Sem. Prod. Utilization of Sapota, Salem, pp. 20.
- Srivastava, J. S., 1998, Comparative study on RTS drinks prepared from Dashehari and Banganpalli mangoes. Indian food packer, 52(2): 38-42.
- Srivastava, R.P. and Sanjeevkumar, 2012, In Fruit and Vegetable Preservation Principles and Practices. Inter. Book Distri. Co., Lucknow, p. 64-98.
- Sudha, D. K., Kumar, S., Dikshit, A. and Shukla, D. K. 2007, Storage study on sapota Squash. Indian Food Packer, 59(6): 91.
- Sudhir, K. S. and Kilara, A., 1983, Temperature response of frozen peas to di-thermal regimes. J. Food Sci., 48: 77-83.
- Suhali, K., Sreenivas, K. N., Shankarappa, T. H. And Ravindra, 2007, Standardization of recipe for value added nutraceutical beverage of guava blended with aloe vera and roselle. Environ. and Ecol. 30(3): 995-1001.
- Surender, S. R. K., Godara, R.S., Saini and J. R. Sharma, 2005, Standardization of processing technology for bael/blended bael (*Aegle marmelos*) ready-to-serve beverages. Haryana J. Horti. Sci., 34(3-4):263-265.
- Swamy, V., Gowda, A.R. and Vijayamma, R, 1977, Utilization of unconventional fruits for the preparation of ready to serve beverages. Indian Food Packer, 31 (3): 47-52.
- Teotia, M.S., Kaur, S and Berry, S.K., 1997, Utilization of muskmelon (*Cucumis melo*) for ready-to-serve beverages from enzyme clarified juice. Indian Food Packer, 51(1): 11-17.
- Thakur, K. S. and Barwal, V.S., 1998, Studies on preparation and evaluation of squash from unmarketable kiwi fruit. Indian Food Packer, 52(1): 26-29.
- Tiwari, R. B., 2000, Studies on blending of guava and papaya pulp for RTS beverages. Indian Food Packer, 54: 68.
- Tripathi, V. K., Singh, M. B. and Singh, S, 1988, Studies on comparative compositional changes in different preserved product of aonla. Indian Food Packer, 42(4): 60-66.
- Umme. A., Aubi. B. A., Salmah Y., Junainah A. H. and Jamilah B, 1997, Characteristics of soursop natural puree and determination of optimum conditions for pasteurization. Food Chem. 58(1-2):119-124.
- Upale, K. B., 2005, Studies on processing of jamun juice and its beverages. M. Sc. (Hort.) Thesis submitted to Univ. Agri. Sci. Dharwad.

- Urmil, M. and Satinder, B., 1988, Effect of storage and methods of preparation on the physico-chemical characteristics of citrus juice. *Indian Food Packer*, 37(4): 42-51.
- Verma, W. 2007, Consumer acceptance of functional foods: socio-demographic cognitive and attitudinal determinants. *Food Quality and Preference*. 16(1): 45-57.
- Vijay, J., Prabhakar, S. and Singh, A.K., 2006, Screening of aonla cultivars for making squash. *Indian J. Arid Hort.* 1(1): 44-46.
- Vijayalakshmi, B. H., 2012, Studies on use of aloe vera (*Aloe barbadensis* Miller.) in health drinks. *MSc. (Hort.) Thesis* submitted to Univ. Hort. Sci. Bagalkot.
- Vijayanand, P., Reena, P., Kulkarni, G. S., Asha, M. and Ramana, K. V. R., 2003, Preservation and quality characteristics of aonla juice prepared from different cultivars. *Proc. 5th Int. Food Conv., Mysore*, pp.186.
- Vishal, V. and Sharma, R. K., 1998, Screening of aonla (*Emblica officinalis* Gaertn) cultivars for processing. *Prog. Hort.* 30(1-2): 76-79.
- Waskar, D. P. and Khurdiya, D. S., 1987, Processing and storage of phalsa beverages. *Indian Food Packer*, 41(5): 7-16.

Appendix I: Metrological data recorded for the experimental period from January-2013 to December 2013 at Agriculture Research Station Arabhavi-591 218

Month	Temperature (°C)		Relative humidity (%)	Rainfall (mm)
	Min	Max		
January -2013	12.8	31.3	60	0.0
February -2013	14.0	32.5	63	3.6
March -2013	15.5	35.6	52	0.0
April -2013	19.3	38.2	52	6.1
May -2013	22.3	38.1	66	87.8
June -2013	21.6	30.9	77	11.7
July -2013	21.2	27.9	86	53.5
August -2013	20.4	28.6	81	31.3
September- 2013	20.3	29.4	79	77.2
October -2013	19.8	29.8	76	83.8
November- 2013	13.7	29.5	70	0.0
December- 2013	11.6	28.5	66	0.0

STUDIES ON PROCESSING AND PRESERVATION OF CUSTARD APPLE PULP, SQUASH AND READY-TO-SERVE BEVERAGES

KAVYA D.

2014 Dr. LAXMAN KUKANOOR
Major Advisor

ABSTRACT

Investigation on “Studies on processing and preservation of custard apple pulp, squash and ready-to-serve beverage” was conducted during 2013-14 in the Department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi (UHS, Bagalkot), Karnataka.

The custard apple pulp was prepared by two methods and was stored for 15 days and they were analysed at fresh, 5, 10 and 15 days intervals. Initially, TSS was maintained at 26° B and acidity at 0.5% for chemically preserved pulp and pasteurized at different temperatures respectively. TSS, total and reducing sugars were maximum, while titratable acidity and total bacterial count was minimum in pulp treated with KMS at 1500 ppm similarly pulp pasteurized at 90 °C for 25 min stands superior in maintaining physico-chemical and organoleptic parameters.

In squash, significantly maximum TSS, reducing, total sugars and a^* value were found to increased during storage. Whereas titratable acidity, ascorbic acid, non-reducing sugar, L^* value, and b^* value decreased respectively at initial, 1, 2 and 3 MAS. The treatment T_2 (pulp 25% + 42 % TSS) stands superior with respect to all the sensory parameters and physico-chemical.

In ready to serve beverage, the maximum TSS reducing, non-reducing and total sugars were observed with 14 per cent pulp + 16 per cent TSS and highest a^* value was observed in treatment with T_4 (12 per cent pulp + 14 per cent TSS). The organoleptic evaluation of RTS revealed that the treatments T_2 (Pulp 10%+15% TSS) observed maximum acceptability based on organoleptic scores for all the parameters.