TECHNOLOGIES FOR CASHEW APPLE PROCESSING

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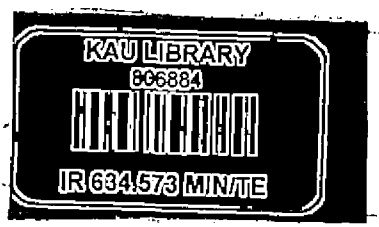

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English

Technologies for cashew apple processing

1st Edition: November 2005 (500 copies)

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Published by:
Director of Extension, Kerala Agricultural University
Mannuthy, Thrissur - 680 651

Printed at Luniere Printing Works, Thrissur

Financed by:
Directorate of Cashewnut and Cocoa Development, Cochin-11

Correct citation: Mini,C., Mathew, J. and Augustine, A. 2005. Technologies for cashew apple processing. Kerala Agricultural University, Vellanikkara - 680 656, Thrissur.

FOREWORD

Cashew nut, an important horticultural crop of India, has moved from forest confines to commercial plantations through technological advancements in propagation, improvement, production and protection. Cashew nut provides good quality protein, unsaturated free fatty acids, rich blend of minerals and many vitamins and is considered to be an excellent dietary supplement. India is a major producer, exporter and processor of cashew.

While India pioneered in the utilization and promotion of nuts, it failed in the exploitation of cashew apple. It is strange to note that the nutritious cashew apple, to which the nut is attached, is getting wasted in developing countries like India, even while the country faces umpteen nutritional problems. It may also be mentioned that the fruit has some innate disadvantages from the consumption point of view, but these factors can be rendered beneficial to meet the consumers needs and industrial requirements. It is high time to exploit the cashew apple commercially.

Institutes like Kerala Agricultural University, Central Food Technological Research Institute, Mysore and University of Agricultural Sciences, Bangalore, have done commendable works in the utilisation of cashew apple and development of products. Transfer of these technologies to different stakeholders can help farmer to earn additional income and generate lot of employment. This book is an attempt in that direction.

This book provides technical information on the various technologies developed for the processing of cashew apple. To make this book practical and useful, detailed methodologies are given on the preparation of different cashew apple products. Recipes for different products, utilization of apple residue and requirement for establishing a commercial processing unit etc have been fully dealt with. The colourful photographs add to the value of the publication.

I am sure this book would prove to be a useful and comprehensive reference and guide for all those wish to take up cashew apple processing at homescale or commercially.

I congratulate the authors, Dr. Mini.C, Assistant Professor, Cashew Research Station, Madakkathara and Dr. Jose Mathew, Associate Professor & Head, Cashew Research Station, Madakkathara and Dr. A. Augustine, Associate Professor, CPBMB, College of Horticulture, Vellanikkara for their sincere efforts in bringing out this publication.

I wish this book to be comprehensive enough to attract the attention of a wide circle of readership like teachers, students, farmers, extension personnel's and entrepreneurs.

Dr. K.V.Peter
Vice Chancellor
Kerala Agricultural University

PREFACE

It is estimated that around 40 lakh tones of cashew apple is produced annually in ~~Kerala~~ India, which is largely wasted at present. Several studies have clearly indicated that the quality of cashew apple is comparable to that of many fruits, and sometimes even better. An attempt has been made in this book to give a comprehensive account of the different technologies available for the economic utilization of cashew apple. The problems associated with the processing, methods to reduce astringency and spoilage, recipes for different products and utilization of cashew apple residue are discussed in detail. The requirements for establishing a commercial processing unit is also given along with colour photographs.

The technologies developed by different institutes, for cashew apple processing, both national and international has been presented. The technology package developed by Kerala Agricultural University for each product is given emphasis in the text by highlighting it. The appendices include FPO specifications for different products, application forms for getting license and submission of regular reports and determination of different quality parameters.

We take this opportunity to express our sincere gratitude to Directorate of Cashew nut and Cocoa Development, Ministry of Agriculture, Cochin for giving financial assistance for publishing this book.

We are grateful to Dr. K.V. Peter, Hon. Vice Chancellor, Kerala Agricultural University for writing a foreword to this book.

We are thankful to Dr. P.B. Pushpalatha, Dr. K.B. Sheela and Dr. V. Indira for providing necessary support to complete this work. We also extend our thanks to all those, who have directly or indirectly contributed in bringing out this publication.

We sincerely hope that this book shall be useful to all those who wish to take up homescale or commercial processing of cashew apple.

Authors

CONTENTS

CHAPTER 1

INTRODUCTION

Cashew (*Anacardium occidentale* L) is an important cash crop of India. It is a crop native to North East Brazil. Portuguese traders introduced it to coastal India in 16th century, with the main intention of cultivating it to stop soil erosion on the coastal regions. Subsequently, the commercial value of cashew nut has been identified by Indians. Since then the area under its cultivation has been steadily increasing in the country. India has been the leading cashew producer in the world, since its commercial cultivation was started.

At present cashew is mainly grown for its nut in most of the countries including India. The cashew apple, to which the nut is attached, is almost completely wasted at present. Analysis of the nutritive and qualitative characters of the apple has clearly indicated its superior/ comparable position compared to other fruits. Research works conducted in several countries has revealed the potential for utilizing cashew apple for the production of nutritious and refreshing products. But most often the technology has been confined to the laboratories and reports on the commercial exploitation of cashew apple is very limited.

While India pioneered in the utilization and promotion of nuts, it failed in the exploitation of cashew apple. As a result, vast tonnage of cashew apple is currently wasted without economically utilizing it. The state of Goa is the only exception.

Kerala Agricultural University (KAU) has done pioneering work in the utilisation of cashew apple processing. Among the several products, for which technologies have been developed by KAU, cashew apple syrup is being produced and marketed commercially by Cashew Research Station, Madakkathara, with good profit. Training progammes are regularly conducted at the station for cashew farmers, rural youth and housewives for the popularization of cashew apple processing.

The Central Food Technological Research Institute, Mysore, India has also evolved a number of processes for the profitable and commercial utilization of cashew apple. Research work at the University of Agricultural

Sciences, Bangalore, has also succeeded in producing several novel products from cashew. Certain private companies like Pioneer Cashew Industries Ltd., Chennai, has plans to prepare juice extract from apple and market it in tetra pack.

Though no authentic data is available on the market demand of cashew apple products, experiences at Cashew Research Station, Madakkathara indicated good acceptance by consumers. Further growth in demand is expected in view of the increased preference for natural products in the coming years.

This book is a compilation of the technologies available for cashew apple processing. It is also intended to serve as a guide to all those who wish to take up processing of cashew apple at home scale or commercially.

CHAPTER 2

BOTANY OF CASHEW APPLE

The cashew fruit consists of an apple (also called *crab apple*) and a nut, which is a kidney bean shaped appendage at the end of the apple. The true fruit is the cashew nut, which resembles a miniature boxing-glove. It consists of a double shell, containing a caustic phenolic resin in honeycomb-like cells, enclosing the edible kidney-shaped kernel. Cashew apple, the pseudofruit (or false fruit) is soft and nutritious. It is actually the swollen receptacle or the flower stalk of the crop.

Morphology

The apple varies greatly in size, shape, colour and weight. The apples can be almost round, or elongated and scarcely resembling the real apple at all. The apples are often heart-shaped and hence the genus name *Anacardium*, which means "shaped like a heart". In fact, the shape of the fruit is more similar to that of a pear than that of an apple, and hence the Portuguese and Brazilians sometimes call it "pera" (pear).

Apples are about eight to ten times as large as nut but in some cases the apple is not larger than the nut. For practical reasons, a nut to apple ratio of 1: 8 to 1: 10 is commonly used. Fully-grown cashew apple weighs about 50 to 100 g but varies with genotypes. Weight of apple varies from 30 g in VTH, 100 g in BRZ-241 and 150 g in Andur-1(Pushpalatha and Kutty, 2005)

Very young apple is green or purple in colour, turning to green about 40 days after fruit set. The typical colour of the apple appears at the full ripe stage. Ripe cashew apples vary in colour with the genotypes and are yellow, golden yellow, red or cherry coloured.

The ripe apple is very juicy, has a peculiar smell, somewhat fibrous and has a very thin skin that easily gets bruised. It contains about 85 % juice, which has a sugar content of around 10 %, mostly invert sugar. The colour and juice percentage of fully ripe apples of different varieties are given in Table 1.

Table 1. Varietal variation in the apple colour and juice content of cashew

Varieties	Apple colour	Juice content (%)
Varieties from Kerala Agricultural University		
Anakkayam-1	Pinkish yellow	71
Madakkathara-1 (BLA 39-4)	Yellow	72
Kanaka (H-1598)	Yellow	70
Dhana (H-1608)	Yellow	72
Dharasree (H-3-17)	Yellowish pink	67
Amrutha (H-1597)	Yellow	72
Akshaya (H-7-6)	Yellow	68
Anagha (H-8-1)	Orange red	66
Sulabha (K-10-2)	Light orange	70
Priyanka (H-1591)	Yellowish red	67
Madakkathara-2 (NDR-2-1)	Red	68
K-22-1	Red	68
Raghav	Golden yellow	68
Damodar	Red	62
Varieties from Kongan Krishi Vidyapeed		
Vengurla –1	Yellow	65
Vengurla-2	Red	45
Vengurla-3	Yellow	77
Vengurla-4	Red	76
Vengurla-5	Yellow	86
Vengurla-6	Yellow	85
Vengurla-7	Yellow	86
Varieties from Andhra Pradesh Agricultural University		
BPP-1	Yellow	68
BPP-2	Yellow	67
BPP-3	Yellow	67
BPP-4	Yellow	64
BPP-5	Yellow	64
BPP-6	Yellow	74
BPP-8 (H 2/16)	Yellow	64
Varieties from Tamil Nadu Agricultural University		
Vridhachalam-1 (M10/4)	Yellow with slight red tinge	74
Vridhachalam-2 (M 44/3)	Pinkish yellow	82
Vridhachalam-3 (M 26/2)	Red	73
Varieties from University of Agricultural Sciences		
Ullal-1	Yellow	64
Ullal-2	Red	64
Ullal-3	Dark red	66
Ullal-4	Yellow	65
Chintamani-1	Yellowish red	65
UN-50	Yellow	65
Varieties from National Research Centre for Cashew		
NRCC-1	Red	
NRCC-2	Pink	
Varieties from Bhidan Chandra Krishi Viswavidyalaya		
Jhargram-1	Yellow	64
Varieties from Orissa University of Agriculture and Technology		
Bhubaneswar-1	Reddish yellow	
Varieties from ICAR Research Complex, Goa		
Goa-1	Yellow	68

Chemical composition

Cashew apple is a valuable source of sugars, minerals and vitamins. Different authors (Table 2) have reported great variability in chemical composition of cashew apple.

Table 2. Chemical composition of cashew apple

Constituents	Augustine (2001)	Gopalan (1989)*et al.*	Morton (1987)
Moisture (%)	87.8	86.3	84.4 –88.7
Proteins (%)	0.2	0.2	0.101- 0.162
Fat (%)	0.1	0.1	0.05 – 0.5
Carbohydrate (%)	11.6	12.3	9.08 – 9.75
Crude fibre (%)	0.9	0.9	0.4 – 1
Calcium (mg /100g)	10.0	10.0	0.9 – 5.4
Phosphorus (mg/100g)	10.0	10.0	6.1 – 21.4
Iron (mg/100g)	0.2	0.2	0.19 – 0.71
Vit.C (mg/100g)	261.0	180	146.6 – 372
Minerals (g/100g)	0.2	0.2	
Thiamin (mg/100g)	0.02	0.02	0.023 – 0.03
Riboflavin (mg/100g)	0.5	0.05	0.13 – 0.4
Vitamin A (Carotene)	39 IU	23 ¼g	0.03– 0.742 mg

A comparison of the nutritive value of cashew apple with other common fruits is given in Table 3. It can be seen that cashew apple is comparable with other fruits in most of the nutrients but superior in vitamin C.

Table 3. Comparison of the nutritive value of cashew apple with other fruits (per 100 g)

Name of fruit	Moisture (g)	Protein (g)	Fat (g)	Calcium (mg)	Iron (mg)	Carotene (ug)	Vit.C (mg)
Cashew apple	86.3	0.2	0.1	10	0.2	23	180
Apple	84.6	0.2	0.5	10	0.66	0	1
Banana	70.1	1.2	0.3	17	0.36	78	7
Orange	87.6	0.7	0.2	26	0.32	1104	30
Mango	81	0.6	0.4	14	1.3	2743	16
Papaya	90.8	0.6	0.1	17	0.5	666	57
Citrus	89.3	0.9	0.6	40	0.6	-	50

Cashew apple juice contains fructose, glucose, sucrose, maltose and acidic substances. The polysaccharides on hydrolysis give D- glucose, D-galactose, D- arabinose and oligouronic acids with traces of D- xylose and L- rhamnose. Water soluble poly saccharides include mainly starch and arabino galactan (Haq *et al.*, 1975).

The fruit contains malic acid. The free aminoacids identified in the juice of the cashew apple are alanine, aspartic acid, asparagine, glutamic acid, glycine, leucine, proline, serine, threonine, tryptophan and valine. The major polyphenolic constituent of the juice is leuco- delphinidins (CSIR,1985).

The astringent and acrid principles in cashew apple produce a rough, unpleasant and biting sensation on the tongue and throat. The phenolic compound, tannin, determine the astringency of fruits to a certain extent. (Sastry *et al.*, 1962).

There are considerable differences in sweetness and astringency of cashew apple among genotypes. Variability in quality characters between red and yellow coloured cashew apples had been reported by many workers (Nanjundaswamy *et al.*, 1984; Chandran and Damodaran, 1984). The greatest variability is found in tannin content, the lowest being 0.06 and the highest 0.22 g per 100 g. Albuquerque *et al* (1960) noticed that the yellow apple tends to be softer and less astringent than red apples. The pH of the apples varies between 4.1 and 4.7 and total sugars from 6.7 to 10.5 %. Ripe apples contain 0.76 to 1.17% pectin.

Acidity ranges from 0.21% in variety Madakkathara-1 to 0.52% in H-1610. Tannin content is lowest in variety Amrutha (0.28%) and highest in Kanaka (0.76%). Pectin content is high in variety Madakkathara-1 (1.26%). β Carotene ranges between 16.42 mg to 52.49 mg per 100g. Variability exists in terms of calcium, magnesium and sodium contents also (Suman, 2005).

Kanaka, Dhana, H 1593, Raghav, Damodar, V3, V4, MDK-II, Sulabha and K19-1 have more than 13% sugar. M 44/3, H 2/16, H 59/2, M 26/2, BRZ-241, BRZ-242 contains less tannin. Cashew apple suited for processing should have medium to large fruit size with more than 70% juice containing more than 11% sugar and 0.39- 0.42% acidity.

Kumar and Aravindakshan (1985) listed K-27-1, BLA 139-1, BLA-1 and Sawantwadi as the varieties suitable for processing. According to Kutty (2000), varieties H-1593, H-1600, V-4, K-19-1, Madakkathara-2, Dhana, Kanaka and M 26/2 had desirable attributes with reference to quality parameters.

In some regions the yellow coloured apple is preferred because of its sweetness. In all colour groups, more or less sweet or astringent apples have been found. Morton (1987) has reported a reddish yellow coloured variant "Dunort cashew apple" from premature dwarf trees. The fruits have less tannin and more sugar than the other cashew fruits, with an average weight of 100 g.

Growth and development

The physical structure and shape of cashew apple change with growth. Along with the dry matter accumulation, changes occur in the composition of apple also. Increase in moisture, TSS, carbohydrate, reducing sugar, fibre content and a decline in acidity and phenolic constituents are the notable changes in cashew apple during maturation and ripening.

Based on the growth pattern, cashew apple belongs to the group of plants where fruits show an exponential growth, where they show an initial slow growth and then there is an increase at high rate. Fruit development in cashew is completed in 52 to 60 days after fruit set (Kutty, 2000).

Difference exists between varieties in terms of apple length, circumference, fresh and dry weight during all stages of growth. After fertilization, the developing nut become visible by the 5th or 6th day (pea stage) (Damodaran *et. al.*, 1966). At this stage the pedicel length is about 0.6- 0.9 cm. By the time the apple attains maturity the pedicel length increases 6 to 10 times. The apple circumference increases 12-24 times and apple volume increases 59 to 112 times through the course of development. Increase in fresh weight of apple from pea stage ranges between 650 – 1500 times. There is an exponential increase in fresh weight from 40- 45 days after fruit set. Apples accumulate a major part of the dry weight from 40 days after fruit set. The Relative Growth Rate is maximum between the period from pea stage to 20 days after fruit set. A second peak is observed between 41 and 50 days after fruit set. The firmness of apple flesh ranges between 5.13 to 7.10 kg cm^{-2} at 40 days after fruit set. There is a sharp

decline in flesh firmness when the apples ripened. Colour change in apple is visible by 50 days after fruit set and typical colour of the variety develops when the apple is fully ripe. Flesh firmness also shows a sharp decline during ripening phase. The skin, which is very tender initially becomes exceedingly waxy as the apple ripens.

The increase in dry weight of fruit is slow up to 36 days from the fruit set and thereafter the rate of increase is rapid till maturity (Augustine and Unnithan, 1982). The slow growth rate of the apple in the early period seems to be associated with high concentration of phenolics, which are considered to be the best group of inhibitors among the secondary plant products. The fruit enlargement in later stage is mainly due to an increase of carbohydrate and moisture percentage.

Specific gravity of young cashew apples range from 1.04 to 1.15. Ripe apples have specific gravity less than one (Augustin and Unnithan, 1982; Kutty, 2000).

Moisture per cent in the initial stage varies from 75 to 79 % and thereafter there is a slight increase and remains almost stable in the range of 85 to 89 %. The soluble carbohydrate and ascorbic acid content increase continuously up to the last stage of maturity. Soluble carbohydrate percentage is maximum during the 44^{th} to the 46^{th} days after the fruit set. The pattern of soluble carbohydrate increase is also similar to that of ascorbic acid concentration. Phosphorus percentage is high in the initial stage of fruit development and decreases in the later stages.

The trends in the content of biochemical constituents viz., fresh and dry weight, sugar, phenolics, ascorbic acid, phosphorus and potassium of cashew apple, over the period of maturity have been worked out. The model is $Y_1=e^{at} + b$, where Y_1 is the biochemical constituent at time t, a, the relative growth rate (RGR) and b, a constant found to be very close fit to the data as is evidenced by the r^2 values (Augustine, 2002).

Phenolics percentage (fresh weight basis) is very high at initial stage of fruit development (16 to 18 %) and its decrease during the course of maturity is drastic compared to the changes in other constituents of cashew apple.

Cashew apple has been grouped as one with non- climacteric behaviour and has also been described as one of the most metabolically active material, indicated by its high rate of respiration (Kays, 1991). In ripe apples, the rate of respiration is 318.4 mg CO_2 kg^{-1} hr^{-1}.

Rate of respiration and ethylene release in and from detached cashew apples at different stages of development has been worked out by Kutty (2000) and is furnished in Table 4.

Table 4. Respiration rate and ethylene release from cashew apple

Stage of development (days after fruit set)	Respiration rate (mg CO_2 kg^{-1} hr^{-1})	Ethylene release (μl kg^{-1} hr^{-1})
20	720.4	-
40	368.9	47.15
50	292.3	160.17
52- 55	316.2	64.92
Ripe	198.6	31.57

Anatomy

Cashew apple, which is morphologically the modified receptacle, has a typical dicot stem anatomy. The unilayered thin epidermis is interrupted by a number of stomata. Below the epidermis, few layers of cortical cells with tannins are observed. Vascular bundles are endarch, collateral, open and dispersed in a ring and a few bundles appear in the centre as well. These vascular elements expand and shift laterally as the apples develop. Entire cortex and pith together develop to form succulent apple. A number of lysogenously formed resin ducts, size of which increases from early stages of growth to ripening stage, are seen dispersed through out the cortex tissues. Occurrence of these resin ducts is a characteristic of the family Anacardiaceae. These ducts enlarge with the increasing bulk of apple.

Starch grains accumulate in the parenchymatous tissues and are visible at 40 days after fruit set. Tannins accumulate in the inter cellular spaces of the cortex. The cuticular layer is about 6.6 μm thick. The epidermal cells are 16 to 50 μm in length and 9.6 to 32.5 μm in width. The cell size is maximum at 30 days after fruit set. The parenchymatous cells of the cortex

vary in size at different stages of development. Average length range between 12.8 to 25.6 μm and width range from 12.8 to 22.4μm at 20 days after fruit set. The parenchymatous cells in ripe apples are 56-64 μm in length and 36-56μm in width (Kutty, 2000).

The structural configuration of cashew apple, especially the absence of a protective peel, is reflected in the storability of the produce and its susceptibility to physical damage. These factors could also influence shrinkage and shriveling due to moisture loss, physical damage and microbial spoilage when collected and stored in bulk.

CHAPTER 3

COLLECTION AND PRELIMINARY PROCESSING OF APPLE

Problems in processing

The seasonal production of cashew apple is one of the greatest handicaps for the processing industry, along with its astringent and acrid principles. The astringent principle present in cashew apple gives an unpleasant biting sensation on tongue and throat when used in the raw form and limits the use of cashew apple as a commercial table fruit. Apart from the presence of astringent principles, cashew apple as a commodity has other limitations as well.

The utility of cashew apple is limited because of its high susceptibility to physical injury, which leads to microbial spoilage during harvest, transportation and storage. More than 63 per cent of cashew apple collected at ripe stage have moderate to heavy damage. The storability of cashew apple is thus very poor and complete spoilage can occur within hours after harvest. It is seen that the apples collected even between 6-12 hours after fall show fungal contamination.

The study at CPCRI Regional Station, Vittal revealed that yeasts and fungi are the primary and secondary invaders, respectively, responsible for the spoilage of cashew apple. The yeasts gain entry into the apple through the bruises during harvesting. The cashew apple borer sometimes attacks the apple in the field which predisposes the fruit for the entry of yeast and fungi. Since the pH of the juice is around 3.8 to 4.0, it does not favour the growth of bacteria and actinomycetes.

The fall of apple to the ground is sufficient to have contact of soil microorganisms. Apple splitting is noticed in certain cases due to *Colletotricum gleosporioids* infection, even when the apple is intact in the tree. The insect maggots and non- insect pests are also responsible for the spoilage of fallen apple in the field.

Transport of apples for processing is another problem. When the soft and delicate apples are stacked in thick layers, those in the lower ones may burst because of the weight and loose their juice.

Fragmented and scattered nature of cashew plantations also creates problem in collection and utilization of cashew apple in some cases (Nanjundaswamy *et al.*, 1984). The system of collection of cashew nuts from fallen fruits after considerable delay also limits the availability of quality cashew apple for processing purposes.

Harvesting

Crisp, firm, tight and full colour developed apples are to be collected and used for processing purpose. The physical and chemical properties of apple are optimum during 44 to 46th days after fruit set. At this stage, apple becomes suitable for processing and it falls to ground along with the attached nut. This period seems to be the best time for collecting apples without spoilage. The apples are to be collected every day after separating the nuts, when it falls to the ground. If the apples are left ungathered for some time, rotting of cashew apples and spoilage of nuts take place. Additional losses may also occur when apples are taken away by birds and animals. These losses can be minimized by spreading polythene sheets under the tree as well as by the use of net or mechanization of harvesting.

If there is no weed cover under the tree, the apples may burst and loose a considerable quantity of juice while falling directly to ground. In such cases, picking of apple from the tree is preferred to avoid damage. Once damaged, the apples may ferment and deteriorate rapidly.

The riper the apple, the sweeter it will be, and therefore, it is recommended to pick the fruit when it is about to fall. At this stage the nut has already been fully grown for a period of about two weeks, and is shrinking. It may be assumed that when apple is ripe, harvesting a day earlier will make very little or no difference as far as the quality of nut is concerned.

Apples that are not within the reach of picker's hands, can be harvested by using a small basket or sac attached to a ring at the end of a long stick. Fully ripe apples will drop into the sac when shaken. When apples are not fully matured, apples may have to be removed with a small knife, attached to the stick used for harvesting. An experienced person can distinguish ripe and unripe fruits with out difficulty.

In Brazil, plastic containers are used for harvesting apples. When

stapled, the bottom of the top containers rests on a rim at the inside of the container underneath, avoiding the squashing of the fruits. Such containers may be about 20-25 cm high, 25 cm wide and 40-50 cm long.

Sorting and cleaning

After harvesting, fruits are to be sorted to select the best quality ones. The selected fruits are washed with water in different ways, such as soaking or washing with cold or hot water sprays etc.

Containers

Stainless steel or glass containers should be used after sterilization for processing of cashew apple. Jars and bottles of clear white glass, which can withstand heating, are available in a wide variety of designs and capacities. Though glass containers are fragile and require extra care in handling, being visible, the contents can be easily displayed and can be repeatedly used. Iron and brass containers should not be used for cashew processing as it will blacken the products.

Methods to reduce spoilage

Storage of cashew apple under ambient conditions results in 35 to 100% spoilage by the second day itself. Fungal decay and shrinkage are the main causes of spoilage of cashew apple. Harvest of cashew at full ripe stage and separation of the nut with minimum damage to the apple are essential for effective utilisation of the apples. Extraction of apple juice under hygienic conditions at the production sites itself and transportation of the preserved juice could be a viable alternative to minimise spoilage. Along with careful harvesting, washing in water or dipping in solutions with low concentration of antibiotics had been suggested to reduce spoilage of cashew apples by yeast and fungi (Bopaiah, 1983). Low concentration of agriscofulvin or cyclohexamide could also be used to prevent the spoilage of apple. But the residue analysis and a safe recommendation for the treatment of apple are yet to be worked out.

Chattopadhyay and Ghosh (1993) observed lowest incidence of microbial spoilage when apples were treated with one per cent mustard oil and stored at 28° C. Studies conducted at CFTRI, Mysore, have indicated the possibility of reducing the spoilage within the tolerable limit by dip treatment in preservative solutions after harvesting and transportation from the harvesting area to the processing center. Studies at Kerala

Agricultural University revealed that cashew apples dipped in 5 % Potassium Meta Bisulphite (KMS) for one minute could be stored in "Zero Energy Cool Chamber" at temperature of 18-20^0 C without spoilage up to eight days. Zero Energy Cool Chamber is a storage system designed by the Indian Agricultural Research Institute, New Delhi. Since it is operating without power or electricity, it can be fabricated at any place at low cost.

Storage of cashew apple collected directly from tree is possible under refrigerated conditions with 15 to 17°C temperature and 85 % RH up to 12-13 days. Apples collected from fallen fruits could be stored for 6-11 days under similar conditions.

Pre storage treatments with warm water can improve storage life of cashew apple under refrigerated conditions. Pre storage treatment with potassium meta-bisulphite, sodium benzoate or hydrogen peroxide is not effective. Symptoms of chilling injury such as of sunken spots, pitting, water soaked lesions and discolouration appear when apples are stored under freezing temperature.

Packing cashew apple in polythene bags with or without ventilation reduces the storage life. When whole fruits are to be preserved and transported before processing, it is necessary to clean the apples and pack them in well-ventilated crates and transport under refrigerated conditions. It is better to arrange 2-3 layers with proper padding in each pack (Kutty *et al.*, 2003).

Methods to reduce astringency

The components responsible for astringency can be removed by adopting the following methods:-

1. Steaming of cashew apple followed by thorough washing of the steamed fruit in water. Pressure of steam and time of exposure vary from 2 to 6 kg and 5 to 15 minutes respectively, according to the quality of fruit and the product to be prepared.
2. Immersing the fruit for four to five minutes in boiling solution of common salt (2- 3%) followed by washing in water.
3. Immersing the fruit for four to five minutes in boiling solution of 0.2 N sulphuric acid (5.6 ml of concentrated acid diluted in one litre of water), followed by washing in water.

4. The juice of steamed or otherwise treated fruit may contain traces of undesirable constituents, which could be removed by treating the juice with very small concentration of casein, gelatin, pectin or lime juice followed in each case by straining or centrifuging.

- ✓ Mix gelatin (0.25-0.4 %) or pectin (0.35 %) to raw juice and allow to settle for 15 minutes. Decant the clear juice and discard the sediment (gelatin may be dissolved in water by heating). Excess gelatin imparts a disagreeable odour.
- ✓ Mix Poly Vinyl Pyrollidone (PVP) @ 1.4 g per kg of raw juice. Allow the precipitate to settle and decant the clear juice.
- ✓ Mix about 125 ml of fresh rice boiled water and allow to settle. Decant the clear upper layer and repeat the process using 125 ml of rice boiled water.
- ✓ Cheap and easy method like the use of powdered sago is also employed. For every kg of juice, 2 g cooked and cooled sago is added.
- ✓ Clarification using high doze of calcium hydroxide turns the cashew apple juice reddish black and gives a bitter taste.

CHAPTER 4

UNFERMENTED PRODUCTS

A. BEVERAGES

Several nutritious and refreshing beverages can be made from the unfermented juice extracted from cashew apple.

Extraction and storage of juice

Extracting by simple hand pressing gives 50 % of juice from the cashew apple. Extraction can be done by using screw press, basket press, cashew juice expeller or hydraulic press for enhanced juice recovery. Extraction using a screw type extractor yields more (66 %) juice (Sastri *et al.*, 1962). Studies at CFTRI showed that extraction of juice first in screw type extractor and subsequent pressing of the residue in basket press gave higher yields. In Goa, extraction is done in specially prepared depressions made by carving stones, locally known as "kolmbi", followed by keeping the residue under heavy stone to squeeze out the juice completely. In this method, 3.5 kg cashew apple gives one litre juice (Mandal, 1992). An improved juice expeller is capable of crushing an average of 150 kg apple per hour with 70% extraction efficiency.

The juice does not keep well for long and rapidly deteriorates unless sterilized by heat or treated with preservatives. Heat treatment is found to adversely affect the flavour of the juice and impart a cooked taste. Cold storage of cashew apple juice in earthen pots covering the juice surface by 0.5 cm layer of gingelly oil retains the quality of juice satisfactorily for a period of 21 days. Earthen pots internally coated with 10 % calcium hydroxide and mouth covered by polythene paper is recommended for open storage of cashew apple juice for a period of nine days. Reduction in tannin content of cashew apple juice during storage was favoured by internal pasting of containers by 10% calcium hydroxide(Vilasachandran *et al.*, 1984)

For processing during the "off" season, bulk storage of the juice in vats and barrels is also possible by chemical preservation with 350 ppm sulphur dioxide after boiling the juice for a minute followed by rapid cooling to room temperature.

Varieties / lines having processing quality attributes

Kanaka

Dhana

Madakkathara-2

Damodar

H-1593

Apples ready for processing

Unfermented Products

Candy

Drink - ready to use →

The following beverages can be prepared from cashew apple:-

1. Juice

Both clarified and cloudy juice can be prepared from cashew apple.

Clarified juice

KAU technology

The juice, after extraction, is strained through muslin cloth and clarified by adding 1.4 g of Poly Vinyl Pyrollidone (PVP) per litre of juice. Stir the mixture for two minutes after which it is strained again through muslin cloth. Boil the juice after adding 60 g sugar. The finished product may be chemically preserved by using sodium benzoate at the rate of 0.08 g and citric acid one g per 100 ml to provide acidity. The clear juice could be poured into well-sterilized bottles, cork air tight and stored in cool dry place (KAU, 1989).

Mandal (1992) has recommended the use of 100 g sugar and 5 g citric acid for every litre of clear juice to raise its brix to 15^0 and acidity to 0.4 %. The juice is then heated to 35^0, cooled down, added 0.5 g sodium benzoate, filled in bottles, crown corked and processed for 20 minutes at 80^0 C.

Cloudy juice

Nair *et al.* (1979) and Lal *et al.* (1998) reported that cashew apples can be used for preparation of cloudy juice. Cashew apples steamed at 2-4 kg pressure for 5-10 minutes or boiled in 0.2 N sulphuric acid or common salt for 4-5 minutes followed by cooling and washing in water are used for juice extraction. The extracted juice is again treated with 0.045% gelatin, 0.1% caesin or 0.05% lime juice. The precipitate is separated and the brix of the juice is raised to 15^0 and acidity to 0.4% by addition of sugar and citric acid. The juice is boiled for a minute and preserved by overflow pasteurization at 85-90^0 C for 30 minutes in glass bottles.

2. Syrup

The technology recommended by Kerala Agricultural University for the preparation of cashew apple syrup is given below.

KAU technology

The juice is extracted, strained through muslin cloth and clarified by adding 1.4 g of Poly Vinyl Pylrollidone per litre of juice. The mixture is stirred for two minutes after which it is strained again through muslin cloth. Sugar is added at the rate of 1.00 to 1.25 kg for every litre of juice. 20-22 g citric acid per litre and 0.08% sodium benzoate are added to the juice. Sodium benzoate is to be dissolved in a small quantity of warm water before adding to the mixture. All the ingredients are mixed thoroughly and kept as such for three to five hours so that clear syrup forms a separate layer, which can be easily siphoned. Bottling can be done as described for juice. The bottle should not be completely filled. Keep it in a cool dry place. Dilute the syrup five times its volume with plain water to use it as fresh drink (KAU, 1989). PVP has now been replaced by powdered sago. For every one litre juice, 2gm cooked and cold powderedm sago is added.

Jain *et al.* (1952) described that the juice from cashew apple steamed at 2-4 kg steam pressure for 5-10 minutes can be treated with 6 to 7 % of its quantity of lime juice, accompanied by stirring, allowed to settle for about 15 minutes and strained through thick cloth. Appropriate quantity of sugar can be added to raise the brix to 35^0 and the mixture can be brought to a quick boil. After holding for a minute at boiling temperature, the syrup can be cooled quickly and bottled after preservation with 350 ppm sulphur dioxide. The syrup can be used after dilution.

CFTRI Experiment Station, Thrissur has developed a technique for the preparation of golden syrup from cashew apple juice (Satyavathi *et al.*, 1963). The cashew apple juice is clarified adjusting the pH to 7.4 using calcium oxide and heated to 195^{0}F so that all the suspended matter and other substances settled down. The clear juice is siphoned off, pH adjusted to 6.0 using phosphoric or citric acid and concentrated under vacuum in a forced circulation evaporator. The concentrated syrup has a bland taste and contains 400-500 mg ascorbic acid. The colour of the concentrate is rather brown with good clarity. The colour can be improved on dilution to 15^0 brix.

3. Squash

KAU technology

As in cashew apple syrup preparation, the juice is extracted, strained through muslin cloth and clarified by using Poly Vinyl Pylrollidone. After straining, 0.4 kg sugar, 12.5 g citric acid and 0.75 g sodium benzoate are added per litre of the clear juice. All the ingredients are mixed thoroughly and bottling can be done as described for juice. (KAU, 1989).

4. Juice Concentrate

The clear and cloudy juice can be made to concentrates at 50-55° vacuum, which can be used for preparation of aerated drinks. A concentration of 30-35° brix could be reached in the case of cloudy juice and 65-70° brix in case of clarified juice.

5. Blended and Carbonated Beverages

Cashew apple juice can be blended with other fruit juices to produce mixed or composite beverages of greater appeal. Jain *et al.* (1954) reported that clarified and cloudy juices could be blended with lime, pineapple, orange, grape and apple juices. They also reported the possibility of carbonating the juice and preparation of spiced cashew apple juice. Carbonation is the process of mixing sufficient carbon dioxide with beverage so that when served, the product gives off the gas in fine bubbles and has the characteristic pungent taste. Satyavathi *et al.* (1963) reported that the clarified cashew apple juice with 10% lime juice and adjusted to 20° brix gave a good palatable product. Mandal (1992) reported the possibility of blending cashew apple juice with lime juice or pineapple + lime juice as shown below:-

	Blended with lime juice	Blended with pineapple + lime juice
Cashew apple juice	1.0 kg	500 g
Lime juice	60 g	60 g
Pine apple juice	-	500 g
Sugar	100 g	100 g
Preservative	0.5 g	0.5 g

Vaidehi (1994) has described preparation of cashew apple juice blended with watermelon juice.

6. OTHER DRINKS

a. Cashola is a ready- to – serve carbonated beverage from clarified cashew juice, which is standardized by Sri Lankan Cashew Corporation. Carbonated beverage is prepared from juice with 0.4 % acidity and 29° brix and dilution with three volumes of water. Besides being a refreshing drink, cashola contains 40-60 mg ascorbic acid per 100 ml.

b. Cashew drinks from South Brazil

Cajuda is the most popular bottled cashew apple juice without any additive.

Cajuada is the apple juice mixed either with water or combined with milk and sugar.

Cajuina is a less common, clear, light non alcoholic drink prepared by pasteurizing and filtering the juice.

Cajuvita is a vitamin – enriched juice.

Caju aperativo is the juice mixed with sugarcane brandy.

B. OTHER PRODUCTS

Technology is available for conversion of fresh cashew apple, after removal of astringent principles, into various processed products like jam, pickles, chutney, candy etc.

I. Pulp products

The most important pulp product, jam is prepared by boiling the fruit pulp with a sufficient quantity of sugar to a reasonably thick consistency, firm enough to hold fruit tissues in position. Generally cane sugar (sucrose) of good quality is used for jam preparation. The proportion in which it is added depends not only on the fruit, but also on its acidity and degree of ripeness. Sweet fruits require less sugar than tart fruits do. The quantity added should be adequate to give the maximum strength to the pectin-sugar-acid gel. Jam should contain a minimum of 68.5 percent total soluble solids. (Determination of TSS is shown in Appendix - 6)

Jam

KAU Technology

Fresh fruits are used for preparing jam. Cashew apple is washed thoroughly to remove any adhering dust and dirt and immersed in 3% salt solution for three days to reduce the tannin content, after which the fruits are steamed for 15 to 20 minutes at 0.7 to 1.05 kg steamed pressure. Then the apples are made into pulp and mixed with 750 g sugar per kg of apple and cook the mixture. A pinch of citric acid is added towards the end of the cooking process to improve the taste. The finished hot jam is stored in well sterilized glass bottles covering with a disc of waxed, tissued paper or molten paraffin wax on the surface of the jam after cooling (KAU, 1989).

According to Jain *et al.* (1954), steaming of fruits is done at 4-6 kg pressure for 10-15 minutes. DCCD (1985) suggests that for every 150 m rise in altitude, decrease of 0.6°C should be effected in the cooking temperature of 105°C. According to Mandal (1992), the concentration of salt solution is 2% and the fruits after taking out from salt solution are washed in warm water and steamed for 15 minutes at one kg steam pressure. After pulping the apples, it is mixed with equal quantity of sugar and boiled at 105°C, till the consistency of jam is attained. The remaining process is same as detailed above.

Mixed fruit jam can be prepared by mixing cashew apple pulp with equal quantity of banana pulp or pineapple pulp.

The end point of jam can be judged by sheet or flake test. A small quantity of jam is taken with a large spoon, cooled slightly and then allowed to drop off. At the correct end point, it falls in the form of flakes or sheets.

Fruit bars

By adding pectin, sugar, glucose and potassium metabisulphate (KMS) to the cashew fruit pulp, the brix of the pulp is adjusted to 24-30° . The pulp is layered on aluminium trays after heating to 90°C for two minutes and dried in cabinet drier to 15% moisture. After drying, the fruit sheets are cut into slabs of fruit bar having 80° brix (Vaidehi, 1994).

Leather

Ripe cashew apple is blended into fine paste after adding 1% citric acid. The fine paste is spread on a clean polythene sheet placed in a tray and sun dried. This spreading out and drying are repeated to form about six layers, one on top of the other. Dried leather is cut into required size or as such rolled and stored until use. The layers, placed one on top of the other, after smearing sugar syrup and pressed together can be eaten like fruit wafers.

Pulp products of Brazil

The cashew apple pulp, cooked into thick jam like typical sweet (*doce*) and cooled pulp formed into balls and coated with sugar (*caju cristalizado*) are used in Brazil for serving as dessert (CPCRI, 1979).

II. OTHER FRESH APPLE PRODUCTS

Candy

The fruit impregnated with cane sugar and subsequently drained and dried is called a candied fruit. Fruit and sugar are the main raw materials required.

KAU technology

a. Preparation of fruit

Cashew apple is thoroughly cleaned by washing with water. Immerse the apple in 3% salt solution to reduce the tannin content. Drain out the salt water next day and steep the fruits in fresh salt solution and repeat the process for three days. Remove the salt water and add potassium metabisulphite (625 mg/kg) and keep apples in this solution for another two to three days. The apples are then thoroughly washed in water. Keep them in a perforated crate made of aluminium or stainless steel and blanched in boiling water for five minutes, followed by steaming in a pressure cooker for five minutes at 0.35 kg pressure. The apple should not be very soft, while steaming.

b. Candy processing

Candy processing is then carried out, starting with 30° brix syrup (Preparation shown in Appendix - 4) containing 0.1% citric acid and 500 mg potassium metabisulphite per kg of apple. Pour the syrup over the apples until they are completely submerged. Keep the fruits immersed in the syrup by placing stainless steel, wooden or glass disc. Cover the container with lid and keep it as such for one day. Next day the fruits are taken out and sugar is added to the same syrup for raising the concentration up to 35° brix . Syrup is again boiled for about ten minutes and pour back over the apples. The strength of the syrup is progressively increased by 5° brix at a time for the next three days and then by 10° brix at a time for the 6th and 7th day, until the final strength of the syrup reaches 70° Brix. Keep the apple for eight to ten days in the syrup for complete absorption of sugar. The fruits are removed from the syrup, drained for half an hour and subjected to slow drying in shade. Candied cashew apples can be stored in screw capped glass jars in a cool dry place (KAU, 1989).

The syrup left over from the candying process can be used for

sweetening chutneys, in vinegar making or for candying another batch of fruits.

Based on crude fibre, tannin and sugar content suitable varieties for making cashew apple candies are Amrutha, Anakkayam-1, Dharasree, V-5 and VTH 30/4. One kilogram of cashew apple on processing gives 745g candies (Suman, 2005).

Tutty fruity

Cashew apple can be utilized for the preparation of tutty fruity. The procedure is followed as in the preparation of candy, and before final drying, the apples are removed from the syrup and allowed to drain off the syrup completely. The apples are cut into small cubes and again immersed in 70° brix syrup for 2-3 days. After three days the syrup is drained off and the bits are dried in shade. The dried tutty fruity can be packed in 200 gauge polythene covers and stored under ambient storage conditions for a period of six months in hard board cartons. The varieties suited for candy making are suited for making cashew apple tutty fruity also. One kilogram of cashew apple on processing gives 715g tutty fruity (Suman, 2005).

Fruit toffee

The whole fruit can be processed into nutritious toffee, a feasible dessert item with extended shelf life. Vaidehi (1994) observed that toffee could provide 7.5 g of protein and 442. K calories per 100g.

Preserves in other countries

Caju ameixa, (cooked and partially dried apples in syrup), *doce emcalda*, (stewed apples in syrup) and jelly are the three types of preserves made in Brazil.

Bottled apples are sold in Ceara in Brazil to Tourists (Johnson, 1977). While the peduncle is small, the nuts are removed and the peduncle introduced into bottle with branches and allowed to grow. When fully matured, the apples are separated from the main branch and the bottle is filled with sugarcane brandy.

Canned cashew apple

KAU technology

Cashew apple is treated in boiling 0.5% sodium hydroxide solution for five minutes, followed by peeling and rinsing in water and a subsequent treatment for about five minutes in boiling 0.2 N solution of sulphuric acid. Wash the apple thoroughly to remove the sticking peel pieces and steam them for about five minutes, taking care that the fruit should not become very soft. The apples are kept in well sterilized cans after trimming the undesirable portions and washing. Pour the hot sugar syrup of 40^0 brix over the fruit in the can and keep it over water bath. Seal the can, cool under running water without contamination and store in dry and cool place (KAU, 1989).

Canned curried vegetables from raw green fruit of cashew in combination with potatoes (1:1) or potatoes and tomatoes (2:1) with or without tamarind are also reported (Jain *et al.*, 1954). The unpeeled fruit is steamed; cut and prepared as for canning; potatoes and tomatoes are prepared as for cooking and 420 g of mixed vegetables are packed in can and 85 g gravy added. Gravy is prepared from 16 g red chilli powder, 16 g each of coriander, mustard and caraway, 43 g turmeric, 83 g salt, 343 g vegetable fat and water enough, to make the total weight to 1.35 kg. Cans are exhausted for 6-7 minutes in steam or boiling water and processed for one hour at 0-6 kg/ cm^2 steam pressure.

Chutney

KAU technology

Wash the cashew apple after three days of salt treatment just as jam preparation. Remove the undesirable portion and slice them. Chutney is prepared using one kg sugar, one large sized onion, 30 g ginger, one teaspoon each of cumin seed, pepper, cardamom, cinnamon and coriander powder, salt to taste and 20 ml vinegar for every one kg of fruit slice. Tie all the powdered spices in a clean thin piece of cloth. Make a syrup of the sugar by adding equal quantity of water. Add the sliced apples, chopped onion, grated ginger, vinegar and salt to it. Drop the spice bag in syrup just a little before the final stage of boiling. Boil the mixture until it is sufficiently thickened and store in sterilized jars (KAU, 1989).

Jain *et al.* (1954) recommend an additional steaming of fruits at 4.0 kg steam pressure for 5-7 minutes after salt treatment.

Pickle

The process of preservation of green fruit in common salt or in vinegar is called pickling. Raw green cashew apple can be made in to pickle.

KAU technology

Raw green fruit is washed, sliced and kept in 5% salt solution for three days by changing the solution daily. On the fourth day, salt water is removed and pickle is then prepared in the usual way, using 50 g chilli powder, 100 ml gingelly oil, 20 g fenugreek powder, 100 g asafoetida, 5 g turmeric powder, 10 g garlic, mustard powder, a pinch of sodium benzoate and salt to taste for every one kilogram of sliced apple. Asafoetida, dissolved in hot water, is added to the boiling gingelly oil. Powdered turmeric, fenugreek, chilli and mustard are added to it. Cashew apple slices are added after a thorough stirring. Citric acid, salt and sodium benzoate are dissolved in hot water. Mix all ingredients well. Transfer the pickle into clean dry glass jar and store the product for one week before use(KAU, 1989).

Steaming of fruits at 4.0 kg steam pressure for 5-7 minutes followed by washing and keeping in 10% brine for a week is recommended before pickling (Jain *et al.*, 1954).

III . NOVEL PRODUCTS

Frozen deserts and dairy confectionery prepared by optimization of juice concentration and spray drying open an excellent avenue for cashew apple utilisation. The only constraint here is the large capital investment required for spray drier equipment. Technical expertise and multiple use of the machines for a variety of agro- based products are a must for the year round profit from such enterprise. The following products have been prepared on a laboratory scale by the University of Agricultural Sciences, Bangalore (Vaidehi, 1994).

1. Dehydrated cashew apple products

Dehydrated cashew apple powder can be prepared with and without juice. The fruits after visual examination and cleaning are soaked in 2% salt solution. Then it is taken out and rinsed in water. After surface drying, the fruits are sliced, steam blanched and treated with sulphur dioxide. Then juice is extracted, clarified, spray dried and packed as cashew apple

powder with juice. The pulp or the residue of apple, obtained after juice extraction, can be dried, powdered, sieved and packed as **cashew apple powder without juice.**

10 to 30% dehydrated cashew apple powder can be used in various value added products like wheat laddu, masala buiscuits, sweet and masala doughnuts, sponge cake, steamed kadabu, tomato cashew apple powder soup, powder koftas, chocolates, sweet and hot bread products and cashew apple blended chocolates. *Nutri-Cashew,* a ready mix have been prepared using cashew apple powder for the elderly as high fibre fruit (drink) float mix for instant use.

The sieved cashew apple powder is mixed with maida, baking powder and salt and the mixture is rubbed with saturated fat and sugar. Then add green masala and curd and kneed to a soft dough. Roll it to 1/8 inch thin sheet, cut with a fancy biscuit cutter and bake for 20 minutes at 102° F (Vaidehi, 2002) to prepare **cashew apple powder masala biscuit.**

Cashew apple powder, Cocoa powder and powdered sugar are mixed with little water. After rubbing with butter or fat, it is double boiled till pour consistency. Pour it into chocolate mould keeping cashew nut at the centre, cool and pack in aluminium foil, as **cashew apple powder chocolate.**

2. Cashew apple milk blended spray dried products

Ten to 15% clear and cool cashew juice mixed with skim milk powder can be spray dried for the production of cashew milk powder and can be utilised for the preparation of novel products like milk shakes, ice creams and ice- candy. The extracted cashew apple juice must be clear and cold storage is a must before use in preparation of novel products (Vaidehi,1994).

3. Fruit- milk Lassi mix

Cashew apple pulp can be used for the preparation of a ready - to - serve beverage mix (Vaidehi, 1994) and the procedure is given in Fig. 1.

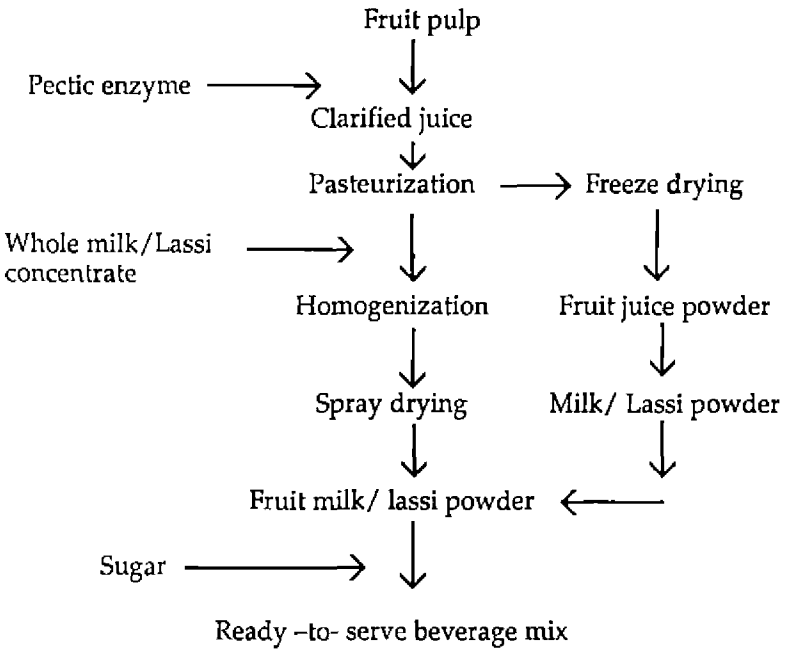

Fig.1. Procedure to prepare ready- to- serve beverage mix from cashew apple pulp

CHAPTER 5

FERMENTED PRODUCTS

Fermented cashew apple juice can be used as a raw material for the manufacture of wine, vinegar, liquor and alcohol. KAU and CFTRI have standardized technologies for utilization of cashew apple for the manufacture of the fermented products.

1. Vinegar

Cashew apple juice can be used for preparing vinegar which is perhaps the oldest known fermentation product. It is a liquid derived from various materials containing sugar and starch, by alcholic and subsequent acetic fermentation.

KAU Technology

The brix of the juice is raised to 15^0 by adding sugar. The juice is cooled and inoculated with pure strain of brewers' yeast or *Saccharomyces cerevisiae* for alcoholic fermentation. After keeping it as such for four to five days the juice is filtered and the fermented juice is mixed with one third mother vinegar. Mother vinegar containing acetic acid bacteria is added in order to check the growth of undesirable microorganisms and to hasten the process. It is kept in a wide mouth clay pot for fifteen days. Filter and pasteurize the same, which is having five to six percent acidity (KAU, 1989).

2. Liquor

Cashew liquor is not made by blending of spirits (as done in case of foreign liquor) but distilled exclusively from the pure juice of cashew apple without addition of any extraneous matter.

Kerala Agricultural University has standardized the method of producing liquor with different grades of cashew flavour viz., (1) strong flavour (2) mild flavour (3) free from cashew flavour and (4) blended flavour (Patent No. 195/ MAS/82).

The steps involved in the production of cashew liquor are:- 1. Extraction of cashew apple juice and detanning 2. Fermentation in polythene barrels 3. Distillation in glass vessels 4. Ageing process in wooden casks and 5.

Fermented Products

Indigenous preparation of fenni

Source NRCC

Fermentation

Source NRCC

Distillation →

Vermi compost frrom apple residue

Vermicompost unit

Partially decomposed

Final product

Instruments for processing unit

Hydraulic press

Refractometer

Crown corking machine

Removal of astringent smell. Use of good ripe apples is very important, as unripe or overripe apples would affect the quality of final product. Eight litres of cashew apple juice is required for getting one litre of 60-62% ethyl alcohol.

Acidity has negative influence on the quality of cashew liquor. Passing the distillate through inert clay like bentonite reduces the acidity. Keeping the liquor in wooden cask for a period of six months can produce pleasant smell of cashew and colour to the produce.

Quality of liquor involves factors like colour, flavour and its action on human beings. Cashew liquor has no obnoxious smell, astringent taste and hangover, instead it gives a feeling of freshness on the following day of its consumption (Augustine, 2002).

3. Fenni

Goa is the only place in India where cashew apples are utilized exclusively for the preparation of liquor by distillation through crude and unhygienic country methods of distilling on cottage industry basis in almost each plantation. The secret of making cashew fenni lies with Goan ingenuity. *Fenni* is derived from the word *fenno* in Konkini language (vernacular of Goa) meaning froth (Naronha, 1975).

The good and sound cashew apples are collected preferably by plucking from the trees, cleaned, squeezed, left to ferment at the right temperature and then distilled to give *caju fenni.* The distilleries, known as *Bhatti* comprise of a copper cauldron *Bban,* a clay pot *Lawni,* a pipe made of bamboo and an open hearth.

In the conventional method of fenni preparation, the apples after collection are kept in a prepared carving stone, locally known as *Kolmbi* and crushed by legs for juice extraction. To squeeze out the remaining juice from the residue, those are bundled (locally known as *mudi*) by tying with strong creepers and kept under heavy stone and thus the juice is collected in an earthen vessel or tin.

The process of distilling is based on the general principles of distillation. The copper cauldron is fixed to the open hearth leaning towards the opposite direction of the mouth of the hearth. This copper cauldron has a

small hole at the upper half in which a 60 cm long pipe is fixed properly. The other point of the pipe is fixed to the mouth of the clay pot. The clay pot is erected above ground on a stand at a distance to avoid heat from the hearth. The pipe acts as a transformer of the vapour from the copper cauldron to the clay pot which acts as a condenser (Mandal et al., 1979).

The extracted juice is kept 2 to 3 days to get it fermented with addition of yeast to improve liquor quality. The fermentation is verified on the basis of formation of the film floating over the juice. Fermentation efficiency can be increased to 98% by optimizing the controlling factors like type and kind of yeast, temperature, aeration of juice, etc.

In the indigenous techniques, fermentation is done in earthen pots for about 7-9 days. Occasionally, apples are also mixed with jaggery for better alcohol yield. After full fermentation the material is poured into a bigger vessel and a cloth is tied loosely inside the vessel. A collecting vessel is kept inside the bigger vessel. An earthen or aluminum pot with cold water is kept over the vessel and the distillation is done. As the water on the top vessel gets heated the hot water is replaced with cold water. The alcohol vapour escape and get cooled due to the cold water on the top and get collected in the vessel kept inside the bigger vessel. The hot water has to be replaced 7-8 times and the complete alcohol extracted is condensed in small collecting vessel inside the bigger vessel.

Manekar (1975) described the method of preparation of cashew fenni in Goa. According to him, the juice of cashew apples is collected in vats which when allowed to stay, is acted upon by the bacteria present in the apple causing fermentation. The fermented juice is distilled in pot stills to give *arrack (Uraq)* which on further distillation produces *fenni* and on maturation in wooden barrels gives fineness to the product.

The fenni is obtained by distilling Uraq mixed with fermented juice at 1:2 ratio. About 35 litres of Uraq is distilled from 50 litres fermented juice which contains 40% alcohol. A mixture of three litres Uraq + 60 litres juice produce 15 litres of fenni which contains 75% alcohol in five hours. To get a litre of Uraq, 12 kg of cashew apple and for a litre of fenni, 30 kg cashew apples are required.

Taking the brix of fresh cashew juice as 10.5°, after complete

fermentation under anaerobic conditions, the alcohol content would be 10. 5 x 0. 575 = 6.03. Since eight litres of cashew apple juice are required to obtain one litre of fenni, the alcohol content will be 6.03 x 8 = 48.24%(Naronha, 1975).

In the recent days vessels with some modifications (pipe fitted vessels) are used and the alcohol is directly collected outside in bottles through rubber tubing. Similarly the distillation is now done using pressure cookers. Cashew fenni so prepared is either consumed afresh or after preserving for one year until next season of fruiting (NRCC, 2004).

On modern scientific lines, the cashew apple juice should be extracted from good fruits by mechanical means, filtered, detanned, pasteurized, cooled, inoculated with a strain of pure yeast for fermentation, raked and the distillation should be done by modern techniques.

Good quality brandy / fenni has been developed from cashew apple wine by Subbarao (1972) and by Patel *et al.*, (1984) at CFTRI by distillation using columnar stills. After complete fermentation, the fermented brew is fed into a pot and distilled to recover the alcohol. The brandy is adjusted to contain 60 % alcohol and kept in selected wooden (Oakwood) barrels in the cellar at 15°C for ageing. After sufficient maturation, the strength of the distillate is adjusted to 43% by addition of water. It is then filtered, bottled and labeled as brandy.

4. Wine

Wine is one of the most complex beverages containing many substances that are important to health. As a dietary liquid, it is second only to that of milk (Blevins and Morris, 1997). The beneficial aspects of wine can be attributed to the presence of antioxidants.

Cashew wine is a product of fermentation of hexose sugar of cashew apple juice by intact yeast cells to form ethyl alcohol and carbon dioxide. Kerala Agricultural University has developed methods (Patent No. 196/ MAS/82) for producing four grades of wines such as soft, medium, hard and sweet based on the alcohol percentage and sweetness.

Fresh, crisp, tight and fully colour developed cashew apples are used for wine preparation. The steps involved in wine production are:- 1. Extraction of juice and detanning 2. Fermentation 3. Filtration and 4.

Ageing. All grades of wine preparation except soft wine, involve one more step of adding sugar. Wine fermentation is complete within 15-30 days depending on the grades of wine. Ageing can be done in wooden cask or glass vessel. Minimum period of ageing is 6-12 months. Longer ageing can give good quality wine. Stirring at one day interval for the first seven days and keeping the fermentation vessel in cool dry place are important. Sweet wine is prepared by adding sugar syrup, preferably cashew syrup, just before bottling. Nine litres of wine can be obtained from 10 litres of cashew apple juice. The volatile acidity is below 0.07/100ml and aldehyde percentage ranges from 0.088-0.418 (Augustine, 1987). Sensory evaluation showed that the preference was in the order of sweet, medium, hard and soft wines.

The quality of cashew apple wine is influenced by the clarifying agent used for clarification of cashew apple juice. The wine prepared from juice clarified with 1% gelatin produces an appealing black colour, appreciable taste, aroma and sugar acid blend (Carvalho, 2001). Use of juice clarified using 0.4% Poly Vinyl Pylrollidone and later treating with 200 mg potassium meta bisulphite (KMS) per litre of juice, though effective in reducing the tannin content, is not economic. Rice gruel, which is cheaper and easily available in every household of South India can also be used for clarification of juice to prepare wine of satisfactory sensory quality.

MTCC 180 strain of wine yeast, *Saccharomyces cerevisiae* produces cashew apple wine of high alcohol content and low acidity. Jaggery is a better ameliorant than cane sugar in cashew wine preparation. Apples of Madakkathara-1 and Dhana are found suited for wine making. Wine from the apples of Madakkathara-1 had high alcohol content, good flavour and overall acceptability, while Dhana produced wine of least astringency and possessed a favorable high brix- acid ratio (Carvalho, 2001).

Srilankan Cashew Corporation has standardised a method for production of semi sweet wine named *Cazholeena* by adding wine yeast in the dry form to single strength fresh pulp for fermentation. It contains 11.4 % alcohol and 2 % sugar and free from volatile acids and turbidity.

Wine based products

a. Blended wines

Cashew apple wine can be blended with grape, pineapple and banana

wines for better acceptability.

b. Wine coolers

Cashew apple wine can be mixed with fresh juices of orange, pineapple, tomato, grape and cashew apple as well as tender coconut water to produce wine coolers of high consumer acceptance. Wine coolers serve as good health drink as they contain both wine with its medicinal properties and fruit juices with high amount of nutrients and minerals (Carvalho, 2001).

CHAPTER 6

UTILIZATION OF APPLE RESIDUE

When bulk quantities of cashew apple is utilised for the manufacture of soft drinks or fermented beverages on a commercial scale, considerable amount of cashew apple residue is obtained as waste. This fruit waste, which is highly perishable and seasonal, sometimes creates problems for disposal. Several techniques are available for the utilisation of this waste by converting them into value added products.

Nutrient status of residue

Nutrient status of cashew apple residue, on dry weight basis, is given in Table 5

Table 5. Nutrient content of cashew apple residue on dry weight basis

Constituent	*Content (%)*
Total ash	1.6
Total tannin	5.2
Ether extractives	4.6
Calcium	0.021
Phosphorous	0. 153
Total pectin as Ca- Pectate	10.7
Proteins	8.8
Crude fibre	8.4
Iron	0.04

Utilization

The cashew apple residue can be utilized after drying or without drying for the preparation of cattle feed, pig feed and poultry feed. Studies conducted on digestibility of cashew apple waste at the College of Veterinary and Animal Sciences, Thrissur, Kerala reveals that the results are highly encouraging.

The cashew apple is dried and powdered into a meal which can be used as a bait for catching crustaceans (Johnson, 1977). Cashew peel (7.6%

protein, 12.3 % fat and 59.2% carbohydrate) is a good poultry feed and can also be used for the extraction of tannin.

Apple residue could be effectively utilised for the production of vermicompost having a nutrient composition of 1.69 % N, 0.44 % P and 0.58 % K (Mini *et al.*, 2004).

The residue, after extracting juice for fenni preparation, is used as fuel in liquor industry in Goa.

Another valuable by- product that can be obtained from fruit wastes is pectin. Pectins are mixtures of polysaccharides that originate from plants, containing pectinic acids as major components and are water soluble. The pectin is used in manufacturing jams, jellies, marmalades, preserves etc. It is useful as a thickening agent for sauces, ketchups, flavoured syrups and as a texturising agent in fruit- flavoured milk desserts. It also finds numerous applications in pharmaceutical preparations, pastes, cosmetics etc. It is also used as an emulsifying agent in the preparation of products like cod liver oil, ice cream etc. The fibrous residue after extraction of cashew apple juice can be utilized for the extraction of low methoxyl pectin (Nanjundaswamy *et al.*, 1984).

The cashew apple pomace or the fruit waste has been identified as the ideal medium for pectinase enzyme production for *Aspergillus foetidus* 115 through solid state fermentation (Venkatesh, 2003).

Medicinal uses of apple products

Cashew apple preparations have been extensively used traditionally for several ailments. Cashew apple is used as a curative against scurvy and stomach ailments like dysentery and diarrhoea. It is used as a tonic to mothers in confinement. It is a medicine for women after parturition. Cashew apple juice, without removal of tannin, is prescribed as a remedy for sore throat and chronic dysentery in Cuba and Brazil. Fresh or distilled, it is a potent diuretic possessing anti scorbutic properties, and is useful for kidney troubles, and in advanced cases of cholera. It is given for uterine complaints and dropsy. The brandy is applied to relieve the pain of rheumatism and neuralgia (CSIR, 1985). The cashew fenni is used to cure various ailments of infants and aged. Cashew apple liquor is used for medicinal purposes, for ailments like worms, sickness, cold, body ache,

fever or flue, toothache, fresh wounds and cuts, cramps due to chilling weather, muscular pain, irregular movement of bowels, low blood pressure, loss of sleep for aged people and cholera (Mandal,1992).

CHAPTER 7

ESTABLISHMENT OF A COMMERCIAL PROCESSING UNIT

Processing of cashew apple is to be considered as a programme of agricultural waste utilization, adding income to the growers. It can generate considerable employment, particularly for women. In the context of shortage of natural food products, it is high time to exploit cashew apple commercially or else it will be a national waste.

Year round functioning of processing units or distilleries can be ensured by preserving fermented and unfermented juice from cashew apple juice for extended periods. The fluctuation in annual production of cashew apple, problems in the off season functioning of the processing unit and the need for capital investment can be overcome, if units for cashew apple processing are established along with cashew nut processing industries or similar type of processing units/distilleries.

Intensive training programmes and support for small scale processing units with extensive participation of the growers is required for popularizing the processing technologies. Women and youth should be given incentive to start product oriented industrial units by utilizing cashew apples particularly in areas where cashew is cultivated in large scale.

All mass communications media should be intensively and persistently used to popularise the benefits of cashew apple and their products, particularly the nutritional aspects.

a. Investments required

The capital outlay required for establishing a commercial unit includes investment on land, factory, building and machinery. The running or operational expenses include the cost of raw material, labour, processing, storage, transportation and distribution.

Infrastructure requirement

Building

The building should be concrete, well lighted, ventilated and

independent without any direct connection with the residential or commercial portion. The flooring should be firm and should be cemented, tiled or laid in stones to withstand the constant use of water. A slope of about one quarter of an inch per foot is necessary for proper drainage. There should be sufficient drainage system and adequate provision for disposal of refuse.

The room should be white washed with washable paint up to 5 feet. All doors, windows and ventilators should be provided with fine wire-gauze to prevent entry of flies, wasps and other insects. The doors must be automatically closing with mesh fitted. The roof of the building should be high and well ventilated to provide outlet for vapors and steam.

Surroundings of the building should be maintained clean, hygienic and free from open drains, garbage and cowsheds. All operations in connection with preparing or packing of product shall be carried out carefully under strict sanitary conditions.

A sufficient number of dressing and toilet rooms should be provided separately for men and women workers in the factory premises. The workers should be taught the importance of personal hygiene.

Space requirement

Based on the annual processing capacity of the processing laboratory, units are divided into different category, for which the space requirement and the license fee vary. The space required for each category of processing unit and the license fee is given in Table 6.

Table 6. Space and annual fee for different categories of processing units

Category	Annual production (t)	Space requirement (m^2)	Annual license fee (Rs.)
Home Scale-A	5	25	20
Home Scale-B	5-10	50	100
Cottage Scale	10- 50	120	250
Small scale-A	50-100	200	400
Small scale- B	100-250	300	600
Large scale	>250	600	1500

As furnished in Table 6, space for small scale A- category processing unit having annual processing capacity ranging from 50-100 t, should be 200 m^2. Out of that, manufacturing area should be 100 m^2, space for storage of raw materials 40 m^2 and 60 m^2 area is to be provided for storage of finished goods.

Water supply and electricity

There should be abundant supply of potable water. Free flowing good quality pipe water is to be ensured to the processing hall. Large quantities of water are required for cleaning fruits, making syrup and brine, washing floor, vessels and machinery etc. Chemical and bacteriological analysis of water is to be done, if the water source is other than the municipal corporation. The water should not be alkaline or very hard or salty, and should be free from organic matter. Presence of iron and sulphur compounds in water renders it unsuitable for processing. Water testing facilities are available at different Engineering Colleges, Regional Analytical Laboratories etc. Continuous supply of electricity is to be ensured in the processing laboratory for smooth functioning of machinaries.

Labour

All the workers should have clean cloths, head wears, aprons and towels to ensure hygenic conditions. They should be medically examined at regular intervals as a precaution against infectious diseases. A record of these examinations signed by a registered medical practitioner shall be maintained for inspection.

Equipments and accessories

Great care is needed in the selection of machinery and other equipments. They shall be of such design, which permit easy cleaning. Vessels, container or other equipment, the use of which is likely to cause metallic contamination and injurious to health shall not be employed for the preparation, packing or storage of products. Adequate arrangement for cleaning of containers, tables, working parts of machinery etc. should be provided. The whole equipments should be arranged in a proper order so that minimum time and effort are needed in handling the products at all stages of manufacture. The list of equipments and other accessories needed for cashew apple processing are furnished in Table 7.

Table 7. List of equipments and other accessories needed for processing unit

Name of equipment	Use
Autoclave	To sterilize bottles, vessels etc.
Basins, buckets, mugs etc. (assorted)	To clean and soak the fruits for different preparation.
Bottle filler	To fill jam, juices etc. in bottles
Bottle washer	To wash the bottles
Cans, bottles, jars, closures etc.	To fill / pack the products
Clay pot with lids	To keep cashew apple juice for fermentation
Crown corking machine	To seal the bottle using crown cork
Counter pan balance with weights	To weigh the ingredients
Grinder/ Mixer	To mix or grind the ingredients for pickle, chutney etc.
Hydraulic press	To extract juice from cashew apple
Label gumming machine	To paste label on bottles
Pilfer proof cap sealing	To seal the squash bottle using pilfer proof cap
Preparation table	To prepare different products
Pressure cooker	To cook the fruits
Pulper/ Fruit masher	To pulp the fruits
Miscellaneous items like filter cloth, dusters, rubber gloves & glass wares	For quality control
Refractometer	To test the brix of the products
Screw type juice extractor	To extract juice from fruits like cashew apple, pine apple, orange etc.
Spoons and forks	To take sample and to make holes in fruits for candy preparation
Stainless steel knives	To cut the fruits and vegetables
Water bath tank	To clean fruits and vegetables

b. Licensing

For commercial production and sale of any processed food, including cashew apple products, license under Fruit Products Order (FPO), 1955 of the Government of India, Ministry of Food and Agriculture is needed, which can be obtained from Deputy Director(Fruit & Vegetable Production), Department of Food Processing Industries, C- Wing, D- Block (C-1,D), Rajaji Bhavan, Basant Nagar, Chennai-600 090. The fruit products coming under FPO license include the following:-

1. Fruit juices or beverages prepared from fruit pulp (squash, crush, cordial, RTS (Ready- To- Serve) beverage and barley water)
2. Synthetic beverages, syrups and sharbats
3. Artificial fruit juices
4. Vinegar, whether brewed or synthetic
5. Pickles and dehydrated products
6. Jam, jelly and marmalade
7. Tomato products like ketchup and sauces
8. Preserve, candied and crystallized fruits and peels
9. Chutney
10. Canned and bottled fruit juice, pulp and vegetables
11. Frozen fruits and vegetables
12. Aerated water containing fruit juices or pulp
13. Fruit nectars
14. Fruit cereal flakes

After satisfying the basic requirements, the license can be applied in duplicate in Form A(Appendix-2). The duration of license is for one calendar year. Application for renewal should be given one month in advance before the date of expiry of the license. The renewal can be done for a period of five years also. The unit should get another license, PFA (Prevention of Food Adulteration) license from the concerned panchayath, Municipality or Corporation.

The details of production and sale should be entered in separate register, which should be submitted for verification if necessary. Every manufacturer shall submit the return in duplicate in Form No C (Appendix-3) to licensing officer, in respect of each class of fruit products manufactured by him, during that term as soon as possible after the end of every term.

Labels

To increase the sale of produce and to make the product attractive, an

apt and attractive label should be used. As per the FPO specification, every container in which any fruit is packed shall bear a label, which may be approved for different products. After preparing the labels, triplicate copy should be sent to FPO office for approval. Following particulars shall be clearly marked on the container.

- Kind and variety of fruit
- Nature of the product
- Net weight or volume of the contents
- Name and address on trainees of manufacturer and place of manufacture
- Ingredients
- Maximum retail price (including tax)
- Code number indicating the lot and date of manufacture
- Batch Number
- License Number
- Identification mark of the manufacturer

A statement should be printed in the label stating that it contains permitted preservative and/ or colouring agent, other than natural colour, in the prescribed level only. The FPO specification for different products is shown in Appendix - 5. If the produce is made from single fruit/ fruits or vegetables, photos of that can be included in the label. But if the produce is made artificially with out adding fruits, *Non- Fruit* should be printed on the label and the label should not carry the picture of any fruit. The letter size in the label should be at least 2 mm.

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Appendix- 1

PRODUCT INDEX

Appendix 2

FORM A

Application for licence under the Fruit Products Order, 1955

1. Name and address of the applicant
2. Address of the factory
3. Description of the fruit products which the applicant wishes to manufacture
4. Period for which the licence is required
5. Plan of the factory and list of equipments
6. Whether any power is used in the manufacture of fruit products. If so, state the exact horse power used
7. Licence fee paid during the previous year
8. Total value of fruit products manufactured during the previous year
9. I/We hereby undertake to comply with all the previsions of the Fruit Products Order, 1955
10. I/We have forwarded a sum of rupees in respect of the licence fee due according to the provisions of Fruit Products Order, 1955

Appendix 3

FORM C

1. Name and address of licensee

2. Address of the authorized premises for the manufacture of Fruit Products

3. F.P.O. License No

4. Statement showing quantities of fruit and vegetable products manufactured in kg with their sale value during the term

Statement showing quantities of fruit and vegetable products manufactured in kg with their sale value during the term

Sl. No	Name of the fruit prod-uct	Size of can or bottle	Quantity in kg	Sale price per kg or per unit of packing	Value	Quantity exported (kg)	Name of the country or port of export	Rate per kg or per unit of packing C.I.F/ F.O.B	Value	Remark
1	2	3	4	5	6	7	8	9	10	11

Signature of the licensee

Appendix - 4

Relationship between percentage of sucrose sugar (^{0}Brix) and grams of sugar per litre of water

Degree Brix (percentage by weight of sugar)	Grammes of sugar per litre at 68 ^{0} F
0	0.0
1	9.6
2	20.4
3	30.0
4	40.7
5	50.3
6	61.1
7	71.9
8	82.7
9	93.5
10	104.0
11	115.0
12	126.0
13	137.0
14	147.0
15	158.0
16	170.0
17	181.0
18	198.0
19	205.0
20	216.0
21	228.0
22	240.0
23	252.0
24	264.0
25	276.0
26	288.0
27	301.0
28	313.0
29	325.0
30	338.0
31	351.0
32	363.0
33	376.0
34	389.0
35	403.0
36	416.0
37	429.0
38	442.0
39	457.0
40	470.0
41	484.0
42	498.0
43	512.0
44	526.0
45	540.0
46	555.0
47	570.0
48	585.0
49	599.0
50	614.0
51	629.0
52	645.0
53	660.0
54	676.0
55	691.0
56	707.0
57	723.0
58	738.0
59	755.0
60	772.0
61	788.0
62	805.0
63	821.0
64	839.0
65	856.0
66	872.0
67	889.0
68	907.0
69	924.0
70	942.0
71	961.0
72	978.0
73	997.0
74	1015.0
75	1033.0
76	1052.0
77	1071.0
78	1090.0
79	1110.0
80	1129.0

(Courtesy : Sunkist Growers, California, USA)

Appendix 5

FPO specifications for different products

1. Juices and concentrates

Net volume or weight	
Juice content	
Un sweetened	Natural – 100%
Sweetened	85%
Concentrate	Natural - 100 %
Total soluble solids	Unsweetened juice - natural Sweetened juice – not less than 10 percentage w/w
Acidity as anhydrous citric acid	Not greater than 3.5 percent (other than lime and lemon juice)
Synthetic sweetening agents	Not permitted
Preservatives- sulphur dioxide	Benzoic acidNot more than 350 ppmNot more than 600 ppm
Added colour	Permitted colours
Carbon dioxide- if aerated	
Organoleptic quality	Free from objectionable taints and flavours
Incubation test	No sign of bacterial growth on incubation at 37°C for seven days

2. Soft drinks- Ready to Serve beverages- natural

Net volume	
Juice content (other than lime)	Not less than 10 %
Total soluble solids	Not less than 10%
Preservatives - Sulphur dioxide	Not more than 70 ppm
Benzoic acid	Not more than 150 ppm
Synthetic sweetening agents	Not permitted
Added colour	Permitted colours
Carbon dioxide, if aerated	

3. Squash and fruit syrup

Juice content (other than lime)	Not less than 25%
Total soluble solids – squash	Not less than 40%
syrup	Not less than 65%

Acidity, as anhydrous citric acid	Not more than 3.5%
Added colour	Permitted colours
Preservatives - Sulphur dioxide	Not more than 350 ppm
Benzoic acid	Not more than 600 ppm
Synthetic sweetening agents	Not permitted
Organoleptic quality	Free from objectionable taints and flavours

4. Jam and jelly

Fruit content	Not less than 45%
Total soluble solids – Jam	Not less than 68% W/W
Jelly	Not less than 65 % W/W
Preservatives - Sulphur dioxide	Not more than 40 ppm
Benzoic acid	Not more than 200 ppm
Synthetic sweetening agents	Not permitted
Added colour	Permitted colours
Mould growth	Absent
Fermentation test	Negative pressure at sea level. Retain flavour of original fruit and free from burnt or other objectionable flavours
Crystallization	Absent

5. Fruit chutney

Fruit content	Not less than 40%
Total soluble solids	Not less than 50 % W/W
Acidity total	Not more than 2.0 %
Mould count	Not more than 40% of fields examined
Rot and insect fragments, Extraneous matter	Absent
Preservatives - Sulphur dioxide	Not more than 100 ppm
Benzoic acid	Not more than 250 ppm
Alum	Not permitted
Incubation test	Negative at 28-30 ^{0} and 37 ^{0} C
Sign of fermentation	Negative

Pickles in vinegar	
Drained weight	Not less than 67%
Drained liquid	One- third of the total content
Total acidity as acetic acid	Not less than 2% in the liquid
Clarity	Reasonably free from sediment
Preservatives	Not permitted
Alum	Not permitted
Mineral acids	Not permitted
Added colour	Not permitted
Added copper	Not permitted
Heavy metals	
Lead	Not more than 4 ppm
Copper	Not more than 10 ppm
Zinc	Not more than 5 ppm
Arsenic	Not more than 0.5ppm
Tin	Not more than 200 ppm
Fungal attack, insect fragments	
Extraneous matter	Absent
Fermentation test	Negative

Appendix – 6

Chemical determination of products

1. Determination of soluble solids

The instrument generally used for determining the total soluble solids content of fruits and fruit products is either Abbe or hand refractometer. It gives refractive index as well as *Brix*.

Procedure

A sufficient quantity of a representative lot of the homogenized sample should be taken and cooled immediately; so that the percentage composition of soluble solids may not alter due to evaporation of water. Determine the refractometer reading by placing a drop of product on the prism of the refractometer and reading the corresponding percentage of dry substance from either direct reading, if sugar refractometer is used, or from standard tables, if the instrument gives readings in terms of the refractive index. If the determinations are made at temperatures other than 20°C (at room temperature) readings are corrected to standard temperature of 20 ° C using the corrections given in table below.

Temperature corrections for the standard model of sugar refractometer calibrated for 20° C

Percentage of dry substance														
Temp. (° C)	5	10	15	20	25	30	35	40	45	50	55	60	65	70
Subtract from dry substance percentage														
15	.29	.31	.33	.34	.34	.35	.36	.37	.37	.38	.39	.39	.40	.40
16	.24	.25	.26	.27	.28	.28	.29	.30	.30	.30	.31	.31	.32	.32
17	.18	.19	.20	.21	.21	.21	.22	.22	.23	.23	.23	.23	.24	.24
18	.13	.13	.14	.14	.14	.14	.15	.15	.15	.15	.16	.16	.16	.16
19	.06	.06	.07	.07	.07	.07	.08	.08	.08	.08	.08	.08	.08	.08
Add to dry substance percentage														
21	.07	.07	.07	.07	.08	.08	.08	.08	.08	.08	.08	.08	.08	.08
22	.13	.14	.14	.15	.15	.15	.15	.15	.16	.16	.16	.16	.16	.16
23	.20	.21	.22	.22	.23	.23	.23	.23	.24	.24	.24	.24	.24	.24
24	.27	.28	.29	.30	.30	.31	.31	.31	.31	.31	.32	.32	.32	.32
25	.35	.36	.37	.38	.38	.39	.40	.40	.40	.40	.40	.40	.40	.40
26	.42	.43	.44	.45	.46	.47	.48	.48	.48	.48	.48	.48	.48	.48
27	.50	.52	.53	.54	.55	.55	.56	.56	.56	.56	.56	.56	.56	.56
28	.57	.60	.61	.62	.63	.63	.64	.64	.64	.64	.64	.64	.64	.64
29	.66	.68	.69	.71	.72	.72	.73	.73	.73	.73	.73	.73	.73	.73
30	.74	.77	.78	.79	.80	.80	.81	.81	.81	.81	.81	.81	.81	.81

2. Determination of acidity

Ten grams of the sample are dissolved in water, the solution brought to a boil and titrated with standard N/10 sodium hydroxide solution, using phenolphthalein as indicator. When the end point is not sharp, the solution should be diluted further, and phenolphthalein paper used as external indicator. The pH can also be determined with any standard pH meter having glass electrodes or pH indicator strip.