FORMULATION AND DEVELOPMENT OF NATURAL JACK FRUIT CORDIAL

by

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Declaration

I carried out the work described in this thesis at the Kelani Valley Canneries Limited, and the Faculty of Applied sciences, under the supervision of Mr.M.A.J.Wansapala and Mr.T.D.Samarakoon.

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LOVING DEDICATED

TO

MY FAMILY MEMBERS

AND ALL OF MY TEACHER

Acknowledgement

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Abstract

Jack fruit (***Artocarpus heterophyllus***) is a large ever green tree which belongs to the genus Artocarpus of the Moracea family.

Because of the unutilized nature large quantities of jack fruits are available during certain months of year .The modern innovative preservation technologies could be applied to make value added product from them.

Preliminary market research was conducted to obtain the consumer's preference for the natural jack fruit cordial. Standard formula for the natural jack fruit cordial was developed according to the SLS standards. The three different samples of cordial were processed using waraka (ripen jack fruit) pulp. First and third samples were prepared by changing the amount of sugar and water and the second sample was prepared by adding lime juice as a flavour. The sensory and physico-chemical characteristics of the processed products were studied and the best sample was selected. The shelf life was evaluated for the best sample.

Based on sensory evaluation, the sample which was contained around 48% fruit content was the best one. This sample was not shown any discoloration, acid development, mould growth or any type of deterioration in appearance within 29 days storage period.

Natural jack fruit cordial can be prepared from ripen jack fruit (waraka) pulp with brix 52^0, pH 3.8 and titrable acidity 0.6 at consumer satisfactory level.

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Abbreviation

Et al	;	and others
TSS	;	total soluble solid
CMC	;	Carboxy methyl cellulose
SMS	;	Sodium Meta bisulphite
App.	;	appendix
SLS	;	Sri Lanka Standard
Kg	;	Kilogram
g	;	Gram
KMS	;	Potassium Meta bisulphite

CHAPTER 01

Introduction

1.1. Introduction

The majority of fruits and vegetables grow in short seasons and one main reason for processing is therefore to secure a supply of these foods when they are not available in a fresh state.

In different societies through out the world, the consumption of fruits and vegetables has different levels of significant in the diet. In some areas, such as the cold, infertile conditions of central Asian steppes, mountainous regions of Latin America and arid deserts of Africa and Asia, fruit and vegetables cultivation is difficult and has a short annual growing season. These products do not there for play an important role in local diets and there is greater reliance on animal products. However, the requirement to eat fruit and vegetable products to maintain health means that in almost all of these societies, small amounts of leafy vegetables and collected fruits are preserved for winter or dry seasons and as a result of there shortage, they have a high value.

Presently, fruit cultivation is mainly found in home gardens in Sri Lanka. It is customary for Sri Lankans to plant an orange, a lime tree, a mango plant and few clumps of banana around their homes. The present average extent under fruit crops is about 70,000ha. out of which 50% is under banana. Annual production is about 600,000 of which about 50% is locally consumed, 30-40% is wasted and 10% is being exported.

Jack fruit belongs to the genus Artocarpus of the Moraceae family and contains about fifty species. Its botanical name is ***Artocarpus heterophyllus***.It is an ever green tree. The jack fruit is believed to have originated in the tropical rain forests of the Western Ghats in India. It is now considered a native species of the Asian tropics, common in India, Burma, Sri Lanka, the Philippines and Bangladesh. Jack fruit contains 38 nutrients. It also is rich in curative properties and is used in the treatment of around 30

illnesses. Over one hundred traditional dishes can be prepared using jack and around fifty more can be produced using modern food processing technology.

Large quantities of jack fruits are available as seasonal surpluses during certain month of the year (during the Yala season from May to September and few trees that bear fruit from October to April) and they go unutilized. The use of these surpluses may be extended if suitable processing method could be developed for the preservation of jack fruit. Jack is devoid of chemical fertilizer, insecticides and weedicides. It does not contain additives or other forms of artificial ingredients. Due to this reason, it would be a wise move to purchase jack related food items, from the market. Annual production of jack fruit in Sri Lanka is approximately 12.3 metric ton (Abesinha, 1991).

Ripe jack bulbs can be processed in a number of products such as jams, candies, chutneys, canned bulbs in syrup and jack fruit nector.But published data on processing of jack fruit is scanty. Jack fruit pulp could be preserved successfully by canning them in sugar syrup in the presence of citric acid. The possible preparation of a beverage concentrate has also been reported (Sathasivum et al, 1991).

There are two principal varieties of jackfruit in Sri Lanka which are distinguished by the nature of there flesh, soft or crisp. The soft type is known as "vella" and crisp "waraka".The sweetness of the flesh is an important character when the fruits are used as dessert or making fruit juice. Two waraka varieties have been selected by the Department of Agriculture, namely "fatherlong" and "rosakos".The "Singapore jack" is another crisp fleshed waraka type (Gunasena et al, 1996).

Both "vella" and "waraka" varieties were found to be suitable for cordial preparation and the varieties of fruit pulp (vella and waraka) have no effect on brix value, PH and titrable acidity of the cordial (Sathasivum, et al. 1991). There is no significant different between the waraka and vela varieties in terms of keeping quality and the storage period of jams and cordials (Gunasena et al, 1996).

1.2. Objectives

Major objectives

1. Investigation of a better extraction method for a good quality fruit juice.
2. Development of a formula for natural jack fruit cordial.

Minor objectives

1. To find out the suitable solution for the surplus of jack fruit during the season.
2. Reduction of enzymatic browning and non enzymatic browning of the juice and cordial, during processing.
3. Preservation of jack fruit pulp for the off season, using a accurate method
4. Sensory evaluation to select the best product.

CHAPTER 02

Review of Literature

2.1. Classification

Family	:-Moraceae
Genus	:-Artocarpus
Botanical name	:-Artocarpus heterophyllus
Synonyms	:-Artocarpus integra
	Artocarpus integrifolia

2.2. Vernacular Names

Sinhala	Kos, Herali, Pana
Tamil	Murasabalam, Pilaka
English	Jack fruit
Malayasia	Jackfruit, jak, jaca
Philippines	Nangka
Thailand	Khamum
Cambodia	Khnor
Laos	Makmi or May mi
Vietnam	Mit

(Rajapaksha, 1998).

2.3. Related Species

The genus Artocarpus consists of twelve species which bear edible fruits.

Artocarpus altilis	Breadfruit
Artocarpus integer	Chempedak
Artocarpus lakoocha	Lakoocha
Artocarpus nitidus	Butong

Artocarpus rigidus	Monky jackfruit
Artocarpus sericicarpus	Pedalai
Artocarpus ansiophyllus	Entawak
Artocarpus kemando	Padau
Artocarpus sarawakensis	Pingan
Brosimum alicastrum	Breadnut
Brosimum gaudichaudii	Mama – cadela
Pourouma cecropiaefolia	Amason Tree Grape

2.4 Varieties

Two principle types of fruit have been recognized which are distinguished by the nature of their flesh, soft or crisp. The soft types are generally known as "vela" and the crisp as "waraka".The are distinguished purely on flesh characteristics.

These two types can not be morphologically differentiated until they reach reproductive maturity of the age about 6 to 8 years. The acrylamide gel electrophoresis technique can be used to differentiate "waraka" and "vela" types of jack at the seedling stage (Gunasena et al, 1996).

There is a common belief among villagers in Kandy district, that when seeds are planted with the ovary sac (outer seed cover) infact, the plants turn out to be waraka, the crisp flesh variety.

2.4.1. Vela

Less popular variety than waraka. Because of the soft flesh and higher acid content, people do not like to eat vela as a fruit.

Vela types:-

- **Gop vela**

  Contain very sweet taste pulp.

- **Kakiri vela**

2.4.2. Waraka

Most popular variety of jack fruit. It contains hard or crisp type flesh. Waraka has high potential for processing and export.

Waraka types:-

- **Pani waraka**

  Have very sweet flesh and also known as honey jack.

- **Kuruwaraka**

  This type is clearly distinguished from the common form. A dwarf type, somewhat inferior to the others. It is reported to maintain its genetic characteristics when propagated from seed.

- **Fatherlong and Rosa kos**

  These two varieties have been selected by the Department of Agriculture.The fatherlong variety bears in 3-4 years continue for about 15-20 years. Its fruits are borne year around, weighing 7-9 kg each and flesh is firm and yellow. The fruits of rosa kos are similar, except that the flesh is light pink when cooked (Gunasena et al, 1996).

- **Singapore jack or Cylone jack**

  Another introduction is known as Singapore jack or Cyclone jack an early bearing variety. It bears in 18-36 months. It produces fruits of the crisp fleshed waraka type profusely during the "off season "from November to February. This variety was planted extensively in India in 1949.Johore jack may be a synonym for this variety .It was introduced to Sri Lanka as a result of a jack fruit planting campaign headed by Arthur V. Dias of Panadura, Sri Lanka in the early1930 s (Gunasena, 1993).

- **Ela waraka**
- **Diya waraka**
- **Hath waraka**

Other improved varieties:-

- Arthur V.dias
- They japalai
- Kundasale varanaya 1

- Gannoruwa varanaya 2
- Kuru
- Champa dena

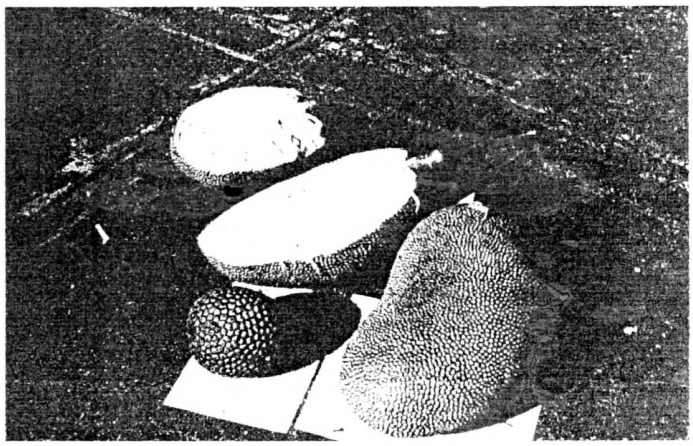


Fig.2.1.Common jack fruit and a small fruit of dwarf type ("kurukos") (Source: Gunasena et al, 1996).

2.5. Cultivars

Being cross-pollinated and mostly seed propagated, the jack fruit has innumerable types or forms considering the fruit characteristics. The types differ widely among themselves in density of spikes on the rind, bearing, size, shape, quality and period of maturity. Wide variations in sweetness, acidity, flavour and taste are observed in jack fruit growing areas. Such variations among clones offer scope for improvement of this fruit crop by Clonal selection method. Many types available under various local names have originated in this way (Rose and Mitra, 1990).

Table 2.1. Cultivars

Cultivar	Country	Characteristics		
		Fruit	Flesh	Flavor & Aroma
1).Bali Beauty	Indonesia	Elongated and Large.	Dark orange & medium firm	Excellent flavor with a sweet aroma.
2).Black Gold	Queensland,Australia	Medium sized fruit.	Deep orange & soft.Can easily removed from the fruit.	Strong sweet flavor & aroma.
3).Cheena	-	Long, narrow & uniform in size & shape.	Deep orange, & somewhat fibrous.	Excellent flavor & intense, earthy aroma.
4).Chompa Grob	Thailand	Light green to yellow colour.	Deep orange & crunchy.	Sweet rich flavor
5).Cochin	Australia	Small & smooth	Firm & mild with little latex.	Little flavor & aroma.
6).Dang Rasimi	Thailand	Bright green to pale yellow.	Deep orange & firm.	Mild,sweet flavor & sweet aroma.
7).Golden nugget		Small, green & rounded.	Deep orange flesh is soft to medium firm.No fibers.	Excellent flavor
8).Honey gold	Queensland, Australia	Black,dark green fruit.	Dark yellow to orange & firm	Sweet flavor with strong sweet aroma.
9).J-30	Malayasia	Uniform & hang singly on the major limbs.	Deep orange & firm.	Rich & sweet with only a slight aroma.
10).J-31	Malayasia	Large & irregular shape.	Deep yellow & firm with thick walls.	Sweet flavor with strong earthy aroma.
11).Kun Wichan	Thailand	Uniform & rounded.	-	Mild flavor with no aftertaste.
12).Lemon Gold	Queensland, Australia	Bright green & blacky.	Lemon yellow , thick walled & firm.	Sweet & aromatic flavour.
13).NSI	Malayasia	Dark green & blacky.	Dark orange & firm.	Rich & sweet taste.
14).Singapore	Singapore	Medium size & dark green color.	Firm & dark orange color.	Excellent rich flavour.
15).Sweet fairchild	Florida	Large size & light green to yellow.	Light yellow & firm.	Mild & sweet flavor.
16).Tabouey	Indonesia	Long ,thin & tapered at the stemend.	Firm & pale yellow color.	No aroma & mild & pleasant flavor.

Source: Rose and Mitra 1990.

2.6. Origin and Distribution

2.6.1. Origin

The jack fruit is believed indigenous to the rain forests of the western Ghats of India.

2.6.2. Distribution

It spread early on to other parts of India, Southeast Asia, and the East Indies and ultimately the Philippine. It is often planted in central and eastern Africa and is fairly popular in Brazil and Surinam. The major jack growing countries are Bangladesh, Burma, Brazil, India, Indonesia, Nepal, Philippine, Thailand and Sri Lanka.

2.7. Description

2.7.1. About plant

Jack fruit is a large evergreen monoecious plant, that reaches 20m hight.The trunk is relatively short and straight, bearing thick branches. The bark is thick, blackish and deeply cleft when old. The stem is straight and cylindrical. The bark is smooth or slightly rough, green or black, 1.25cm thick, exuding a milky latex.

2.7.2. About leaves

The leaves are dark green and shiny. Old leave burnt-orange; fall thought the year. The leaves are simple, alternate 10-20cm long elliptic or obviated, acuminate entire or those of the young shoots sometimes lobed, dark green and shining on the upper surface , rather rough beneath, base narrowed, main nerves 7 or8 pairs, petiole 1.2-2.5cm long, stipules large, glabrous soon caduceus (Rose and Mitra, 1990).

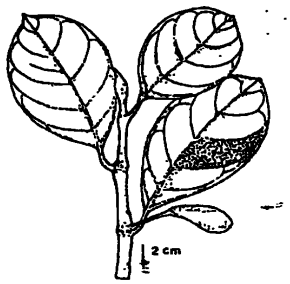


Fig.2.2. Stem with leaves and female inflorescence of ***Artocarpus heterophyllus*** (Source: Gunasena, 1993).

2.7.3. About flowers

Male and female flowers are borne in separate flower-heads are on new wood among the leaves or above the female. They are swollen, oblong, from an inch to four inches long and up to an inch wide at the widest part. They are pale green at first, and then darken. When mature the head is covered with yellow pollen that falls rapidly after flowering.

The female heads appears on short, stout twigs that emerge from the trunk and large branches, or even from the soil-covered base of very old trees. They look like the male heads but without pollen, and soon begin to swell. The stalks of both male and female flower-heads are encircled by a small green ring (Rajapaksha, 1998).

2.7.4. About fruit

Large, globes or cylindrical 30-75cm long 15-30cm broad, hanging on short stalks from the trunk and larger branches. The rind is pale green to dark yellow and covered with short, sharp, hexagonal, fleshy spines. The interior consists of large edible bulbs of yellow, banana flavored flesh that enclose a smooth, oval, light-brown seeds. A well-ripe fruit emits a very pleasant smell, has a sweet taste and the flesh is waxy and golden-yellow in color.

2.7.5. About seeds

The seed is kidney-shaped and has thin, white coraceous smooth testa.Each fruit can contain between 100 and 500 seeds. The seed is ¾ to1½ inches long and ½ to ¾ inches thick and is white and crispy within. Seeds are viable for no more than three or four days.

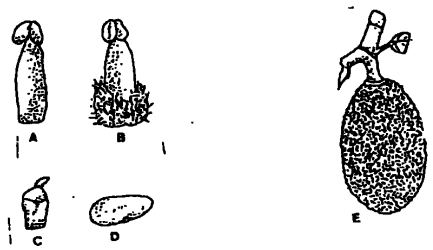


Fig.2.3. A.heterophyllus-floral parts and young fruit A. Stamen B. Male flower C.Female flower D. Seed E.Young fruit (Source: Gunasena, 1993).

2.8. Cultivation

2.8.1. Ecology, Propagation and Planting

2.8.1.1. Ecology

Jack fruit is found in association with permanent human settlements throughout Sri Lanka, especially in the portion which lies between the wet low land, coastal belt, the dry flat country and the mountains. This ecological zone is frequently referred to as the "Intermediate zone" representing a transmission between the wet tropical rain forest of the South and Southwest, the dry evergreen forest of the Northwest, North & East and the mountain vegetation of the central mountain group. This zone includes a small area in the province of Uva around Badulla but its most extensive range is a rough triangle of approximately 493km^2, with Kurunegala (North-Western province) Kegalla (Sabaragamuwa), and Giriulla (North-western province) as the apices.

Artocarpus heterophyllus can grow on a variety of soil, provided they are well drained. It grows best on deep alveoli soils and in areas with heavy rainfall. In areas with less than 1,250mm annual rainfall, irrigation is essential for good growth. In shallow limestone soils it will grow more slowly and not as tall. It is sensitive to frost in its early life and cannot tolerate either drought or "wet feet". If the roots tough water, the tree will not bear fruit and might even die (Gunasena, 1993).

2.8.1.2. Propagation

By seeds

The most common method of propagation of jack fruit is seeds. Generally 4-5 seeds are planted *in situ* so that the tap root can grow undisturbed. Germination requires 3-8 weeks but is expedited by soaking seeds in water for 24 hours. After one or two years the seedlings are planted at site.

The seeds germinate satisfactorily in coconut husk containing enough soil to cover the seed and out planted with the husk. Small bamboo pots or plant baskets may also be used but young seedlings do not remaining healthy for more than a month in such containers. Seed germination is hypogeal. The laterals distributed down the main root.

Different types of growth regulators have been used to improve seed germination in jack fruit. Giberalic acid (GA) has been shown to improve seed germination and shoot growth.

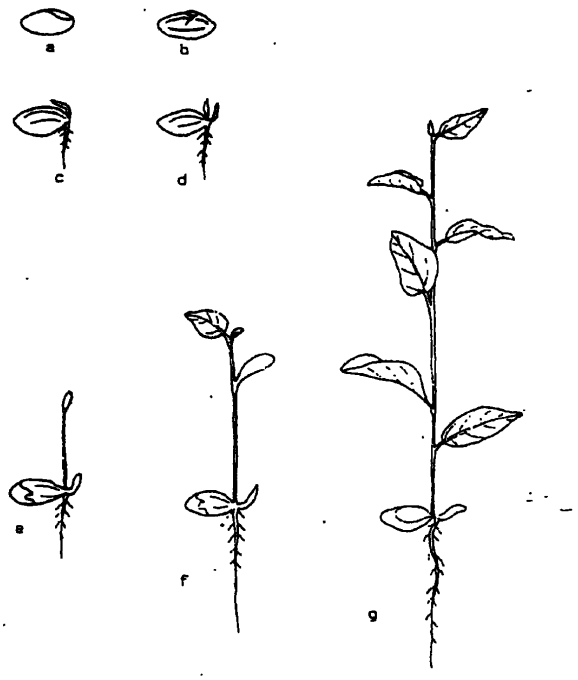


Fig.2.4. *A.heterophyllus* Stages in germination:
a = Seed; b – d = Germination stages; e – g = Development of seedling to end of first season (Source:Gunasena, 1993).

Vegetative

A number of vegetative propagation methods have been attempted by different workers. But the plants were not superior to the seedlings although they could reproduce true to the type.

- Cutting

  Around 84% success in rooting of cutting by etiolating and forcing of shoots followed by treatment with 5000ppm IBA, and then keeping under a mist.

- Air layering

  About 100% successes in rooting of air layers. Treatment with IBA markedly improved the root formation.

- Grafting

  There are two types known as inarching and epicotyl grafting.

- Budding

  Several methods of budding tried at different research stations have been proved to be successful.

  - Forkert budding
  - Chip budding
  - Putch budding (Rose and Mitra, 1990).

2.8.1.3. Planting

Commonly, the square system is followed for planting. In fertile soil spacing up to 12m*12m accommodating 70 plants per hectare will suffices for this field crop. For planting jack fruit, 1m cube pits are dug at least 10 days before planting. About 30kg well –rotten farmyard manure and 500g superphospate are mixed with the soil of each pit and the pit is refilled. After planting, the soil is pressed firmly to avoid water-logging in pits during rainy season.

The best time for planting grafts or seedlings is June through August. Prolonged dry weather after planting may lead to the death of plants.The taproot should not be disturbed while planting to avoid damage to plants (Rose and Mitra, 1990).

2.8.2. Stage of maturity

Jack fruit mature 3 to 8 months from flowering. When mature, there is usually a change of fruit color from light green to yellow brown. Spines,

closely spaced, yield to moderate pressure, and there is a dull, hollow sound when the fruit is tapped. After ripening, they turn brown and deteriorate rather quickly.

The stages of maturity at which fruits are harvested depend on the intended use. When used as a vegetable, immature fruits are picked when they are rather dark green. The production of a dull, hallow sound when tapped is considered as the most reliable indicator that the fruit is mature but not ripe. Harvesting at this stage permits fruits to be handled and distributed to distant markets or held for longer periods before consumption.

2.8.3. Harvesting

Harvesting is done at various levels of maturity as immature or mature or ripe according to the needs of the people. Plucking of fruit is done by men who climb the trees. Fruits available at lower height are plucked by women using long poles. A good tree yields 400-700kg per annum.

2.8.4. Storage

Cold storage trials indicate that ripe fruits can be kept for 3 to 6 weeks at 52^0 to $55f^0$ and relative humidity of 85% to 95%.Sun dried segments and seeds (Atukos) can be stored more than a year. It is a very good source of food for off-season. Heaping seeds covering with a dry layer of sand (welikoseta) can be kept for more than 6 months. Mature (kos) and ripe (waraka) segments are canned and stored for a long time (Rajapaksha, 1998).

2.8.5. Insect pest and diseases

No serious diseases have been observed on jack fruit. However, several fungal diseases and borers are found on it mostly in humid areas.

Table 2.2. Diseases

Diseases	Nature of damage
(1). Die back disease of tree (*Erwinia carotovoara*)	Infection occurs in mature trees as well as seedlings. The bacteria attack the upper growing shoots which gradually spread downward and killed the trees.
(2). Fruit rot (*Rhizopus artocarpi)* (*Rhizoctonia solani*)	Fruit rot diseases occurs during flowering stage, mature stage, and post harvest stage. Fruit drops off early stage of infection. At maturity the fruits rot completely.

Source: Rose and Mitra, 1990

Fig.2.5. A diseased jack fruit tree (Suspected fungus)

(Source: Gunasena, 1993)

Although a number of pests are known to attack jack fruit, the most important are described below.

Table 2.3. Insect pests

Insect pest	Nature of damage
(1). Fruit and shoot borers (*Ochyromera artocarpi)* (*Diaphania caesalis*)	Caterpillar makes tunnels into buds, young shoots and fruits. Infestation during flowering stage causes fruit drop. At mature stage infestation increase and as a result, it fetches less price in the market.
(2). Trunk and bark borers (*Batocera rufomaculata)* (*Indarbela teraonis*)	Insects make tunnels inside the trunk. Secondary infestation by fungus also causes damage of the whole trunk. The insects feed on bark also.
(3). Mealy bug (*Planococcus lilacinus)*	Mealy bugs feed on saps. Hot and less humid environmental condition is favors infestation to seedlings.

Source: Rose and Mitra, 1990

A root disease of A.heterophyllus has been reported recently on Sri Lanka. According to available information, fruit growth is arrested at the initial stages and shrivels while leaves turn yellow. Gradually the base of the stem appears wet, as if under fungal attack. Later, the bark, root and the entire tree dies (Gunasena, 1993).

2.8.6. Fruit bearing habits

There are three major fruit bearing habits in jack fruit. Those are,

- **Fruit bearing on the trunk of ground level**

Fig.2.6. Fruit bearing on the trunks at ground level

- **Fruit bearing on the secondary and tertiary branches**

Fig.2.7. Fruit bearing on the secondary and tertiary branches

- **Fruit bearing on the main trunk and branches**

Fig.2.8. Fruit bearing on the main trunk and branches

2.8.7. Nutritional value

The jack fruit is essentially, a carbohydrate food and is useful as a source of energy. The perianthes is rich in sugars, contain carotene but is low in vitamin C. Protein, fat, calcium, phosphorus and iron present in quantities similar to those found in other fruits (See App.04 & 05).The sugars present are fructose (1.74%), glucose (5.96%) and sucrose (6.9%).The typical composition of the edible parts of the jack fruit is shown in table2.4 and 2.5.

Table 2.4. Composition of 100 g of the edible portion of jack fruit pulp.

Element	Amount
Water (%)	72
Food energy (cal)	98
Protein (g)	1.3
Fiber (g)	1.0
Ash (g)	0.0
Calcium (mg)	22.0
Phosphorus (mg)	38.0
Sodium (mg)	2.0
Potassium (mg)	407.0
Thiamine (mg)	0.03
Niacin (mg)	4.0
Ascorbic acid (mg)	8.0

Source: Gunasena et al, 1996.

Table 2.5. Composition of the edible parts of jack fruit

Element	Edible parts		
	Tender	Ripe	Seeds
Moisture (g)	84.0	76.2	64.5
Protein (g)	2.6	1.9	6.6
Fat (g)	0.3	0.1	0.4
Carbohydrate (g)	9.4	19.8	25.8
Fiber (g)	2.8	1.1	1.5
Calcium (mg)	30.0	20.0	50.0
Phosphorus (mg)	40.0	41.0	97.0
Phytin P (mg)	-	0.5	1.5
Iron (mg)	1.7	0.5	1.5
Carotene (mg)	-	175.0	10.0
Thiamine (mg)	0.05	0.03	0.25
Riboflavin (mg)	0.2	0.4	0.3
Vitamin C (mg)	14.0	7.0	11.0
Minerals (g)	0.9	0.9	1.2
Energy (kcal)	51.0	88.0	133.0

Source: Gunasena et al, 1996

The seeds are mostly starchy, but contain moderate amount of protein, calcium and thiamin and have high pectin content.

2.8.8. Therapeutic value

The intriguing jack fruit is extremely nutritious and medicinal.

- The bark of the jack tree is used mainly for medicinal purposes including sprains and fractures.
- Nursing mothers are given "polos" and boiled jack to increase milk.
- Polos curry also helps those recovering from diarrhea.
- "Vela" or the soft ripe jack is a laxative which can be eaten as it is. It helps clear the bowels and assists in digestion.
- It also helps relive bronchitis when kept in bees honey and given to the patient each morning.

- "waraka" or the hard jack variety is beneficial to diabetic patients. The leaves are dried, powdered and made in to a coffee- like drink to be given to diabetic.
- The leaves are used in skin diseases.
- Roots are used for diarrhea and fever. The roots are also used for skin diseases and as an antiasthmatic.
- The milky and juicy stuff mixed with vinegar is applied for healing of abscesses and snake bites and reduce glandular swelling.
- The starch from the seeds is given in bilious colic and the roasted seeds have an aphrodisiacal action.
- An infusion of the mature leaves and barks is given for stones in the bladder.
- Ash of the leaves is useful in healing ulcers.
- The leaves can be made in to poultices by heating and placing them on wounds.
- The wood has a sedative property and its pith is said to induce abortion.
- The latex shows bacteriological activity equal to that of papaya latex.
- An extract of the seed stimulates the heart and cause a fall in arterial blood pressure.
- The seed also demonstrate inhibitory action against trypsin and chymotrypsin.
- Crushed inflorescence is used to stop bleeding in open wound.
- A tea made with dried and powdered leaves is taken to relieve asthma (Rajapaksha, 1998).

2.9. Non food uses of different plant parts

2.9.1. Timber

Jack fruit timber is used for making high quality furniture and house construction (door, windows, and roof rafters) as well as mats, oars, implements and musical instruments like violin and tambooras. Roots of old trees are greatly prized for wood- carving and picture framing. In Sri Lanka, the Dutch it extensively in their buildings and cabinet work. Jack fruit is golden

– brown coloured, termit resistant and greatly valued for furniture and also yields a yellow dye (Rajapaksha, 1998).

2.9.2. Bark

Bark from the main trunk contains betulinic acid and two flavanone pigments, cycloheterophyllin ($C_{30}H_{30}O_7$) and isocycloheterophyllin (yellow needle). The bark also contains 3.3% tannin. It is used in dying and taning .Also bark yields a fiber that can be used to make roper.

2.9.3. Latex

Jack fruit exudes a latex which displays bacteriolytic –activity. Latex drawn from young shoots has greater bacteriolytic –activity four times as much. The latex from the fruit contains cycloartenone, cycloartenol, butyrospermol and the amino acids leucine, isoleucine, tripsine and valine. Bark latex contains a large amount of resins (85%) which is valuable in manufacturing varnish. The resinous latex is used to mend earthenware, water containers, pitches and dry pots (Gunasena et al, 1996).

2.9.4. Other non food uses

- Jack fruit can be used as a shade tree species in coffee, areca nut, cardamom and pepper.plantation.
- Wood yields a yellow dye when chips are boiled. Buddhist priests use this to color their robes.
- The tree may be used as a.living support for pepper (*Piper nigram*)
- Dining plates are made by stitching the leaves together.
- As it is an evergreen, considerable little fall occurs throughout the year, forming good mulch and enriching the soil.
- In India and Nepal, flowers and fruits are offered to Lord Vishnu on the eleventh day of the full moon of shravan from July to August (Gunasena, 1993).

2.10. Food uses of the different parts of jack fruit

Jack fruit is called "rice tree" due to its vast importance as a source of food. Jack could be used to prepare over a hundred traditional dishes, in addition 40 to 50 types of food items could be produced from jack using modern technology.

2.10.1. Fruits

Fruits are valuable food items which are eaten at various stages of their maturity. They are called by different names in Sinhalese at different stages of their maturity.

- Young immature fruits are called as "polos"
- Mature fruits are called as "kos"
- Ripe fruits are called as "waraka or vela"

2.10.1.1..Polos (Immature fruit)

There are many dishes and sweets made from "polos".These may vary from area to area locally and by country to country, but there are several popular food recipes used by the Sri Lankans. Those include,

1) Polos embula -A curry made from immature fruit
2) Polos melluma - Thinly chopped jack axils cooked with scraped coconut
3) Polos achcharu – Chutney like dish
4) Polos omelet - A curry prepared by egg and jack
5) Polos and macaroni
6) Polos pethi embula
7) Polos salad
8) Caned polos

2.10.1.2. Kos (Mature jack)

1) Jack bulbs are sun dried, either boiled or raw. It is important to note that no washing is done at any stage

in processing. If washed, it will increase the moisture content resulting negative effect on sundrying.

2) Tender jack can be pickled.
3) The bulbs of the mature fruit (kos) is cut and boiled with the seed and eaten with coconut and gravy.
4) It is also cooked as a curry with coconut milk and condiments added.
5) Tender fruit (kos) can be cooked as mellum without addition of coconut.
6) Can dehydrate in to thin, round papadam.
7) Salter unripen flakes may also be fried in ghee or oil for use as chips.

2.10.1.3. Waraka/Vela (Ripe jack)

Tender segments of ripe fruit have an aromatic flavour are sweet in taste.

1) Bulb and rind has sweet aromatic odour and can be used as ingredient of ice cream, candies and other form of dessert.
2) Ripe jack can be kept for a long time by the air tightning method of covering it with a mud coating.
3) Canned fruit, syrups, jam, jelly and candy are produced by using ripe jack portion and also jack puree can mixed with banana and mango.
4) Ripe flakes can be bottled after mixing with sugar and honey.
5) Alcoholic beverages can be made by fermenting and distilling the perianthes.

2.10.2. Seeds

1) When roasted, jack fruit seeds are delicious, similar to roasted chestnuts.
2) Seeds can also be fried and salted serving as companion to drinks.

3) The seeds are eaten boiled or roasted after soaking in syrup.
4) A starch flour is also made out of the seeds.
5) The seeds are also eaten boiled or roasted with coconut or with jaggary.
6) The unspoilt seeds are also preserved in earth and store corner of the kitchen to be boiled and eaten as a food called "velikoseta".

2.10.3. Fruit rind

The rind is fibrous and rich in pectin and calcium. It has good jelling properties. It contains colorless oil whose odour resembles that of the fruit. The outer rind of the fruit is relished by cattle. Generally, jack fruit rind is superior to green grass, which it can substitute to a great extent.

2.10.4. Leaves

Young leaves are eaten as a green vegetable and can also be prepared "koskola papadam" by putting jack leaves in oil. This is somewhat similar to the papadam. Apart from its many culinary uses, jack fruit produce useful fodder which seems to be particular relished by goats (see App.05). The leaves and rind of the fruit are excellent source of fodder (Gunasena, 1993).

2.11. Fruit pulp

2.11.1. Characteristics of pulp

The pulp constitutes 25-40% of the fruit's weight and rich in vitamin C. Hydrolysis of the fruit pulp produces rhamnose, xylose, arabinose, glucose, galactose, galacturonic acid and pectic acid. The fruit pulp is also contains beta-carotene (240mg/100g) and when kept at 25-30C^0 for 6 months, shows retention of 97%. Beta-carotene is vital for preserving jack fruit and making it available during off seasons and at places away from centers of production.

The nutritional composition of fruit pulp is given below.

Table 2.6. Composition of fruit pulp

Element	Amount
(1). Calories	98
(2). Moisture	72.0- 77.g
(3).Protein	1.3- 1.9g
(4). Fat	0.1- 0.3g
(5). Carbohydrate	18.9- 25.4g
(6). Fiber	1.0- 1.1g
(7). Ash	0.8- 1.0g
(8). Calcium	22mg
(9). Phosphorus	38mg
(10). Iron	0.5mg
(11). Sodium	2mg
(12). Potassium	407mg
(13). Vitamin A	540I.U.
(14). Thiamin	0.03mg
(15).Niacin	4mg
(16). Ascorbic acid	8-10mg

Source: Dias, 1997.

2.11.2. Uses of fruit pulp

Squash, toffee and jack fruit nectar can be made from the pulp.

2.11.2.1. Previous studies of cordial

Two studies have been reported according to the preparation of cordial and other types of products such as jam, chutney and preserves.

(1). Vela cordial

Preparation of cordial from vela/ waraka pulp was studied at the Department of food sciences and technology, Faculty of agriculture, University of Peradeniya, by S. Ekanayake (Abesinha, 1991).

Method is given below.

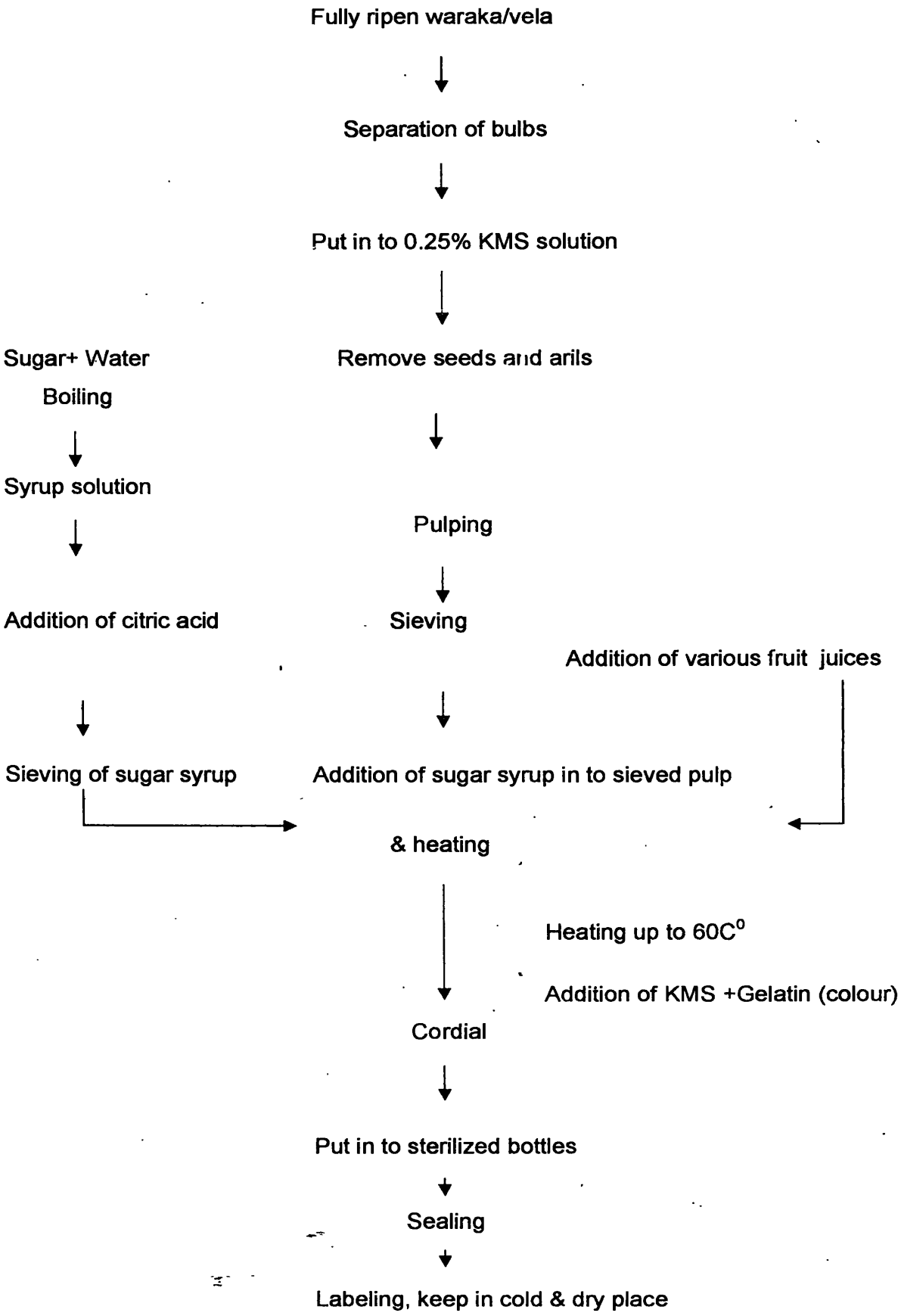

Fully ripen waraka/vela
Separation of bulbs
Put in to 0.25% KMS solution
Sugar+ Water
Boiling
Remove seeds and arils
Syrup solution
Pulping
Addition of citric acid
Sieving
Addition of various fruit juices
Sieving of sugar syrup
Addition of sugar syrup in to sieved pulp
& heating
Heating up to 60C0
Addition of KMS +Gelatin (colour)
Cordial
Put in to sterilized bottles
Sealing
Labeling, keep in cold & dry place

Table 2.7.Ingredients for 1Kg of waraka or vela pulp

Vela/ waraka pulp	1Kg
Sugar	1.8Kg
Water	1.3Kg
Citric acid	35g
Gelatin	0.6g
KMS	100mg

Shelf life: - More than 8 months.

(2). Some processing methods of jack fruit and characteristics of processed products.

This research was conducted by L.R. Sathasivam, G.Ravindran and S.Ekanayake at the Department of food sciences and technology, Faculty of agriculture, University of Peradeniya (Abesinha, 1991).

Method of cordial preparation:-

Fruits were cut and bulb was separated. The seeds and the thin covering (ovary walls or carpel) were then removed by slitting the bulb.

Cut pieces of the bulb were softened by gentle heating in about half there weight of water. While heating, the bulbs were stirred continuously and mashed in to a thin pulp. Then sieved. Sugar syrup was prepared (60^0 brix) by dissolving 1.5 Kg sugar in water and heating for 15 minutes.Ingrediaents (citric acid, syrup, pulp) Blended and strained. Then KMS was added the rate of 200ppm.

Results and discussion:-

Based on sensory evaluation, both vela and waraka varieties were found to be suitable for cordial preparation. But there is tendency for preparation towards vela. This is probably due to the lack of strong flavour in vela pulp. The taste panel also consistently preferred the taste of cordial from vela and this appeared to be related to the slight sour taste of vela pulp.

Table 2.8.Sensory evaluation scores of processed jack fruit cordial

Product	Varity of jack fruit	Sensory characters				
Cordial		Appearance	Colour	Taste	Flavour	Acceptability
	Waraka	7.17	7.16	6.25	6.58	7.00
	Vela	7.58	7.33	7.16	7.00	7.46

Source: Abesinha, 1991

The variety of fruit pulp has no effect on brix value, pH and titrable acidity of cordial.Physico chemical characteristics of fresh pulp and the processed product prepared from waraka and vela varieties given below.

Table 2.9. Physico chemical characters of fresh pulp and the processed product

Fresh pulp	Moisture	Brix	pH	Titrable acidity
Waraka	73.1	23^0	5.0	0.36
Vela	71.8	20^0	4.7	0.33
Cordial				
Waraka	-	24^0	2.7	0.6
Vela	-	22^0	2.9	0.6

Source: Abesinha, 1991

Conclusion:-

Jack fruit pulp can be successfully used for cordial preparation.

2.12. Cordial

2.12.1. Definition

Cordial is a drink that is diluted to taste with water and is thus used a little at a time. It is simply defined as a crystal – clear squashes. It normally contain at least 25% fruit pulp mixed with sugar syrup, are diluted to tastes with water and contain preservatives, because they are used in small quantities over a long period. Most accurate definition for the cordial;

"Cordial is a sparkling, clear sweetened fruit juice from which all the pulp and other suspended materials have been completely eliminated".

According to the Sri Lankan standard,

"Cordial" is a fruit drink requiring dilution before use and prepared from unfermented pure fruit juice, with or without some of the pulp and containing any soluble carbohydrate sweetener and water (SLS 214:1985).

2.12.2. Ingredients

- **Fruit ingredient**

  The fruit ingredient shall be fruit pulp or fruit juice which is free from endocarp of the fruit, seeds and skin. It shall be obtained from fruits which are wholesome, clean and of suitable ripeness. The fruits shall be free from any sign of the fermentation, insect infestation and disease. The fruit content of the products shall be not less than 25 percent by mass of the product (SLS 214: 1985).

- **Sugar**

  Cane and beet sugar are identified in technical terms as sucrose. Sucrose is a natural product of green plants, which combine carbon dioxide, water and energy of the sun. The sucrose molecule is composed of twelve atoms of carbon, twenty -two atoms of hydrogen and eleven atoms of oxygen. Sugar is white or brown colored granules of varying sizes and present in crystalline form; sweet taste; turn in to liquid when boiling; soluble in water. Sugar is

a disaccharide, composed of one molecule of glucose and one molecule of fructose.

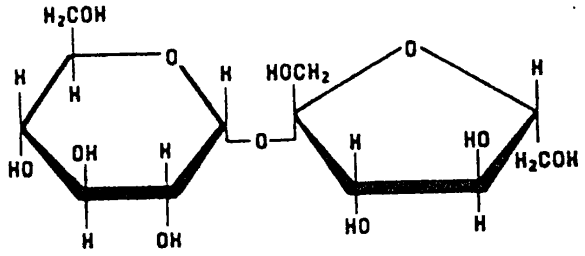


Fig.2.9. Chemical structure of sucrose molecule
(Source: Knecht, 1987)

Preservation by sugar addition:-

If a food is saturated with a highly concentrated sugar solution, it becomes unsuitable for microbial growth; lethal plasmolysis takes place in extreme cases, but the development of microbes is usually stooped in any case.

Fruit juices containing 66% or more of sugar. Sugar absorbs most of the available water with the results that the latter is nit suitable for the growth of micro organisms. Solutions with high total solids have a very low water activity coefficient in regard to growth of micro organisms. Thus sugar act as a preservative by osmosis and not as true poison for micro organisms (Kyzlink, 1990).

In addition to the preservative action, sugars have three other principle flavour functions, namely,

a) Sugars provide the sweetness necessary to balance the acid and other taste – producing components properly and thus produce a balance flavored drink.
b) Sugar furnishes sufficient body to raise the beverafe of the sweetened watery class.
c) Sugars serve to carry the flavor and thus deposit it uniformly when consumed (Jarcobs, 1959).

- **Accidulant**

  Citric acid used as an accidulant in carbonated beverages and fruit drink industry. The major reason for its wide employment is the fact that it combines well with fruity and light flavors.

  Citric acid is versatile, widely used, cheap and safe. It is an important metabolite in virtually all living organisms and is especially abundant naturally in citrus fruits and berries.

  It is practically odorless, colorless solid, forming either translucent crystals, or white granules or powder. Citric acid has a pleasant sour taste and a flavour reminiscent of lemon. It can be prepared synthetically but most commercial citric acid is made by a fungal fermentation of sucrose and some is obtained by extraction from lemon, limes and pineapples.

  Citric acid used in clarifying sugar syrup and also in preventing the syrup from crystallizing on cooling. It should be used in very small quantities as other wise the syrup will taste sour (Jacobs, 1959).

- **Preservatives**

  Sodium metabisulphite (Na_2O, $2SO_2$ or $Na_2S_2O_5$) is commonly used stable source of sulphur dioxide. Being a dry chemical, it is easier to use than liquid or gaseous sulphur dioxide. Sodium metabisulphite is a crystalline salt and is fairly stable in neutral or alkaline media.

  When it is added to the fruit juice or squash, the sodium radical reacts with the acid of the juice forming the corresponding sodium salt, and the sulphur dioxide, which is liberated, forms sulphurous acid with the water of the juice. The reaction involved is as follows;

$$*3Na_2O.\ 2SO_2 + 2\begin{matrix} CH_2.\ COOH \\ |\\ C\ (OH).\ COOH \\ |\\ CH_2.COOH \end{matrix} = \begin{matrix} CH_2.\ COONa \\ |\\ C\ (OH).\ COONa \\ |\\ CH_2.\ COONa \end{matrix} + 6SO_2 + 3H_2O$$

The preservative effect of sulphurous acid depends not on its total quantity, but on the available amount of sulphur dioxide. The combined sulphurous acid has very little antiseptic value against micro- organisms, 6000ppm of the combined form having less toxic action on yeast than 50ppm of free sulphurous acid. The undissociated H_2SO_3molecule which prevent the multiplication of yeast, and the HSO_3 ion which inhibits the growth of bacteria E.coli in concentration of 10mg per 100ml.

Pure sucrose does not combine with H_2SO_3 , but many other substances likes glucose, unidentified aldehydes and ketones, pectin, perhaps also break down products of pectin like arabonoes which are found in fruit juices have the property of combining with sulphur dioxide with the result that the effectiveness of $SO_2$is reduced. Although SO_2 can retard the development of yeast in the juice, it can not arrest their multiplication once their number has reached a high value.

The maximum amount of sulphour dioxide allowed in cordials, in 350ppm. The purity of the chemical and the SO_2content at the time of use require to be known so that the right amount of the preservative can be taken for the preservation of the product.

One great advantage of using SO_2 to preserve fruit juice and squashes is that its strong effect in retarding oxidation prevents discoloration and loss of flavour in the product (Kyzlink, 1990).

- **Stabilizer**

  Stabilizing and thickening agents are natural or chemically modified carbohydrate that absorbs some of the water that is present in food, thereby making the food thicker. Thickening agents "stabilize" factory made foods by keeping the complex mixtures of oils, acids and solids well mixed.

  Carboxy methyl cellulose (CMC) is a thickening and stabilizing agent and prevents sugar from crystallization. It is made by reacting cellulose with a derivative of acetic acid. Studies indicate it is safe. It used as a primary stabilizer in ice cream industry.

Table 2.10. Requirements for reconstituted product

S1. No (1)	Characteristic (2)	Requirement (3)
I.	Sugar content (as sucrose) , Per cent by mass, min.	5
II.	Sulfur dioxide content, mg/kg max.	70
III.	Benzoic acid content, mg/kg max.	160
IV.	Acidity (as anhydrous citric acid), per cent by mass, min.	1.0

Source: SLS 214:1985

2.13. Spoilage

2.13.1. Discoloration due to browning reaction

2.13.1.1. Introduction

The browning reactions are complex reactions which occur when many foods are processed. In some of the brown flavor is highly desirable and is intimately associated on our minds with a delicious, high grade product. Yet, in other foods, browning during processing is undesirable a forms off- flavors and dulled or even objectionable color. In canning or concentrating fruit juice, it is highly desirable to avoid browning (Meyer, 1987).

Browning

Enzymatic browning

- Occurs in many tissues whenever they are injured as a result of bruising, cutting & freezing.
- Principal reaction is the oxidation of phenols or polyphenoles by enzymes.

Prevention

- Use of an antioxidant.
- Heating destroy enzymes.
- Use of concentrated sugar solution.
- So_2 is an effective browning inhibitor.

Non enzymatic browning

- Occurs when some fruits & vegetables are processed.
- Reaction influenced by atmospheric oxygen, moisture& temperature.

Prevention

- So_2 will reduce the Millard browning reaction.

2.13.2. Contamination of fruit juice with metals

The fruit juices can be contaminated with the heavy metals during processing. The cheap source of contamination with metals are the water, pipes, pans and other utensils used in the varies manufacture processes. The product shall not exceed the limits for heavy metals given in table.

Table 2.11. Limits for heavy metals

S1.No (1)	Characteristics (2)	Limit (3)
I.	Arsenic (as As), mg/kg, max.	1.0
II.	Copper (as Cu), mg/kg, max.	20
III.	Lead (as Pb), mg/kg, max.	2.0
IV.	Tin (as Sn), mg/kg, max.	250

Source: SLS 214:1985

2.14. Packaging

2.14.1. Introduction

Packaging has been defined in several ways.

(1). A coordination system of preparing goods for transport, distribution, storage, retailing and end – use.

(2). A means of ensuring safe delivery to the ultimate consumer in sound condition at minimum overall cost (Paine, F.A. and Paine, H.Y.1992).

The basic function of food packaging is to identify the product and ensure that it travels safely through the distribution system to the consumer.

Efficient packaging is a necessary for every kind of food, where it is fresh or processed. It is an essential link between the food producer and the consumer, and unless performed correctly the standing of the product suffers and customer Goodwin is lost (Paine, F.A. and Paine, H.Y.1992).

The product shall be packed in suitable clean containers under strict hygienic conditions and the containers shall be sealed air-tight. Products packed in metal containers shall not contain sulfur dioxide. The containers may be further packed in cases as agreed to between the purchaser and supplier (SLS 214: 1985).

2.14.2. Glass bottles

The traditional glass bottles used for fruit juices and fruit juice beverages provide many advantages in particularly inertness, easy cleaning, durability and rigidity. Glass is not susceptible to mould growth and is impermeable to odour, vapors and liquids (Paine, F.A. and Paine, H.Y.1992).

2.15. Shelf life evaluation

2.15.1. Introduction

Foods are perishable by nature. Numerous changes take place in foods during processing and storage. It is well known that conditions used to process and store foods may adversely influence the quality attributes in foods. Upon storage for a certain period of time, one or more quality attributes of a food may reach an undesirable state. At that instant, the food is considered unsuitable for consumption and it is to have reached the end of its shelf life.

Shelf life determination of the new product often requires storage for significant periods and includes samples from early development stages as well as initial production runs. Through the evaluation of stored samples, potential storage problems can be identified and either eliminated or controlled before the food goes in to production (Man and Jones, 1997).

2.16. Sensory evaluation

2.16.1. Introduction

Sensory evaluation has been defined as a scientific method used to evoke, measure, analyze and interpret those responses to products as perceived through the senses of sight, smell, touch, taste and hearing (Lawles and Heymann, 1998).

Sensory evaluation is also a science of measurement. Like other analytical test procedures, sensory evaluation is concerned with precision, accuracy, sensitivity and avoiding false positive results. A good sensory test will minimize errors in measurement and errors in conclusions and decisions.

Actually, most sensory testing is performed in an industrial setting where business concerns and strategic decisions enter the picture. We can view the outcome of sensory testing as a way to reduce risk and uncertainty in decision making. In most applications, sensory tests function as risk reduction mechanism for both researches and marketing managers. Sensory tests provide useful information about the human perception of product changes due to ingredients, processing, packaging or shelf- life.

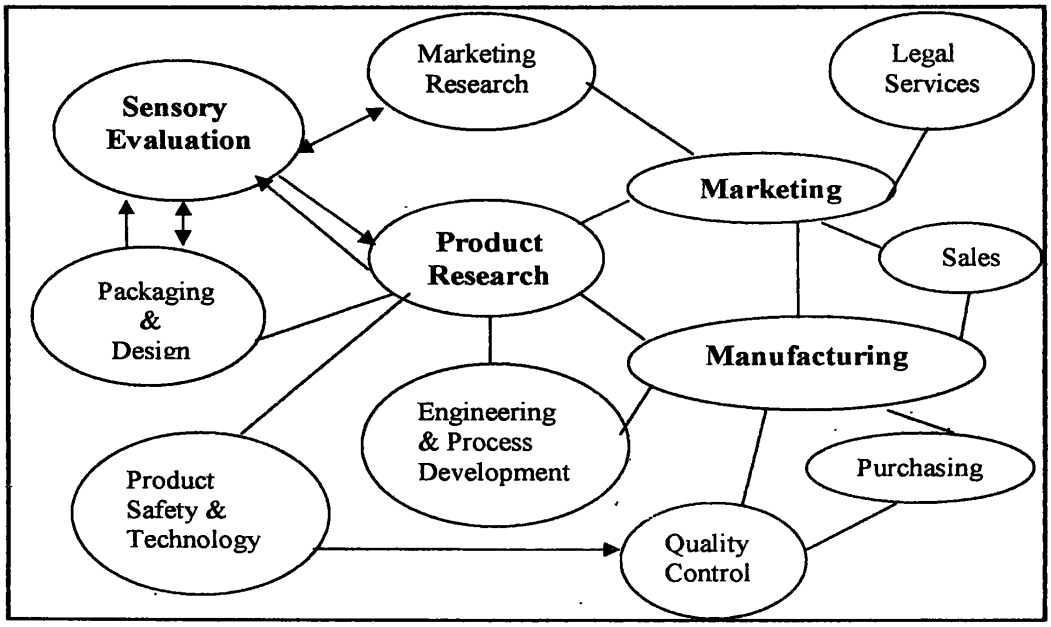


Fig.2.10. A Sensory evaluation department may interact with many other departments in a food or consumer products company. (Source: Lawles and Heymann, 1998).

2.16.2. Types of tests

Sensory evaluation comprises a set of test methods with guidelines and established techniques for product presentation and well – defined response tasks, statistical methods and guidelines for interpretation of results.

Three primary kinds of sensory tests focus on the existence of overall differences among products (Discrimination test), specification of attributes (Descriptive analysis) and measuring consumer likes and dislikes (Affective or hedonic testing).

The discrimination and descriptive procedures require good experimental control and maximization of test precision. Affective tests, on the other hand, require use of representative consumers of the product and test conditions that enable generalization to how products are experienced by consumers in the real world (Lawles and Heymann, 1998).

2.16.3. Hedonic test

Hedonic test is used in the food industry to determine acceptance of food. The major classes of sensory tests are those that attempt to quantify the degree of liking or disliking of a product, called hedonic scale or affective test methods.

This method provided a balanced 9- point scale for liking, with a centered neutral category and attempted to produce scale point labels with adverbs that represented physiologically equal steps or changes in hedonic tone. In other words, it was a scale with ruler like properties whose equal intervals would be amenable to statistical analysis (Lawles and Heymann, 1998).

2.16.4. Sensory parameters

- Flavour

  A complex group of sensations comprising olfactory, taste and other chemical sensations such as irritation or chemical heat.

- Aroma

  The fragrance or odour of a product as perceived by the nose from sniffing through the external naves. In some cultures, aroma may also refer to refronasal smell.

- Odour

  The characteristic smell of a substance.

- Texture

  Characteristic of a product perceived by the visual or tactile senses including geometric quality, surface attributes, perceived changes under deformation.

- Taste

  Specialized sense organs on the tongue and soft palate contain the receptors for our sense of taste. The sense of taste has two important functional properties that it shares with smell. These are adaptation and mixture interaction.

  (1). Adaptation → A decrease in responsiveness under conditions of constant stimulation.

  (2). Mixture interaction → A second feature of taste function is the tendency for mixtures of different tastes to show partially inhibitory or masking interaction.

2.16.5. Sensory panel and panelists

- Panel

  A group of people that comprises a test population chosen for specific characteristic such as product usage, sensory quality or willingness to participate in repeated sensory test.

- Panelist

  Generally, a participant in a sensory evaluation. Panelists cannot a participant as a member of a group that is often tested on more than one occasion.

2.17. Physicochemical properties assessment

2.17.1. Acidity

In evaluating the acidity of any beverage, two aspects must be considered. These are,

(1). The quantity aspect, that is, the total amount of available hydrogen ion present in a given volume of the beverage as estimated by a determination of the total titrable acidity

(2). The intensity aspect, that is, the apparent hydrogen ion concentration usually expressed in terms of pH.

- pH

  The symbol, pH, has been adopted for the logarithm of the reciprocal of the hydrogen – ion concentration. If the hydrogen – ion concentration (represent by [H+]) of a solution is known, the corresponding pH of the solution may be calculated from the formula:

  $$pH = \log 1/[H+]$$

  It is not really necessary to consider the meaning of pH in terms of the theory of solution. The pH numbers need only be accepted as a practical scale of acidity and alkalinity with a pH of 7.00 being the neutral point that is the point where the concentrations of hydrogen ion and hydroxyl ion are equal. Solutions in which the hydrogen – ion concentration is greater than the hydroxyl – ion concentration, that is, acid solutions, have lower pH values ranging down to 1.0 or lower. Solutions in which the hydroxyl- ion concentration is greater than the hydrogen–ion concentrations are alkaline, and the pH is expressed by higher values ranging up to 13 or 14 (Jacobs, 1959).

2.17.2. Total soluble solids

- Brix value (Total soluble solid)

  Since the amount of sucrose dissolve in water is important industrially, a whole series of measuring indices were developed to indicate the

relative proportions of the two materials. The most important of these is the Brix scale, which relates the percentage by weight of sucrose in a water solution. Therefore, 65^0Brix would represent a solution that is 65 percent sucrose and 35 percent water. The Brix scale is also used to measure solutions other than pure sucrose and water. Thus, a Brix reading will normally be used to obtain the corresponding specific gravity or refractive index of a solution that, by practice, is agreed to correspond to a solution of pure sucrose and water at a set reference temperature, usually 20^0C. Sucrose solutions will also refract light in proportion to the amount of sucrose in solution, and this refraction is used as a measure of the solution density. The measure of this refraction is called the refractive index. The instruments used to measure this variable are called refractometers (Knecht, 1987).

2.18. New food product development

2.18.1. Introduction

A simple definition for a new product might be "a product not previously marketed or manufactured by a company" (Fuller, 1994). However, this break down if one includes new packaging (shape or size) or if one enters a product in to a new market.

The definition of new food product development is "an introduction of a product not previously manufactured by a company in to the market place or the presentation of an old product in to a new marketplace or the previously explored by a company" (Fuller, 1994).

2.18.2. Why go in to new food product development?

If new food product development is fraught with so much difficulty, if it is so costly, and if it has a high rate of failure, why go in to it?

The need for new food product development can be seen to be driven by five dominant factors.

1) All products have life cycles. That is, they enter their marketplace, flourish for an indeterminate time, then die and must be replaced.
2) A company's management may adopt a policy that requires an aggressive growth programme to satisfy long- range business goals.
3) The market place may change, requiring new products more suited to respond to the changes.
4) New technology may make new food products available and new knowledge may tailor new food products more suited to the lifecycles of today's consumers.
5) Changes in government legislation, health programme, agricultural policy, or agricultural support programme may dictate that development of new food products be pursued.

2.18.3. Phases in new food product development

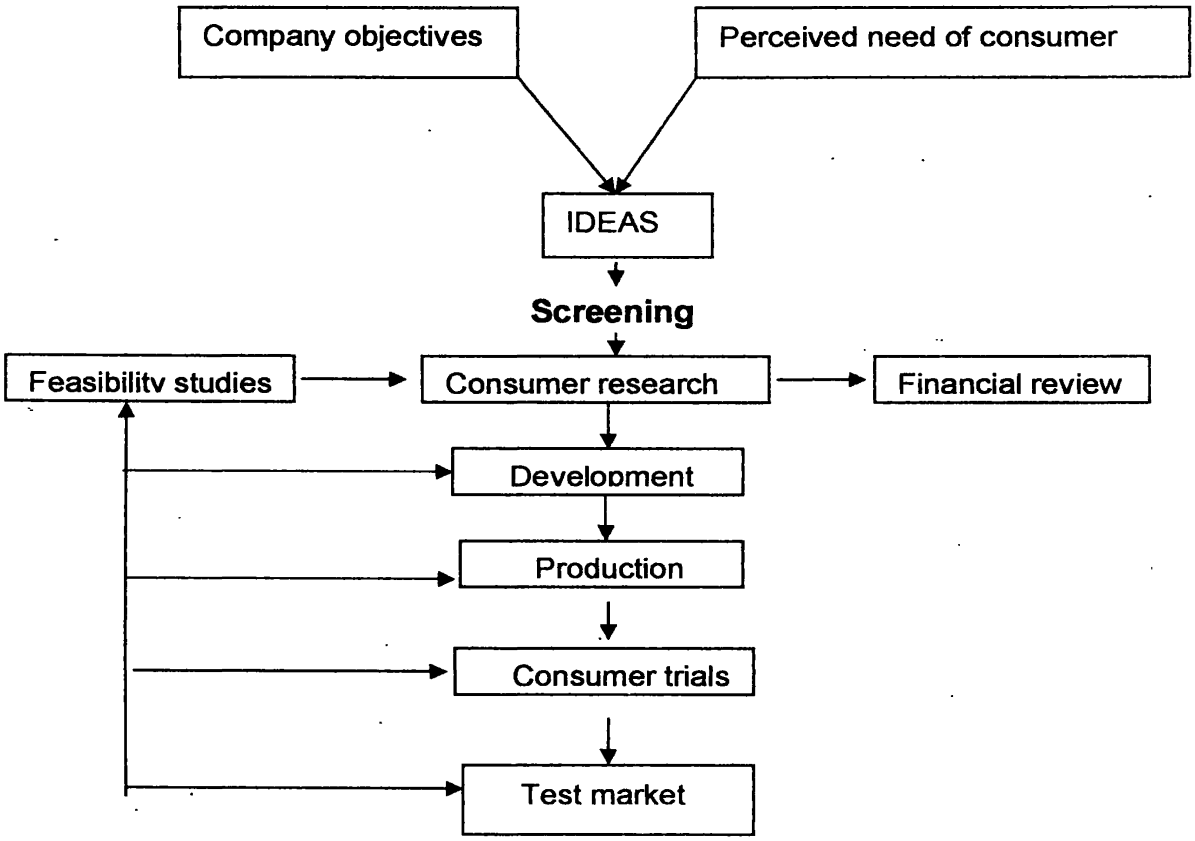


Fig.2.11. Phases in new food product development (Source: Fuller, 1994).

2.19. Market research

2.19.1. Introduction

Marketing research is studying and analyzing the market to find ways and means of satisfying customer needs profitably (Gamage and Menike, 1999).

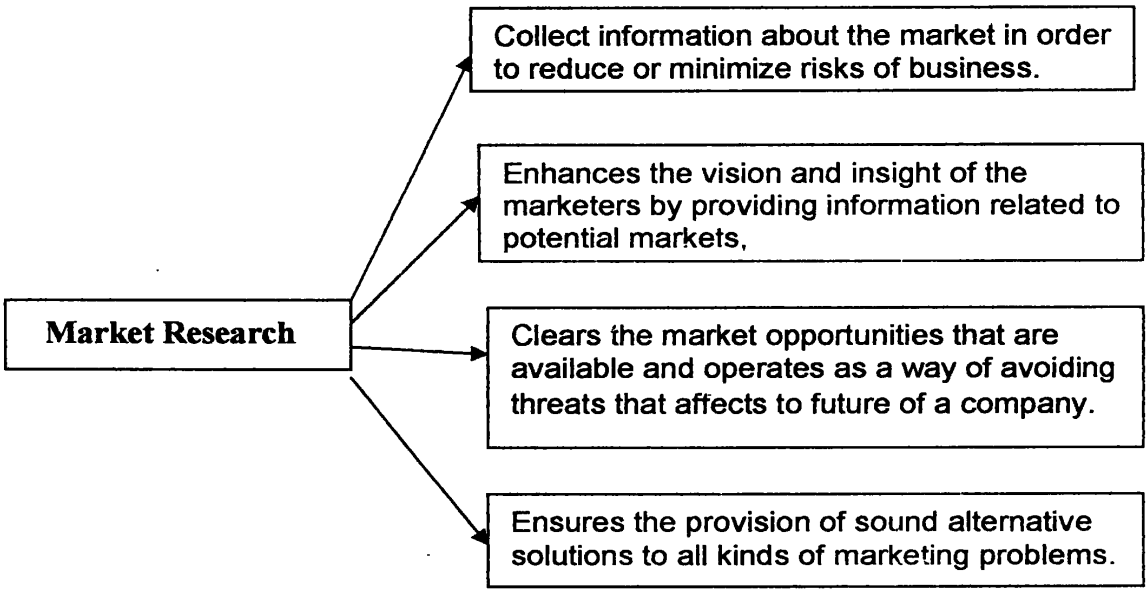


Fig.2.12. Importance of market survey

(Source: Gamage and Menike, 1999).

2.19.2. Marketing research process

Marketing research is a logical process consisting of several steps to be accomplished. The steps of this process are,

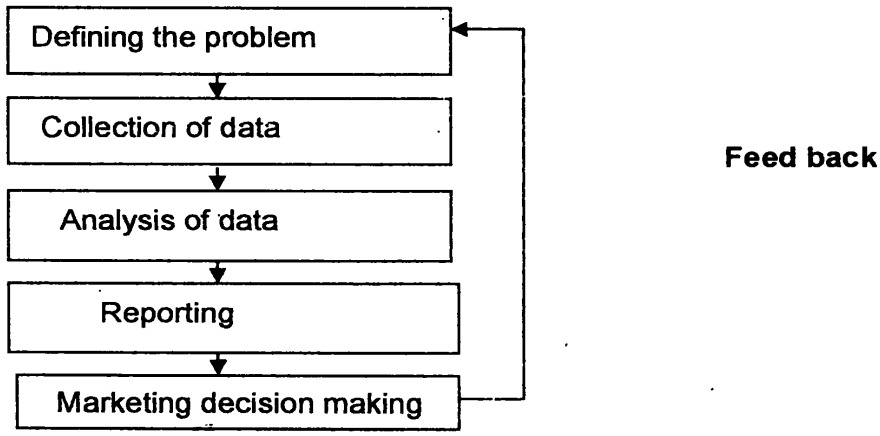


Fig. 2.13. Marketing research process

(Source: Gamage and Menike, 1999).

Within the above broad framework we can further illustrate this process with more steps as stated below.

1) Define the problem and establish the need for information.
2) Decide research objectives and information needs.
3) Determine research design and sources of data.
4) Develop the procedure for collecting data.
5) Design the sample.
6) Collect the data.
7) Process the data.
8) Analyses the data.
9) Present research results (Gamage and Menike, 1999).

CHAPTER 03

Materials and methodology

3.1. Materials

3.1.1. Materials for the market research

- Standard questionnaire

3.1.2. Materials for disinfection of jackfruit

- Stainless steal knife
- Cutting board
- Plastic tray
- Portable water
- Coconut oil
- Plastic basket

3.1.3. Materials for the preparation of sugar syrup and boiling jack bulbs with sugar syrup

Materials

- Sugar
- Portable water

Apparatus

- Refractometer (Model 10)
- Plastic wash bottle
- Gas cooker
- Stainless steel spoon
- Stainless steel sauce pan
- Electronic balance (Yamato, Japan).

3.1.4. Materials for the extraction of jack fruit juice

Materials

- Preservative
- Portable water

Apparatus

- Blender
- Spatula
- Glass
- Plastic jug
- Strainer
- Plastic tray
- Small beaker
- Thermometer (Quartz,-50C^0~+260 C^0)
- Electric sealer

3.1.5. Materials for cordial preparation

Raw materials
- Extracted fruit juice
- Sodium Meta bisulphite (SMS)
- Portable water
- Sugar
- Citric acid
- Stabilizer

Apparatus
- Electronic balance (Yamato)
- Stainless steal spoons
- Sauce pan
- Thermometer (Quartz)
- Gas cooker
- Plastic jug
- Plastic wash bottle
- Sterilized bottles and lids

3.1.6. Materials for the sensory evaluation

- Standard ballot papers
- Coded samples
- Serviettes
- Glasses of portable water

3.1.7. Materials for chemical analysis

Chemicals
- 0.1M NaOH solution
- Phenolphthalein

Apparatus
- Refractometer (Model 10)
- PH meter (Hanna, Japan)
- Burette
- Measuring cylinder
- Metal stand
- Volumetric flask
- Dropper
- Plastic wash bottle

3.2. Methodology

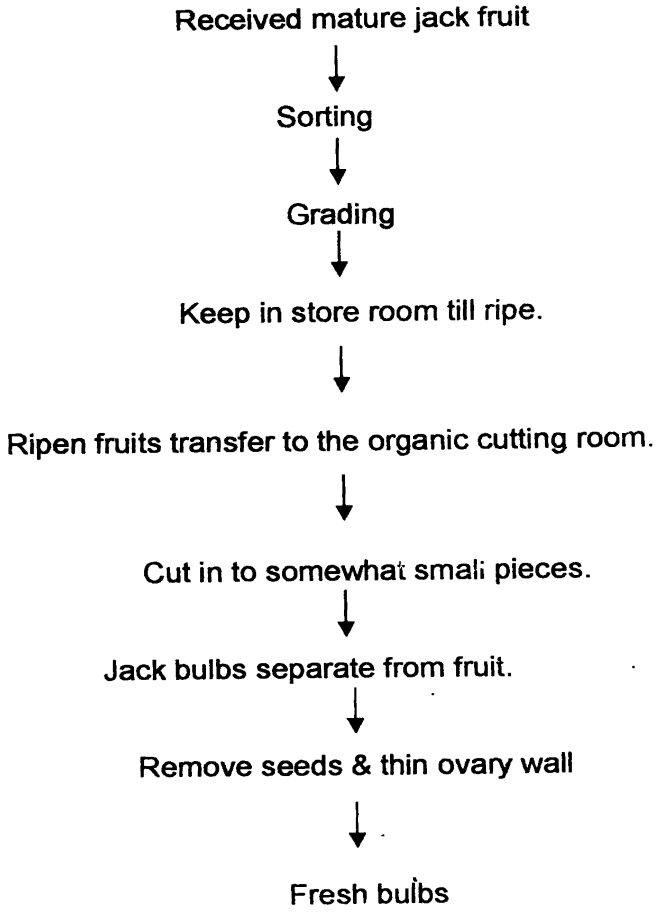
3.2.1. Preliminary marketing research

The aim of the marketing research was to look at natural jack fruit cordial through consumer's eye and to collect ideas about the preferring characters of the natural jack fruit cordial and market demand for this new product.

The standard questionnaire was prepared with simple questions that were related to the preference for the natural jack fruit cordial and most preferred character of cordial (See App.02). Then the questionnaire was

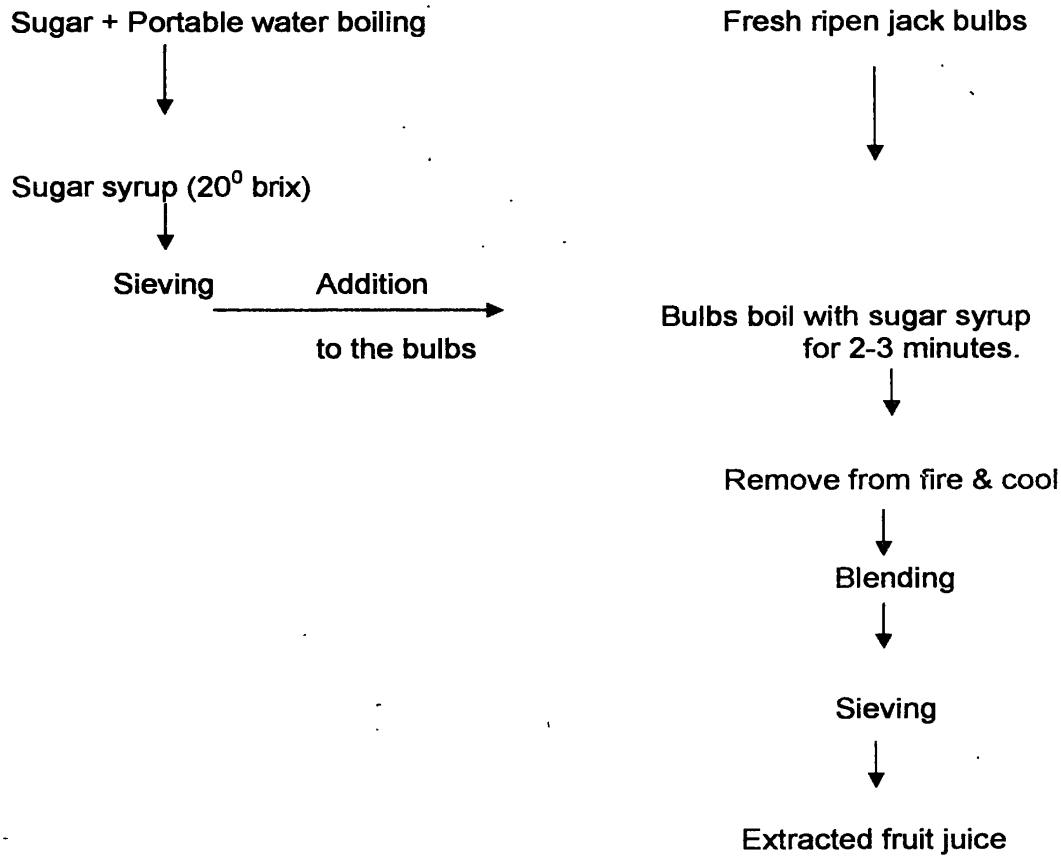
distributed among randomly selected twenty five people, who were represented different socio-economic levels (See App.06). Collected data was statistically analyzed by using Minitab software statistical package.

3.2.2. Disinfection of fruit



The natural jack fruit cordial was prepared by using jack fruit juice which was extracted from fresh jack fruit bulbs. Within 2-3 days storage period, undesirable colour and off flavour were developed. To overcome this problem, fresh jack bulbs were boiled with sugar syrup, before extraction of juice.

3.2.3. Boiling with sugar syrup and extraction of juice



Excess amount of juice were heated up to 85C^0 and preservatives were added. Then the juice was packed in suitable polyethylene bags and kept in cold room under -11C^0 temperature.

3.2.4. Formulation of natural jack fruit cordial

Basic formula was developed for the natural jack fruit cordial according to the SLS standards.

SLS standards

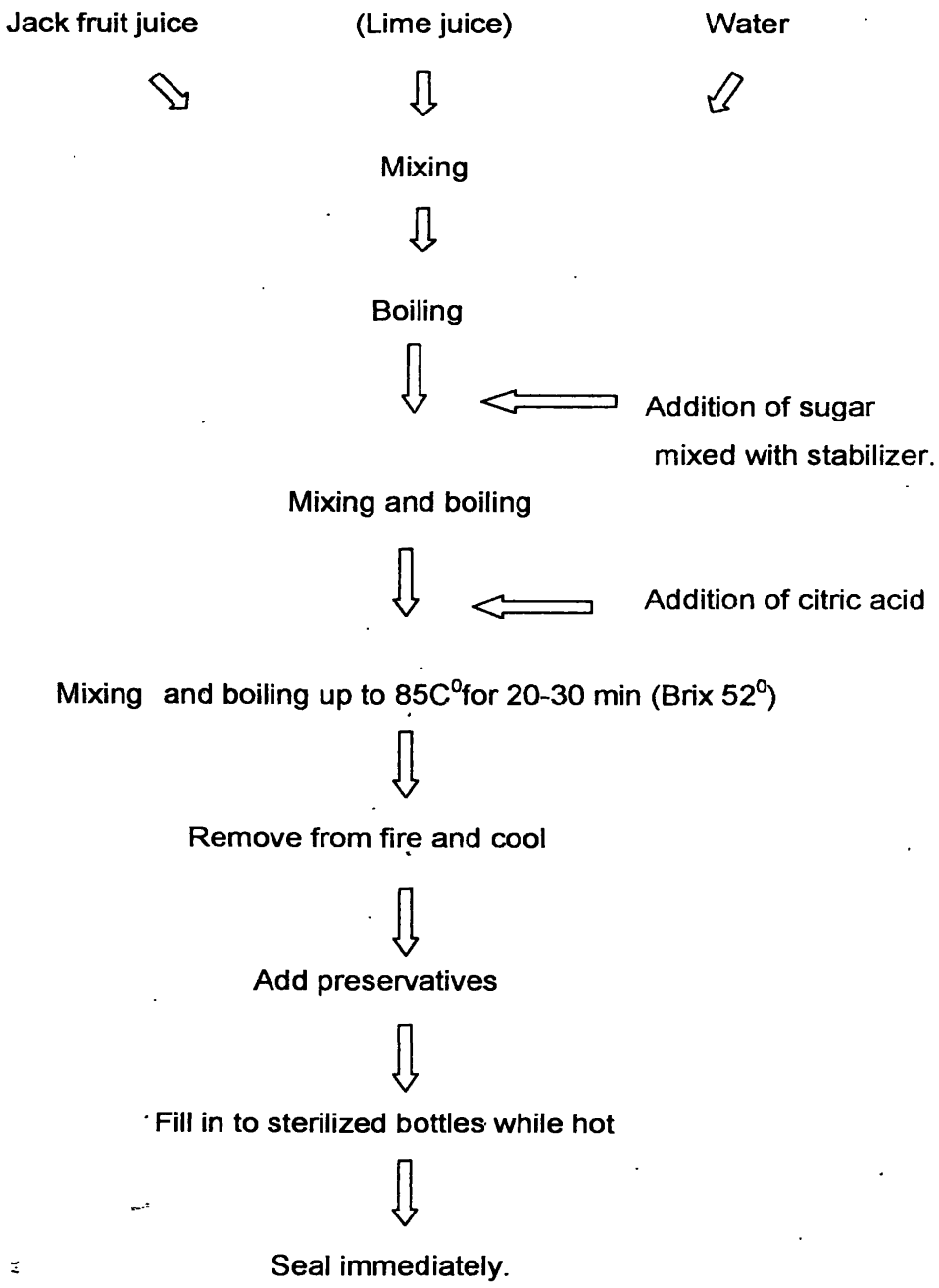
Fruit content	: 25%
Total soluble solids	: 40%
Acidity	: 1.25%
SMS	: 350ppm

The brix value of the cordial was adjusted to 52^0.

3.2.5. Development of natural jack fruit cordial

Three different samples of cordial were developed through number of trials. One sample was prepared by adding 5% lime juice as a flavour. Another two samples were prepared by changing the amount of sugar and water.

- Method for the preparation of sample .



3.2.6. Sensory evaluation

Sensory evaluation was carried out to select the best sample of cordial and to evaluate the effect of treatments (three samples) on sensory attributes.

The taste, colour, smell, appearance & overall acceptability were evaluated with thirty untrained consumer's type panelists by giving standard ballot paper. The 9 point hedonic scale was used to evaluate the degree of liking for particular sensory attributes (See App.01).

Three glasses of diluted cordials were prepared by mixing one part of cordial with three pats of portable water. The samples were coded using three digits random numbers. Coded samples, ballot papers and glasses of portable water were given for each and every panelist. Collected data were statistically analyzed by using Freedman non parametric Minitab software statistical package (See App. 07).

3.2.7. Chemical studies and shelf life evaluation of cordial

The selected best sample was analyzed for proximate composition of Titrable acidity, pH and brix, using standard methods. And also shelf life evaluation was done to selected best sample.

3.2.7.1. Chemical storage studies

1) pH

Calibration of pH meter:-

- The protective cap was removed and immersed the tip of the electrode in to water beaker.
- Stirred gently and waited until display stabilizes.
- Two buffer solutions were prepared for pH 7.0 and pH 4.0 by dissolving calibration tablets in distilled water.
- After that the pH meter was cleaned and dried and immersed the tip of the electrode in to the pH 7.0 buffer solution.
- The pH meter was calibrated to pH 7.0 by using screw type equipment.

- Then the pH meter was immersed in to pH 4.0 buffer solution and adjusted to pH 4.0.

Measuring of pH

- The protective cap was removed and immersed the tip of the electrode in to the sample.
- Stirred gently and waited until display stabilizers.
- The measurement was recorded.
- After, the electrode was rinsed with water to minimize contamination.
- Finally, the protective cap was replaced.

2) Total soluble solids

- Small amount of cordial drop was rubbed on the glass of refractometers, after cleaning it by washing with distilled water and drying by using blotting paper.
- The brix value was measured and recorded by reading the scale.
- Then the glass of refractometer was cleaned by washing with distilled water and dried it using blotting paper.

3) Titrable acidity

- About 10g of the sample was weighed to the nearest milligram and reconstituted according to label directions.
- Then it was transferred to a conical flask with 100ml of recently boiled and cooled distilled water.
- One milliliter of phenolphthalein indicator solution was added and titrated against the standard sodium hydroxide solution.
- Another portion of the sample diluted to the same proportion was used to observe the colour change at the end point (SLS: 214.1985).
- At the end point, the volume of standard sodium hydroxide required for the titration was recorded and the acidity was calculated (See App.03).

3.2.7.1. Shelf life evaluation

Shelf life evaluation was done to selected best sample. The sample was subjected to continuous assessment, to check whether any gas formation, discoloration, acid development and mould growth within 29 days storage. The physico- chemical properties were measured in sample continuously, within storage period.

CHAPTER 04

Results and Discussion

4.1. Preliminary marketing research

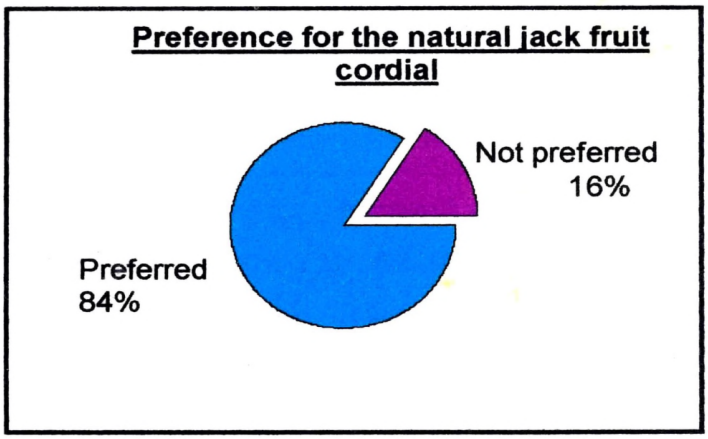


Fig. 4.1. Preference for the natural jack fruit cordial

- Around 84% of customers were preferred to buy the natural jack fruit cordial from the market, if available.

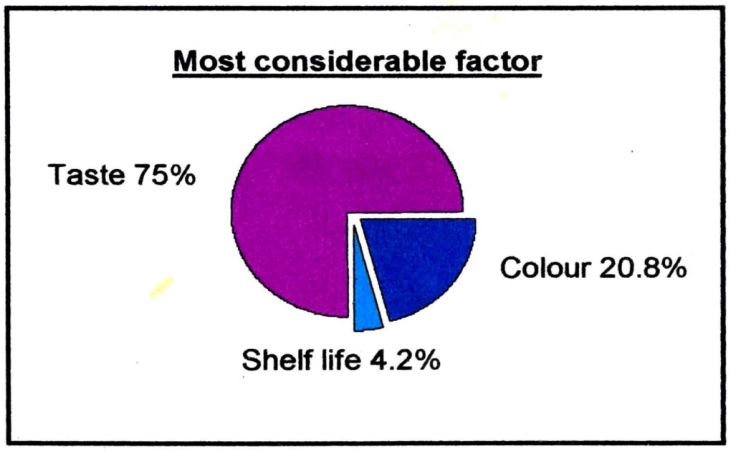


Fig.4.2. Most considerable factor

- Around 75% consumers were believed that, the taste of the cordial, as the most considerable factor, when they purchase it.

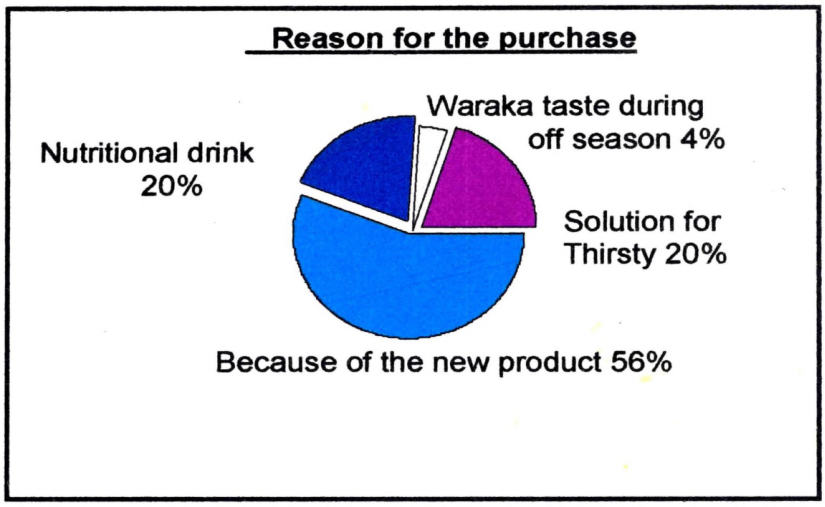


Fig.4.3. Reason for the purchase

- Around 56% consumers were preferred to purchase natural jack fruit cordial as a fruit drink because, it is a new introduction to the fruit beverage industry.

4.2. Formulation of natural jack fruit cordial

Formulated natural jack fruit cordial was appeared with uniform consistency and characteristic yellowish colour.

It was free from seeds, course particles of pulp and extraneous matter.

Table 4.1. Ingredients of formulated jack fruit cordial

Ingredients	Amount
Fruit juice	500 g
Sugar	850 g
Water	600 g
Citric acid	5 g
Stabilizer (CMC)	10 g
SMS	0.7 g

Fruit content of cordial: 25%

Brix : 52^0

4.3. Development of natural jack fruit cordial

Developed three samples of natural jack fruit cordial were appeared with uniform consistency and characteristic yellowish bright colour. They were free from seeds, course particles of pulp and extraneous matter.

Table 4.2. Ingredients of Developed jack fruit cordial

	Ingredients							
Sample	Code	Fruit juice	Lime Juice	Sugar	Water	Citric acid	CMC	SMS
Sample 01	105	825g	-	845g	210g	7g	10g	0.6g
Sample 02	227	825g	90g	845g	210g	5g	10g	0.6g
Sample 03	552	825g	-	740g	150g	7g	10g	0.6g

Fruit content of cordial: 42%-48%

Brix : 52^0

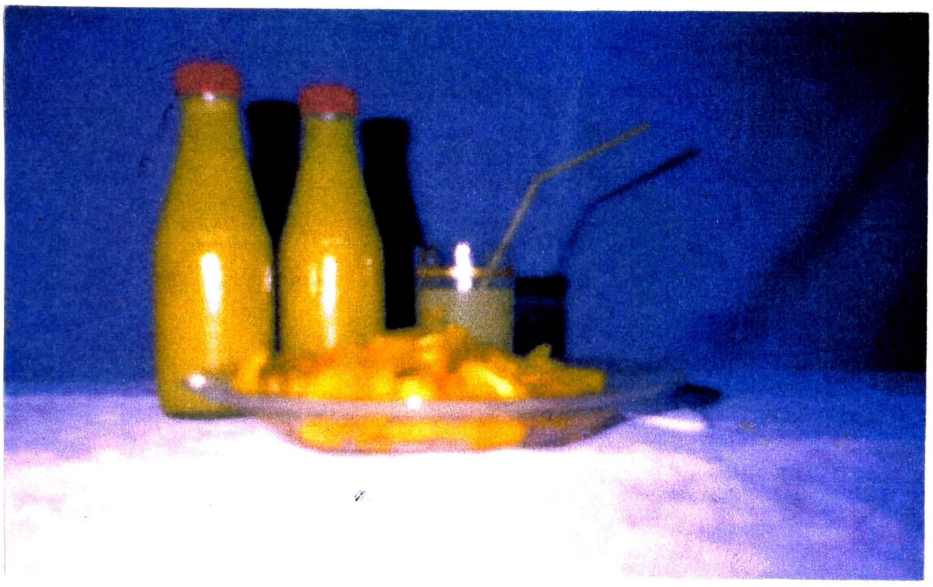


Fig.4.4.Developed jack fruit cordial

4.4. Sensory evaluation

The results of sensory evaluation conducted to determine most appropriate percentage are given in below.

4.4.1. Colour

The probability value (P=0.594) of the test was higher than the minimum probability value (P=0.05) that was required for the test to be significant. There is no significant effect of treatment with regard to colour of the samples.

Results of three samples are presented in the table.

Table 4.3. Sum of ranks for colour

Sample	Code	Colour
1	105	63.5
2	227	56.5
3	552	60.0

4.4.2. Taste

The probability value (P=0.043) of the test was less than the minimum probability value (P=0.05) that was required for the test to be significant. There are at least one treatment was significant with regard to taste. The sample code 552 gained the highest sum of rank (68.0) for taste among three samples.

Results of three samples are presented in the table.

Table 4.4. Sum of ranks for taste

Sample	Code	Taste
1	105	50.0
2	227	62.0
3	552	68.0

4.4.3. Smell

The probability value (P=0.828) of the test was higher than the minimum probability value (P=0.05) that was required for the test to be significant. There is no significant effect of treatment with regard to smell of the samples.

Results of three samples are presented in the table.

Table 4.5. Sum of ranks for smell

Sample	Code	Smell
1	105	58.0
2	227	59.5
3	552	62.5

4.4.4. Appearance

The probability value (P=0.321) of the test was higher than the minimum probability value (P=0.05) that was required for the test to be significant. There is no significant effect of treatment with regard to appearance of the samples.

Results of three samples are presented in the table.

Table 4.6. Sum of ranks for appearance

Sample	Code	Appearances
1	105	61.0
2	227	65.0
3	552	54.0

4.4.5. Overall acceptability

The probability value (P=0.041) of the test was less than the minimum probability value (P=0.05) that was required for the test to be significant. There are at least one treatment was significant with regard to overall acceptability. The sample code 552 gained the highest sum of rank (68.5) for overall acceptability among three samples.

Results of three samples are presented in the table.

Table 4.7. Sum of ranks for appearance

Sample	Code	Overall acceptability
1	105	50 0
2	227	61.5
3	552	68.5

4.5. Chemical studies and shelf life evaluation of the cordial

4.5.1. Chemical studies

The sample code 552 shows the following composition as illustrated in the table.

Table 4.8. Proximate composition

Property	Amount
pH	3.8
Brix	52^0
Titrable acidity	0.6

4.5.2. Shelf life evaluation

There was no significant different were found in brix value, pH and titrable acidity through out the study. Physico chemical properties of selected sample with in 29 days storage as shown in following table.

Table 4.9. Chemical storage studies of sample 552

Storage weeks	Code 552		
	pH	Brix	Acidity
0	3.8	51^0	0.6
1	3.8	51^0	0.6
2	3.8	51^0	0.6
3	3.8	51^0	0.6
4	3.8	51^0	0.6

There was no mould growth or any deterioration of appearance within 29 days of storage life.

CHAPTER 05

Conclusion and Recommendations

5.1. Conclusion

- Natural jack fruit cordial can be produced from ripen jack fruit pulp, as a value added product with 52^0 brix and 42%-48% fruit content.

- Literature shows that the jack bulbs should be heated gently with water, before mash them into pulp. But, the boiling of jack bulbs with sugar syrup is the most appropriate way to gain the better quality natural jack fruit cordial.

5.2. Recommendation

- The new investigation of natural food preservative compound for the production of natural jack fruit cordial is very important.

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Specifications for fruit squashes, Fruit syrups & fruit cordials (FIRST REVISION), SLS 214;1985,Gr.8, SRI Lanka Standard Institute,pp.5-14.

Appendix 01

Sensory evaluation ballot paper

Name.....

Date.....

- This is a product based on ripen jack fruit (waraka).

Instructions :-

- Please taste the samples according to following order.

Sample Codes:-

105 227 552

- Rank the samples according to data given below

Like extremely 9
Like very much 8
Like moderately 7
Like slightly 6
Neither like nor dislike.....5
Dislike slightly 4
Dislike moderately 3
Dislike very much 2
Dislike extremely 1

	105	227	552
Taste			
Colour			
Smell			
Appearances			
Overall acceptability			

Your comments: .....
.....

Thank you!!!!

Appendix 02

Questionnaire for the market research

Questionnaire

(1). Did you ever used cordial as a fruit drink?

Yes ☐ No ☐

(2). Do you buy a cordial, if it is prepared buy adding waraka (ripe jack fruit) as a main ingredient?

Yes ☐ No ☐

(3). In here, you considered about, (Put the numbers according to your priority.)

Taste ☐

Color ☐

Shelf life ☐

(4). What are the reasons for your choice?. (Put the numbers according to your priority.)

Solution for the thirsty ☐

As a way to feel the waraka taste during the off season ☐

As a good nutritious drink ☐

For the test, because of the new product ☐

(5). Your family monthly income,

Less than Rs.5000.00 ☐

Rs.5001.00-10,000.00 ☐

Rs.10, 001.00-15,000.00 ☐

More than Rs.15, 000.00 ☐

Thank you!

Appendix 03

Calculations for acidity (As citric acid)

$$\text{Acidity (as anhydrous citric acid), per cent by mass} = \frac{6.404\ V\ c}{m}$$

Where,

V = Volume, in ml, of standard sodium hydroxide required for the titration;

c = Concentration, in mol/l, of the standard sodium hydroxide solution

m = Mass, in g, of the sample taken for test.

Appendix 04

Analysis of jack fruit as a livestock feed

	Moisture %	Protein %	Carbohydrate %	Ether extract%	Fiber %	Mineral matter%	Calorific Value per 100g %
Ripe jack (waraka)	68.6	1.80	27.54	0.29	0.65	0.91	120.0
Half ripe jack (kos)	67.83	2.33	27.76	0.12	0.91	1.06	121.4
Half ripe jack (dried)	12.58	5.77	76.50	0.30	2.23	2.62	331.8
Half ripe Flaked jack	12.58	6.48	74.96	0.40	3.16	2.04	329.4
Tender jack	86.96	1.78	8.89	0.47	1.65	0.76	46.9
Jack waste (fresh)	89.45	0.62	7.83	0.12	2.12	0.19	34.9
Jack waste (dried)	5.12	5.42	68.20	1.00	18.40	1.69	303.5

Source: Gunasena et al, 1996

Appendix 05

Proximate composition of jack fruit

	DM %	Ash	CF	CP	EE	NDF	ADF	LIG	DO %
		←----------g/kg of DM----------→							
Leaves	31.4	106	201	138	37	439	318	123	43.6
Whole unripe fruit	-	39	99	46	46	-	-	-	-
Empty unripe carpels	26.6	36	49	57	5	-	-	-	-
Mature seeds	-	31	50	110	10	-	-	-	-
Seed	92.5	30	67	131	10	768	153	35	-
Seed meal, dried	-	35	117	79	32	-	-	-	-
Seed without coat	-	34	-	145	-	448	96	9	-
Seed coat	-	50	-	37	-	766	645	193	-
Skin & others	-	57	-	85	-	358	239	53	65.0
Skin & refuse of fruit	28.8	116	164	76	52	-	-	-	-
Unripe carpels & seed	31.8	29	39	36	6	-	-	-	-

Source: Gunasena et al, 1996

DM = dry matter **CF** = crude fibre **CP** = crude protein

ND = neutral detergent fibre **EE** = ether extract **ADF** = acid digestible fibre

LIG = lignin **DO** = digestible organic matter

Appendix 06

Levels of the preferable characters

Person	Taste	Colour	Shelf life
1	1	3	2
2	1	3	2
3	1	3	2
4	1	3	2
5	2	3	1
6	1	2	3
7	1	2	3
8	1	3	2
9	1	2	3
10	1	3	2
11	1	3	2
12	1	3	2
13	1	3	2
14	1	2	3
15	1	2	3
16	1	3	2
17	1	3	2
18	2	3	1
19	1	3	2
20	2	3	1
21	2	3	1
22	2	3	1
23	1	2	3
24	1	3	2
25	2	1	3

Appendix 07

Analyzed results of Friedman statistical test

Friedman Test for taste

```
Friedman test for Taste by Treatment blocked by Block

S = 5.60  DF = 2  P = 0.061
S = 6.28  DF = 2  P = 0.043 (adjusted for ties)

                    Est     Sum of
Treatment      N   Median    Ranks
1             30   3.0000     50.0
2             30   2.8333     62.0
3             30   2.1667     68.0


Grand median  =   2.6667
```

Friedman Test for colour

```
Friedman test for Color by Treatment blocked by Block

S = 0.82  DF = 2  P = 0.665
S = 1.04  DF = 2  P = 0.594 (adjusted for ties)

                    Est     Sum of
Tretmant       N   Median    Ranks
1             30   2.0000     63.5
2             30   2.0000     56.5
3             30   2.0000     60.0

Grand median  =   2.0000
```

Friedman Test for smell

```
Friedman test for Smell by Treatment blocked by Block

S = 0.35  DF = 2  P = 0.839
S = 0.38  DF = 2  P = 0.828 (adjusted for ties)

                    Est     Sum of
Treatment      N   Median    Ranks
1             30   2.3333     58.0
2             30   2.6667     59.5
3             30   3.0000     62.5

Grand median  =   2.6667
```

Friedman Test for appearance

Friedman test for Appearance by Treatment blocked by Block

S = 2.07 DF = 2 P = 0.356
S = 2.28 DF = 2 P = 0.321 (adjusted for ties)

Treatment	N	Est Median	Sum of Ranks
1	30	2.8333	61.0
2	30	3.5000	65.0
3	30	2.1667	54.0

Grand median = 2.8333

Friedman Test for overall acceptability

Friedman test for Acceptability by Treatment blocked by Block

S = 5.82 DF = 2 P = 0.055
S = 6.40 DF = 2 P = 0.041 (adjusted for ties)

Tretmant	N	Est Median	Sum of Ranks
1	30	3.5000	61.5
2	30	2.1667	50.0
3	30	2.8333	68.5

Grand median = 2.8333

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