Development of Ready to Cook Young Jackfruit Mallun

By

Wickramage Dinesha Thanoja Perera

01/AS/031

A research report submitted in partial fulfillment of the

Requirement for the Degree of Bachelor of Science

In

Food science and Technology

Department of Food science and Technology

Faculty of Applied sciences

Sabaragamuwa university of Sri Lanka

Buttala.

June 30th

Declaration

The research work described in this thesis was carried out by me at Faculty of Applied Sciences, Buttala under supervision of Mr.R.M.U.S.K.Rathnayaka.

A report on this has not been submitted to another university for another degree.

.....

Signature of the student

26-08-2005

Date

Certified by,

.....

Mr.R.M.U.S.K.Rathnayaka,
Lecturer,
Department of Food Science and Technology,
Faculty of Applied sciences,
Sabaragamuwa university of Sri Lanka,
Buttala.

Signature

2005.08.30

Date

Mrs.K.M.Somwathie,
Head,
Department of Food Science and Technology,
Faculty of Applied sciences,
Sabaragamuwa University of Sri Lanka,
Buttala.

Signature

2005.08.30

Date

LOVING DEDICATED
TO MY PARENTS

Acknowledgement

First and foremost I would like to express my heartfelt thank to Dr.Mahinda Wickramarathna, Dean of the Faculty of Applied sciences, Sabaragamuwa university of Sri Lanka, Buttala for generous help to make this pleasurable exercise.

Specially, I wish to express my deepest gratitude to my internal supervisor Mr.R.M.U.S.K. Rathnayaka, Lecturer of the Faculty of Applied sciences, Sabaragamuwa university of Sri Lanka, Buttala for his assistance, encouragement. guidance and his valuable time to make this study a success.

Further I wish to extend my deepest gratitude to Mr.S.J.M.N.Anura, Department of Physical sciences for his guidance given in fine-tuning the statistical analysis of my research project.

Also I would like to extend my thanks to all the staff members in Food Science and Technology laboratory for facilities and helps given me at the project work.

I would like to express my sincere thanks to all the staff members in Faculty of Applied sciences, Sabaragamuwa university of Sri Lanka, Buttala for their tremendous encouragement and highly inspiring guidance to make this study a success.

Finally, my heartfelt thanks for my family members and colleagues for their invaluable helps and guidance given to me at all the time, I needed to make my B.Sc. degree a success.

Abstract

Jackfruit (*Artocarpus heterophyllus*) is a large evergreen tree, which belongs to the genus Artocarpus of the Moracea family. It is grown in many tropical countries. Although it gives very high production, seasonal production and modern life style of the people make large quantity of production underutilized. The modern preservation technologies could be applied to make value added, markedly available food products to utilize this high production. Development of ready to cook young jackfruit Mallun was identified as a good solution. It will minimize the wastage and also will provide nutritional benefits.

Young jackfruit is the tender portion of jackfruit, which contains lots of nutrients. Traditionally, Malluns are prepared from young jackfruit with spices and scraped coconut. It can be preserved according to the modern preservation techniques.

In this study, two different young jackfruit Malluns were prepared by dehydration technique and minimally processing technique. The sensory and physico-chemical characteristics of the processed products were studied. The shelf life of the products also was evaluated for both samples.

Sensory evaluation for the characteristics colour, smell, taste, appearance and overall acceptability disclose that the two samples are not significantly different. It was identified that the preparation time for consumption as 5-7 minutes for the dehydrated sample and, s 8-10 minutes for the minimally processed sample. The moisture content of dehydrated sample was 27.6% and minimally processed sample was 75.38%. The total solids content of dehydrated sample was 72.4% and minimally processed sample was 24.62%. Reconstitution ratio of the dehydrated sample was 4.46.

The study to find out antioxidants for coconut revile that the natural antioxidants, turmeric and pepper are better than artificial antioxidants SMS and citric acid.

Table of Content

CHAPTER 03

Materials and methodology

CHAPTER 04

Results and Discussion

List of Figures

List of Tables

Abbreviation

et al.	;	and others
g	;	Gram
kcal	;	Kilo calorie
mg	;	Milligrams
mcg	;	Micro grams
lb	;	Pounds
oz	;	Owns
ppm	;	Parts per Million
IU	;	International Units
CA	;	Controlled Atmosphere
MA	;	Modified Atmosphere
A_w	;	Water activity
SMS	;	Sodium Meta bisulphide
ml	;	Milliliters
conc.	;	Concentrated
SLS	;	Sri Lanka Standard
hrs	;	Hours
etc	;	and so on

CHAPTER 01

Introduction

1.1. Introduction

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

In different societies in the world have different levels of significant in consumption of fruits and vegetables. It is difficult to cultivate fruits and vegetables which are having short annual growing season in some countries like cold conditions of Central Asian steppes, mountainous regions of Latin America and arid desserts of Africa and Asia. This is another reason to preserve highly yielded fruits and vegetables to fulfill the high demand in the export market.

Jackfruit, which is an evergreen tree, belongs to the genus Artocarpus of the Moraceae family. Its botanical name is *Artocarpus heterophyllus*. The jackfruit is believed to have originated in the tropical rain forests of the Western Ghats in India. Now it is considered as a common cultivar of the Asian tropics, India, Burma, Sri Lanka, the Philippines and Bangladesh.

Jackfruit contains more than 38 nutrients, rich in curative properties and is used in the treatment of around 30 illnesses. So, it is famous item in traditional diets. Over 100 traditional dishes can be prepared using jackfruit and around 50 more can be produced using modern food processing technology. (Rajapaksha, 1998)

Jack tree is called "rice tree" due to its vast importance as a source of food. Jackfruits are a valuable food item and it is consumed at various mature stages. Young or immature fruits are called "Polos", mature fruits as "Kos" and ripen fruits as "Waraka" or "Wela".

Large quantities of jackfruits are available as seasonal surpluses during certain months of the year (during the Yala season from May to September and few trees that yield fruit from October to April) and they are become underutilized. Annual yield of jackfruit in Sri Lanka is approximately 12.3 metric ton (Abesinha, 1991). So, by processing can secure the supply of this food for other seasons when they are not available in fresh state. And also jack is devoid of chemical fertilizer, insecticides and weedicides and also it does not contain additives or other forms of artificial ingredients. Due to those reasons, it would be a wise move to purchase jack related food items, from the market.

Among those, immature fruit (Polos) is used to prepare Polos Mallun or Polos ambula/curry. Immature jack / baby jack is a good source of energy, protein, carbohydrates, calcium, phosphorus, iron, vitamin C, etc. (Rajapaksha, 1998) Although immature jackfruit has a high nutritional value, its consumption is limited, because people in modern world haven't enough time to prepare a Polos Mallun like curries. So, it is essential to introduce an easy way to prepare those curries.

Polos Mallun can be preserved by two methods, either dehydration or by minimal processing. Dehydration means, use of mechanical equipment and artificial method under carefully controlled conditions of temperature, humidity, and airflow. It is the process of removal of surplus water without destruction of cellular tissues or impairment of the energy values. Minimal processing includes products that contain live tissues or those that have had slight modifications to their freshness condition but have kept their quality and character similar to those of fresh products. (Luesecke, 1999)

There are three reasons for dehydration: to decrease weight and bulk, to retain the size and shape of the original food and for the production of convenience item. When dehydrate, the extent of the destruction of vitamins, occurrence of undesirable changes in colour, taste and flavour, and also the proper function of cells during dehydration are depending mainly on correct time and temperature combination. When properly done drying can preserve taste, flavour and protect nutritive values.

1.2. Major Objective

Development of ready to cook young jackfruit Mallun with extended shelf life.

1.3. Specific Objectives

1) Introduction of an easy way to consume young jackfruit with scraped coconut.
2) Determination of most suitable antioxidant to prevent to oxidative rancidity of scraped coconut.
3) Determination of the shelf life of the product.

CHAPTER 02

Review of Literature

2.1. Jack Tree

Jack tree (*Artocarpus heterophyllus*) is a large evergreen tree, which is a species of family Moraceae. It is popular as "Kos", "Herali" or "Pana" in Sinhala and "Murasabalam" or "Pilaka" in Tamil. (Rajapaksha, 1998)

Fig. 2.1. Jackfruit tree

2.1.1. Varieties

There is considerable variation in growth, crown architecture, and productivity, bearing habit, fruit type, quality, shape, size and weight. This variation is due to the high level of cross-pollination.

According to the nature of their flesh, that means whether it is soft or crisp, two principle types of fruit have been recognized. The soft types are generally known, as "Wela" and the crisp types are "Waraka". Some crisp types have very sweet flesh, which are known as honey jack or "Pani Waraka".

Another type clearly distinguished from the common form is "kurukos", a dwarf type, somewhat inferior to the others. Two waraka types have been recognized also, namely fatherlong and rosa kos. The flesh is firm and yellow in fatherlong variety and the fruits of rosakos have light pink flesh when cooked. Another introduction is known as Singapore jack, which produces fruits of the crisp fleshed type profusely during off-season. (Gunasena et al. 1996)

Table 2.1 Jackfruit varieties

Variety	Country	Characteristics
1) Bali Beauty	Indonesia	Dark orange flesh with medium firm. Excellent flavour.
2) Black Gold	Australia	Deep orange, soft flesh with a strong, sweet flavour and aroma.
3) Chompa Grob	Thailand	Deep orange and crunchy flesh with sweet, rich flavour.
4) Cochin	Australia	Firm and mild flesh with little texture.
5) Dang Rasimi	Thailand	Deep orange and firm flesh with mild, sweet flavour and a sweet, pleasant aroma.
6) Golden Nugget	Australia	Deep orange flesh with excellent flavour.
7) Honey Gold	Australia	Dark yellow to orange flesh, firm, with a sweet, rich flavour.
8) J-30	Malaysia	Deep orange, firm flesh with rich flavour and slight aroma.
9) Sweet Fairchild	Florida	Light yellow flesh with a mild, sweet flavour.
10)Tabouey	Indonesia	Pale yellow, firm flesh with mild and pleasant flavour and almost no aroma.

(Source: Rose and Mitra, 1990.

2.1.2. Food Use

Jackfruit is one of the most popular substitutes for rice. Because, it is an easily available and cheap form of carbohydrates. From the initial stage of flake formation up to ripening, the fruit is used in many different ways. (Gunasena et al., 1996) That means they are a valuable food item, which are eaten at various stages of their maturity.

1) Young immature fruits (Polos) are used as curry, mallun or pickles.
2) Mature fruits (Kos) are used as an alternative for rice by boiling with water or used as curry.
3) Mature or ripe seeds are eaten as curries. And also they are eaten boiled or roasted with coconut or with jaggary.
4) Tender segments of ripe fruits (Wele or Waraka) are used as dessert or drinks.
5) Leaves are eaten as "Kos kola papadam" which are prepared by putting jack leaves in oil.

(Gunasena et al., 1996 and Rajapaksha, 1998)

2.1.3. Other Uses

Not only jack fruit, but also other parts of the tree are used by many ways other than a food.

1) Jackfruit leaves are used to feed livestock, especially goats. And also rinds of the fruit are excellent sources of fodder.
2) The yellow heartwood is valuable timber and also yields a yellow dye when chips are boiled.
3) The resinous latex is used to mend earthenware, water containers, pitchers and clay pots.
4) Bark latex contain large amount of resin about 85%, which is used to manufacture varnishes.
5) The bark yields a fiber that can be used to make ropes and also used for tanning.

(Rajapaksha, 1998 and Gunasena, 1993)

2.1.4. Nutritional Value

Jackfruit is rich with 38 nutrients and it also rich in curative properties and is used in the treatment of around 30 illnesses.

The tender portion, ripe portion as well as jack seeds rich with nutrients.

Table 2.2 Nutritional values of jackfruit

Nutrient	Tender portion	Ripe portion	Jack seeds
Moisture	84 g	77.2 g	60.9 g
Energy	51 kcal	84 kcal	151 g
Proteins	2.6 g	1.9 g	4.3 g
Fats	0.3 g	0.1 g	0.4 mg
Carbohydrates	9.4 g	18.9 g	32.6 g
Calcium	30 mg	20 mg	35 mg
Phosphorus	40 mg	30 mg	126 mg
Iron	1.7 mg	500 mg	1.2 mg
Thiamine	50 mcg	30 mg	180 mcg
Riboflavin	40 mcg	-	50 mcg
Niacin	0.2 mg	-	0.5 mg
Vitamin C	14 mg	-	17 mg
Carotene	-	54 mcg	25 mcg

(Source: Rajapaksha, 1998)

Table 2.3 Essential amino acids in Tender jackfruit

Essential amino acid	Amount / 16 g N
Arginine	1.92 g
Cystine	1.94 g
Histidine	0.96 g
Leucine	8.0 g
Isoleucine	7.2 g
Lysine	4.8 g
Methionine	1.44 g
Phenylalanine	7.68 g
Threonine	5.76 g
Tryptophan	1.28 g
Valine	8.8 g

(Source: Gunasena, 1993)

Table 2.4 Trace elements in Tender jackfruit

Trace element	Amount / 100 g
Na	35 micro gram
P	328 micro gram
Mg	30 micro gram
Cu	220 micro gram

(Source: Gunasena, 1993)

2.1.5. Medicinal Value

Jackfruit as well as whole jack tree has a high medicinal value.

Table 2.5 Medicinal values of jackfruit

Part of tree	Medicinal value
1) Leaves	• Skin diseases • Ash of the leaves useful in healing ulcers.
2) Roots	• Skin diseases and as an antiasthmatics
3) Latex	• Mixed with vinegar, the latex promotes the healing of abscesses and snakebites. • Reduce glandular swelling.
4) Starch of seeds	• Given in bilious colic • Roasted seeds have an aphrodisiacal action.
5) Infusion of the mature leaves and bark	• Given for stones in the bladder • Given for diabetes

(Source: Rajapaksha, 1998 and Gunasena, 1993)

2.1.6. Processing of jackfruit

Jackfruit is a seasonal crop which gives high yield in specific seasons in the year. But most of them are become unutilized. And it is distributed in Western parts of India and cultivated in most tropical countries like Sri Lanka, Indonesia, Malaysia, and Singapore. (Rajapaksha, 1998) So it is useful to process jackfruit to utilize in off seasons.

India has developed various food products from raw particles, seeds and rind. They are canned in syrup, canned frozen, jam puree mixed with banana and mango, dried fruit perianths, chutney, preserves and candy, concentrate and flour from seeds.

As well as there are many food items prepared from jackfruit in Sri Lanka.

1) Canned polos as a curry or pickled.
2) Squash and toffee made from pulp.
3) Syrup, pectin, jelly can be made from the rind.

And also fermenting and distilling the perinanths can make alcoholic beverages. Rhamnose, xylose, arabinose, glucose, galactose, galacturonic acid and pctic acid can be produced by hydrolysis of the fruit pulp. (Gunasena, 1993)

There are several traditional methods to preserve them in Sri Lanka.

1) Sun-dried segments and seeds (Atukos) can be kept more than one year.
2) The seeds can be heaped and covered with a dry layer of sand (Welikos ata) can be stored for more than six months.
3) Mature fruits can be stored for 3-6 weeks at 11-12^{0}C.
   (Rajapaksha, 1998)

2.1.7. Immature Jackfruit

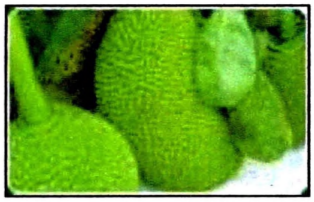


Fig. 2.2. Tender jackfruit/ Polos

Tender portion of jackfruit is called as immature jackfruit or young jackfruit or baby jackfruit and also called as "Polos" in Sinhala. This immature fruit is white in colour and small in size. It can be used as a vegetable in various ways, because of its nutritional value and taste.

2.1.8. Nutritional Value of Polos

Most nutrients, essential amino acids as well as trace elements are reported to be present in the edible portion of the tender portion.

Table 2.6 Nutritional values of Polos

Nutrient	Nutritional value /100 g
Protein	2.6 g
Carbohydrates	9.4 g
Fat	0.8 g
Phosphorus	40 mg
Calcium	30 mg
Thiamin	50 mg
Riboflavin	40 mg
Vitamin C	14 mg
Iron	1.7 mg

(Source: Ranaweera et al., 2003)

2.1.9. Popular food recipes of Polos

There are many dishes 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 Sri Lankans.

1) Polos Embula: - A curry made with coconut milk and condiments
2) Polos Mallun /Malluma: - Thinly chopped jack axils cooked with scraped coconut and condiments.
3) Polos Achcharu: - A chutney like dish
4) Polos Cutlets
5) Polos Wadai
6) Polos Rotty
7) Polos and meat curry: - A curry prepared from Polos and meat
8) Polos omlet curry: - A curry prepared by eggs and Polos
9) Polos and Macaroni
10) Polos Pethi Embula
11) Polos Salad

2.1.10. Polos Mallun

Polos mallun is made from white coloured, immature jackfruit, which is minced into small pieces and added with scraped coconut and condiments.

Ingredients for 8 portions: -

- 1 lb jackfruit
- 2 oz onions
- 0.5 oz green chilies
- 4 oz coconut
- 0.5 teaspoon turmeric
- 2.5 teaspoon salt
- 0.25 pint water
- A sprig of curry leaves
- 3 teaspoon mustard
- 2 teaspoon pepper corns
- 6-7 cloves of garlic

Method: -

Shred the jackfruit very fine, wash it well and put into pan. Chop onions and chilies and add to jackfruit with salt, turmeric, water and curry leaves. Bring to boil and then lower the heat till jackfruit is cooked and all water has been absorbed. Grind the garlic, coconut, mustard and pepper together, add to the pan, toss for a few minutes and take of fire. (Gunasena et al., 1996)

2.2. Coconut

Botanical name: - *Cocus nucifera*

Family: - Palme

Fig.2.3. Coconut

2.2.1. Composition

Table 2.7 General composition of coconut

Nutrient	Coconut kernel mature	Coconut milk without water	Coconut oil	Coconut jaggary
Moisture	51.7 g	42.8 g	-	10.3 g
Energy	312 kcal	430 kcal	882 kcal	340 kcal
Protein	5.2 g	3.4 g	-	1 g
Fats	28.2 g	41 g	99.9 g	2 g
Carbohydrates	16 g	11.9 g	-	83.5 g
Calcium	23 mg	15 mg	2 mg	1638 mg
Phosphorus	112 mg	140 mg	3 mg	62 mg
Iron	2.5 mg	1.6 mg	-	-
Thiamin	40 mcg	-	-	-
Riboflavin	30 mcg	-	-	-
Niacin	0.8 mg	-	-	-

(Source: Rajapaksha, 1998)

2.2.2. Food use and other uses

Coconut milk and coconut oil are basically used to prepare various meals. Desiccated and grated coconut is also used in food preparations and confectionery. Coconut oil is the main oil source in Sri Lankan diet. Coconut sap is used to manufacture trickle, jaggary, toddy, liquor and vinegar. Palm cabbage and coconut apple are also eaten fresh. Liquid endosperm of young coconut is a famous drink.

Coconut tree is used as "Kapruka", because of the multiplicity of uses.

1) Leaves: - used to cover roofs and decorations
2) Oil: - used to produce soap
3) Coconut cake: - to feed animals
4) Shell: - to produce ornaments
5) Shell and leaves: - use as a firewood

(Rajapaksha, 1998)

2.2.3. Desiccated coconut

Desiccated coconut is the dried, disintegrated white kernel of the coconut, processed under strict hygienic conditions for human consumption with retaining original oil and protein of the fresh nut. (Grimwood, 1975)

When manufacturing desiccated coconut for removing the meat from the nut, sterilizing it and then drying it until the moisture content is around 3% make culinary use. (Rice et al., 1990) Desiccated coconut is produced in four standard grades as extra fine, fine, medium and coarse.

There are some major steps to produce desiccated coconut as husking, shelling, removing the testa, washing, sterilizing, disintegrating, drying, sieving and packaging. Drying is the most important step among those. Because the moisture content of wet coconut meat (55%) must be reduced to about 3% during drying. The drying process takes approximately 45 minutes at 88^{0}C. (Grimwood et al., 1975)

Desiccated coconut is produced in many forms as threads, shreds, strips, chips and slices.

Table 2.8 Proximate analysis of typical desiccated coconut

Component	Approximate percentage
Moisture	2.0
Fat	67.5
Carbohydrates	5.9
Protein	9.3
Ash (minerals)	2.4
Fiber	3.9
Pentosans	8.9

(Source: Grimwood et al., 1975)

2.3 Spices

2.3.1. Definition

According to the Oxford English Dictionary spice is "one or other of various strongly flavoured or aromatic substances of vegetable origin, obtained from tropical plants, commonly used as condiments" and also spices are aromatic dried roots, bark, buds, seeds, berries and other fruits. (Norman, 1990)

2.3.2. Curry Leaves

Botanical name: - *Murraya koenigii*

Family: - Rutaceae

Fig. 2.4. Curry leaves

Food use: -

- The leaves are used in flavouring curries.
- Leaves are roasted and ground with other spices to make powders, which are use for curries.
- Young leaves are eaten as salads.
- Extracts of leaves are added to porridge.

Table 2.9 Nutrition values of curry leaves

Nutrient	Amount
Moisture	63.8 g
Energy	108 kcal
Proteins	6.1 g
Fats	1 g
Carbohydrates	830 g
Calcium	57 mg
Phosphorus	7 mg
Iron	7.5 mg
Carotene	80 mcg
Thiamine	80 mcg
Riboflavin	210 mcg
Niacin	2.3 mg
Carbon	4 mg

(Source: Rajapaksha, 1998)

2.3.3. Garlic

Botanical name: - *Allium stivum*

Faily: - Liliaceae

Fig.2.5. Garlic

Food use: -

- Garlic is widely used for flavouring dishes and also eaten as a curry. Both bulbs and leaves are marinated and eaten.

Table 2.10 Nutritional values of Garlic

Nutrient	Bulbs	Leaves
Moisture	66 g	87 g
Energy	122 kcal	12 kcal
Protein	7 g	2.1 g
Fat	0.3 g	0.5 g
Carbohydrates	2.5 g	9 g
Calcium	26 mg	116 mg
Phosphorus	109 mg	56 mg
Iron	1.2 mg	0.4 mg
Thiamine	0.23 mg	0.08 mg
Riboflavin	0.08 mg	0.16 mg
Niacin	0.4 mg	0.7 mg
Vitamin C	7 mg	38 mg

(Source: Rajapaksha, 1998)

The garlic also contains a volatile oil, allin, allicin, allyl disulphide, allyl propyl-disulphide, insulin, choline and myrosinase. Garlic has a high therapeutic value because it is good for many diseases as infantile convulsions, asthma facial paralysis, gout and sciatica. Medicinally it is a stimulant, carminative, anthelmintic, diaphoretic, diuretic and expectorant. (Rajapaksha, 1998)

2.3.4. Green Chilies

Botanical name: - *Capsicum annum*

Family: - Solanaceae

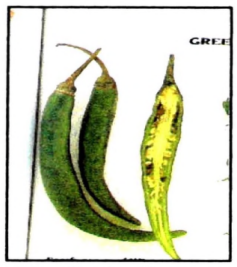


Fig.2.6. Green chilies

Food use: -

- Use in curries, soups and stews or eat raw in salads.
- Sometimes preserve in brine or vinegar.
- Sun-dried chilies are an important spice in Sri Lankan culinary.
- Leaves eat as a cooked vegetable.

Table 2.11 Nutritional value of green chilies (fruit)

Nutrient	Amount
Moisture	85.7 g
Energy	29 kcal
Protein	2.9 g
Fat	0.6 g
Carbohydrate	3 g
Calcium	30 mg
Phosphorus	80 mg
Iron	1.2 mg
Carotene	175 mcg
Thiamine	190 mcg
Riboflavin	390 mcg
Niacin	0.9 mg
Vitamin C	11 mg

(Source: Rajapaksha, 1998)

2.3.5. Mustard

Botanical name: - *Brassica juncea*

Family: - Cruciferae

Fig.2.7. Mustard

Food use: -

- White seeds use as a pickling spice.
- Brown seeds are an important flavouring.
- Black seeds have a strong, pungent flavour.

Nutritional and medicinal value: -

Mustard induces vomiting and is considered a diuretic and stimulant. Mustard plasters are a common treatment for arthritis and rheumatism, but it can irritate sensitive skins. (Norman, 1990)

2.3.6. Onion

Botanical name: - *Allium ascalonicum*

Family: - Liliaceae

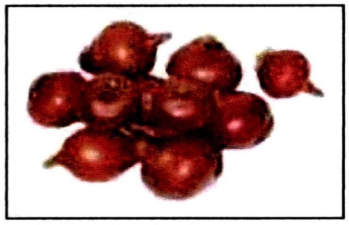


Fig. 2.8. Onion

Food use: -

- It can eat in fresh form or use for salads, curries and pickles.
- Green leaves use as a vegetable.

Table 2.12 Nutritional values of onion

Nutrient	100 g of leaves	100 g of bulbs
Moisture	87.6 g	84.3 g
Energy	41 kcal	59 kcal
Protein	0.9 g	1.8 g
Fat	0.2 g	0.1 g
Carbohydrates	8.9 g	12.6 g
Calcium	50 mg	40 mg
Phosphorus	50 mg	60 mg
Iron	9.5 mg	1.2 mg
Vitamin A	297 mg	-
Thiamine	-	80 mcg
Riboflavin	30 mg	20 mcg
Niacin	0.3 mg	0.5 mg
Carbon	17 mg	-

(Source: Rajapaksha, 1998)

2.3.7. Pepper

Botanical name: - *Piper nigrum*

Family: - Piperaceae

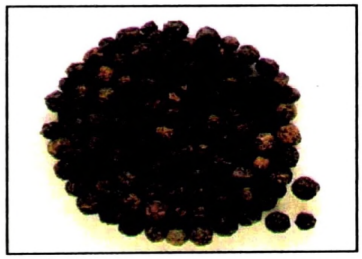


Fig.2.9. Peppers

Food use: -

- Seeds use as a condiment.
- They widely use to increase the taste of foods.
- Pepper has a warm, woody smell that is fresh, pungent and agreeably aromatic. (Rajapaksha, 1998 and Norman, 1990)

Table 2.13 Nutritional values of pepper

Nutrient	Amount
Moisture	13.2 g
Energy	304 kcal
Proteins	11.5 g
Fats	6.8 g
Carbohydrates	49.2 g
Calcium	460 mg
Phosphorus	198 mg
Iron	16.8 mg
Carotene	1.08 mcg
Thiamine	90 mcg
Riboflavin	140 mcg
Niacin	1.4 mg

(Source: Rajapaksha, 1998)

Medicinally, pepper is used to help relive flatulence and to have diuretic properties. (Norman, 1990) And also it is used to dyspepsia, cough, hemorrhoids, intermittent fevers, piles and elephantiasis.

2.3.8. Turmeric

Botanical name: - *Curcuma longa / Curcuma comestic*

Family: - Zingiberaceae

Fig.2.10. Turmeric

Food use: -

- It has lightly aromatic, turmeric smells. It tastes pungent, bitter and musky.
- It is essential in curry powder and also important flavouring for many dishes.
- It is added to mustard blends very often.

(Norman, 1990)

Table 2.14 Nutritional value of turmeric

Nutrient	Amount	Nutrient	Amount
Moisture	8-9%	Energy	349-390 cal /100 g
Fat	51%	Calcium	0.15%
Fixed oil	7.5-8.8%	Iodine	0.01 g/ 100 g
Volatile oil	4.4-9.2%	Lead	0.5 ppm
Protein	6.1-10.8%	Phosphorus	0.28%
Carbohydrate	69.4%	Potassium	2.5 g/ 100 g
Crude starch	48.7-50.4%	Sodium	0.01 g/ 100 g
Pure starch	29.6-40.1%	Ascorbic acid	49.8 mg/ 100 g
Fiber	2.6-5.8%	Vitamin A	50 IU/ 100 g
Minerals	3.5%	Niacin	4.8 mg/ 100 g
Total ash	6-8.5%	Thiamine	0.09 mg/ 100 g
Soluble ash	4.7-6.1%	Nicotinic acid	2.3 mg
		Riboflavin	0.19 mg/ 100 g

(Source: Nethsingha and Paskaranathan, 1976)

Turmeric is used as a tonic and as a remedy for liver problems. It is applied to treat skin diseases by adding to ointments. (Norman, 1990)

2.4. Minimally Processed Vegetables

Minimally processed vegetables are also called as fresh cut vegetables or lightly processed vegetables.

2.4.1. Definition

Minimally processing refers to trimming, peeling, sectioning, slicing and coring of vegetables or fruits. (Arthey and Ashurt, 2001)

2.4.2. Shelf life and quality of Minimally Processed Vegetables

Quality of fresh cut product is depended on variety, maturity, quality at harvest, processing technique, storage temperature and microbial control. Normally minimally processed products are more perishable than unprocessed raw materials. And also the processing should be incurred minimal damage to the product.

2.4.3. Physiology and biochemistry of fresh-cut products

Same as the living tissues, fresh-cut products have a limited energy supply. Stored energy is converted into usable energy by respiration. When the respiration is increased, shelf life of the product decreases. Respiration increase with storage temperature. The temperature coefficient (Q^{10}) of respiration rates was found to range from 2.0-8.6 among various fresh-cut fruits and vegetables. This means that a difference in 5^0C storage temperature increased respiration dramatically for some fresh-cut products. Respiration can be reduced by low temperature or by controlled atmosphere (CA) or modified atmosphere (MA) storage conditions of relatively low O_2 and high CO_2.

And also these products are essentially wounded tissues, and these undergo reaction designed to repair the damage. But, many of these reactions are deleterious to quality of the product. These wounding tissues increase the respiration rate and as a result shelf life of the product is decreased. Wounding also induces other metabolic pathways that result in secondary metabolites that can cause discolouration, off flavour and texture changes.

2.4.4. Techniques to extend the shelf life

There are some methods to extend the shelf life of minimally processed foods.

1) Low temperature storage
2) Chemical preservatives
3) Mild heat treatments
4) Modification of pH
5) Reduction of A_w
6) Irradiation
7) CA or MA storage

2.4.4.1. Low temperature storage

Some products are susceptible to chilling injury, which are appeared as a pitting of the peel. When preparing minimally processed foods, the peel is removed. So, the susceptibility to appear chilling injury is reduced.

2.4.4.2. Chemical preservatives

Chemical preservatives are used to extend the shelf life of fresh-cut products. But the problems with chemical preservatives are the impact on the consumer's impression of product wholesomeness. The exceptions would be nutritional additives such as ascorbic acid (Vitamin C) or tocopherol (Vitamin E) to reduce browning; citric acid, as a chelator or acidulant; or various forms of calcium as a firming agent. Calcium can play a role in delaying senescence.

2.4.4.3. Mild heat treatments

Mild heat treatments can inactive enzymes, which promote deterioration or discolouration, and also can reduce microbial population. But the problem is these treatments can alter the colour, flavour and texture of some fresh products.

2.4.4.4. Modification of pH

This is usually toward the acid side to reduce microbial populations using acidulants such as citric or ascorbic acid. But this can result a sour flavour in the final product.

2.4.4.5. Reduction of A_w

This is widely used for fruits. Using sugars, salts or polyols with relatively high osmotic pressure that are infused into the fruit tissues, can reduce water activity.

2.4.4.6. Irradiation

Ionizing radiation has been explored to extend the shelf life of minimally processed fruits. However, the dose required to affect microbial organisms, may also induce undesirable texture changes or other damage to the product.

2.4.4.7. CA or MA storage

Low O_2 and high CO_2 filled storages are used. So, the shelf life of the product can be extended by reducing respiration, ethylene production, ethylene induced processes such as colour changes, softening and senescence; as well as preventing dehydration and microbial contamination.

2.4.5. Packaging of Minimally Processed Products

CA or MA packaging can use. Which are relatively low O_2 and high CO_2 levels. The O_2 demand of fresh product is depend on respiration rates, which I turn, depend on temperature. So, MAP (Modified Atmosphere Packaging) is designed for cold-temperature storage, under conditions of temperature abuse, can result in anaerobic conditions and possible growth of dangerous anaerobes. For an example, levels of CO_2, however can be microbial static above 10% and atmosphere with 30%, which help to extend the shelf life, but allowed growth of *Escherichia coli.*

Nevertheless, products can pack in semipermiable plastic films that can be manufactured with different gas transmission rates. Polyvinylchloride (PVC) is most widely used for over wrap packaging. Polypropylene, polyethylene and ethylene vinyl acetate can be combined in laminated or co-extruded films for sealed packages of varying permeability characteristics. Vacuum packaging and gas flushing with certain gas mixes such as O_2, CO_2, and N_2 are generally use.

Some novel gas mixtures, such as high O_2, argon, and nitrous oxide are being explored for the MAP of fresh-cut products.

There is a new technology in packaging of fresh-cut products. It is the incorporation of a patch containing side-chain crystalizable polymers. These acrylic polymers with fatty acid based side chains of various lengths alter in gas permeability characteristics in response to temperature. (Arthey and Ashurst, 2001)

2.5. Dehydrated Vegetables

2.5.1. Definition

There are various definitions to dehydration. Loeseck has defined dehydration as, "the process of removal of surplus water without destruction of cellular tissues, or impairment of the energy". (Loesecke, 1998)

According to Potter, dehydration refers to the nearly complete removal of water from foods under controlled conditions that cause minimum or ideally no other changes in the food properties. (Potter and Hotchkiss, 1996)

2.5.2. Nutritive Value

Dehydration causes a concentration of minerals, fat, protein and carbohydrates, and a reduction in the vitamins. Destruction of vitamins is varying according to the variety of vegetables. Safe drying temperature for most vegetables is 140-145^{0}F / 60-63^{0}C for 3 hours. (Desrocier, 1970 and Loesecke, 1998)

2.5.3. Shelf life, Storage and Packaging

Packaging and storing is important to extend the shelf life of dehydrated vegetables. These products should be protected from insects, rodents and dust.

At present, most of dehydrated vegetables are packed in metal containers. The best package must have a property of against nonenzymatic browning, retention of ascorbic acid and retardation of the disappearance of sulfite in sulfated vegetables.

The storage of dehydrated vegetables under such conditions is to prevent deterioration of their quality, both from nutritive value and flavour. Temperature of storage, light and moisture content of the material are the most important factors for storage life. (Loesecke, 1998)

2.5.4. Cabinet Dryer

Cabinet dryer is useful to dehydrate fruits and vegetables in small-scale and laboratory operations. This dryer consists of a chamber in which trays of product can be placed. Air is blown by a fan pass a heater and then across the trays of material being dried. This is usually the least expensive, easily maintain and quite flexible dryer. (Desrosier, 1970)

2.6. Browning Reaction in Vegetables

Browning of vegetables is a major problem during processing. There are two kinds of browning reactions as enzymatic browning and non-enzymatic browning/ Maillard browning.

2.6.1. Enzymatic Browning

This may be caused by enzymatic oxidations of polyphenols and other susceptible compounds if the oxidation enzymes are not inactivated.

Drying temperatures are not sufficient to inactivate those enzymes. So it is best to pasteurize or blanch vegetables with heat or chemicals prior to drying.

2.6.2. Non-enzymatic Browning

This is the reaction of aldehydes and amino groups of sugars or proteins.

This reaction is flavored by high temperature and high concentration of reactive groups in the presence of some water. This cause most rapidly during drying when moisture content is decreased up to 20-15%. But Maillard browning will stop if moisture content is below 2%. Dryers are normally designed to dehydrate rapidly through the 20-15% moisture range to minimize Maillard browning. (Potter and Hotchkiss, 1996)

2.6.3. Prevention of Browning

Because of the colour changes occur in browning reaction, the appearance of the product will decrease. So it is essential to prevent browning during processing of vegetables.

There are two common methods to prevent foods from browning.

1) Pasteurize or blanch foods with heat
2) Use chemicals

There are three methods of blanching as steam at atmospheric pressure, hot water and series blanching. Series blanching is a modification of water blanching in that soluble solids leached from the products during water blanching are allowed to accumulate to about 4% in the blanching water and maintained at this concentration by the gradual introduction of fill water.

Water blanching causes a greater loss of salts and water-soluble vitamins than steam blanching. Steam blanching is best accomplished in a continuous blancher where the steam temperature is maintained as close to 212^0F. Blanching time is not measured until the product reach 190^0F. This is the best method of blanching.

Blanching has another positive point other than prevention of browning. It aids in preserving vitamins during drying, it make for better keeping quality of the dried product, it improves the colour of pigmented vegetables, it aids in more rapid reconstitution of the dried product, it increase the drying rate, it expels the least part of the O_2 from the tissues and it decrease the bacterial population. (Loesecke, 1998)

Various chemicals can be used to prevent browning such as SMS, citric acid and ascorbic acid.

Lowering of the pH value by addition of permissible acid such as citric retards activity of oxidizing enzymes of fruits. (Cruess, 1958)

Sulphur dioxide is the active part of SMS, which inhibit effectively browning. A sulphite concentration sufficient to maintain a free SO_2 concentration of 10ppm will completely inhibit phenolase.

Ascorbic acid retards browning by virtue of its reducing power which is used along with citric acid to reduce browning. Ascorbic acids act as a reducing agent for the oxidized intermediate of a phenolic compound and thus prevent polymerization and subsequent oxidation of the substrate. (Srilakshmi, 1997)

2.7. Rancidity of coconut

Fats and oils are subject to a very important type of deterioration known as rancidity. Rancidity causes deterioration; it produces a disagreeable odour and flavour in fatty substances. Rancidity of fat is caused by two entirely different kinds of chemical changes.

1) Hydrolytic rancidity – reaction of fats with water and liberation of free fatty acids.
2) Oxidative rancidity – more complex and more damaging reaction. Fat is oxidized and decomposes into compounds with shorter carbon chains such as fatty acids, aldehydes and ketones.

2.7.1. Hydrolytic Rancidity

When presence of water hydrolysis of fats is resulted in the liberation of chemical compounds as fatty acids and glycerol.

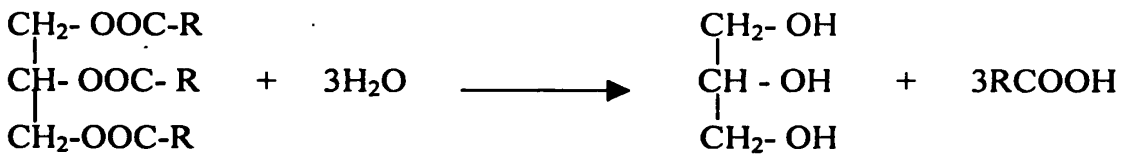


Fig.2.11. Hydrolytic rancidity

The reaction is catalyzed by heat and by enzymes known as lipases.

2.7.2. Oxidative rancidity / Autoxidation

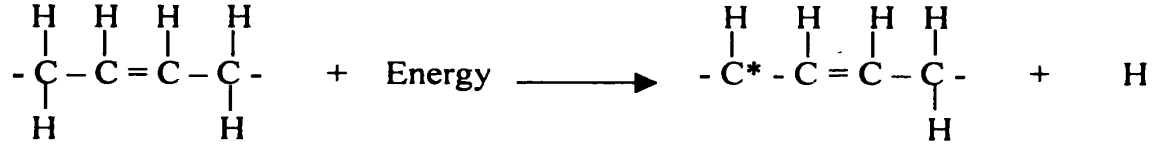
This is the predominate type of rancidity. If more double bonds, the greater opportunity for addition of oxygen to double bonds, increasing risk that fat becomes rancid. This reaction is promoted by heat, light, certain metals (iron, copper) and enzymes known as lipoxygenases.

There are three main stages in this reaction.

1) Initiation
2) Propagation
3) Termination

Initiation: -

This is the formation of a free radical. Hydrogen on a carbon atom adjacent to one carrying a double bond is displaced to give a free radical.



Unsaturated fatty acid | free radical | labile hydrogen

Fig.2.12. Initial stage of autoxidation

These free radicals are unstable and very reactive.

Propagation: -

This involves oxidation of the free radical to give activated peroxide. This, in turn, displaces in hydrogen from another unsaturated fatty acid, forming another free radical. The liberated hydrogen unites with the peroxide to form hydro peroxide, and the free radical can be oxidized as just described. Thus, the reaction can repeats itself.

Hydro peroxides are very unstable and decompose into compounds with shorter carbon chains, such as volatile fatty acids, aldehydes and ketones. These are responsible for the characteristic odour of rancid fats and oils.

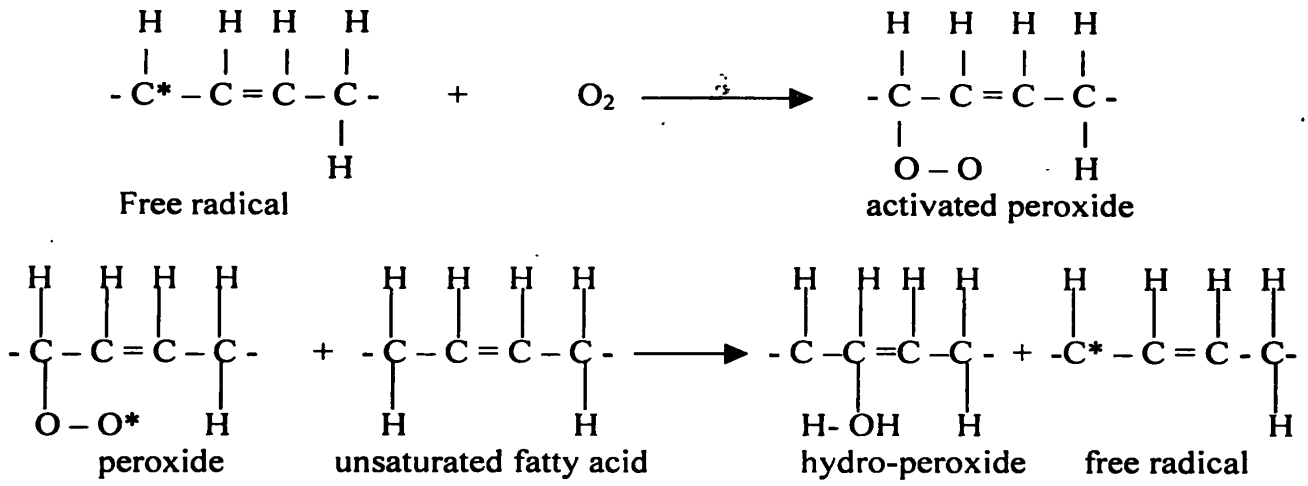


Fig.2.13. The two reactions of the propagation stage of autoxidation

2.7.3. Prevention of Rancidity

Naturally saturated fats are relatively resistant to oxidative rancidity. On the other hand antioxidants can block the oxidative rancidity. Antioxidants prevent rancidity by donating a hydrogen atom to the double bond in a fatty acid and preventing the oxidation of any unsaturated bond. They halt the chain reaction along the fatty acid, which leads to rancidity. Most antioxidants are phenolic compounds. Natural antioxidants appear in the form of tocopherols (vitamin E), ascorbic acid (vitamin C), citric acid, amines and some phenolic compounds.

SO_2 is the mostly usable antioxidant in artificially use. There are other synthetic antioxidants.

1) BHA (butylated hydroxyanisole): - effective in animal fat
2) BHT (butylated hydroxytoluene): - effective in animal fat
3) TBHQ (tertiary-butyl hydroquinone): - for frying process rather than baking
4) Propyl gallate

(Kordylas, 1990 and Vaclavik and Christian, 1998)

On the other hand some spices have antioxidant properties like turmeric, pepper, etc. Curcumin in turmeric is responsible for the antioxidant properties. The antioxidant index of turmeric is more than 5. It protects oil in water emulsion and edible fats against O_2 agsorptio and peroxide development. It was found to have a stabilizing action on coconut, groundnut, mustard, safflower, sesame oil and ghee. (Nethsingha and Paskaranathan, 1976)

2.8. Sensory Evaluation

2.8.1. Definition

Sensory evaluation is 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.

2.8.2. Interaction with other departments

In addition to the product development, sensory evaluation may provide information to other corporate departments.

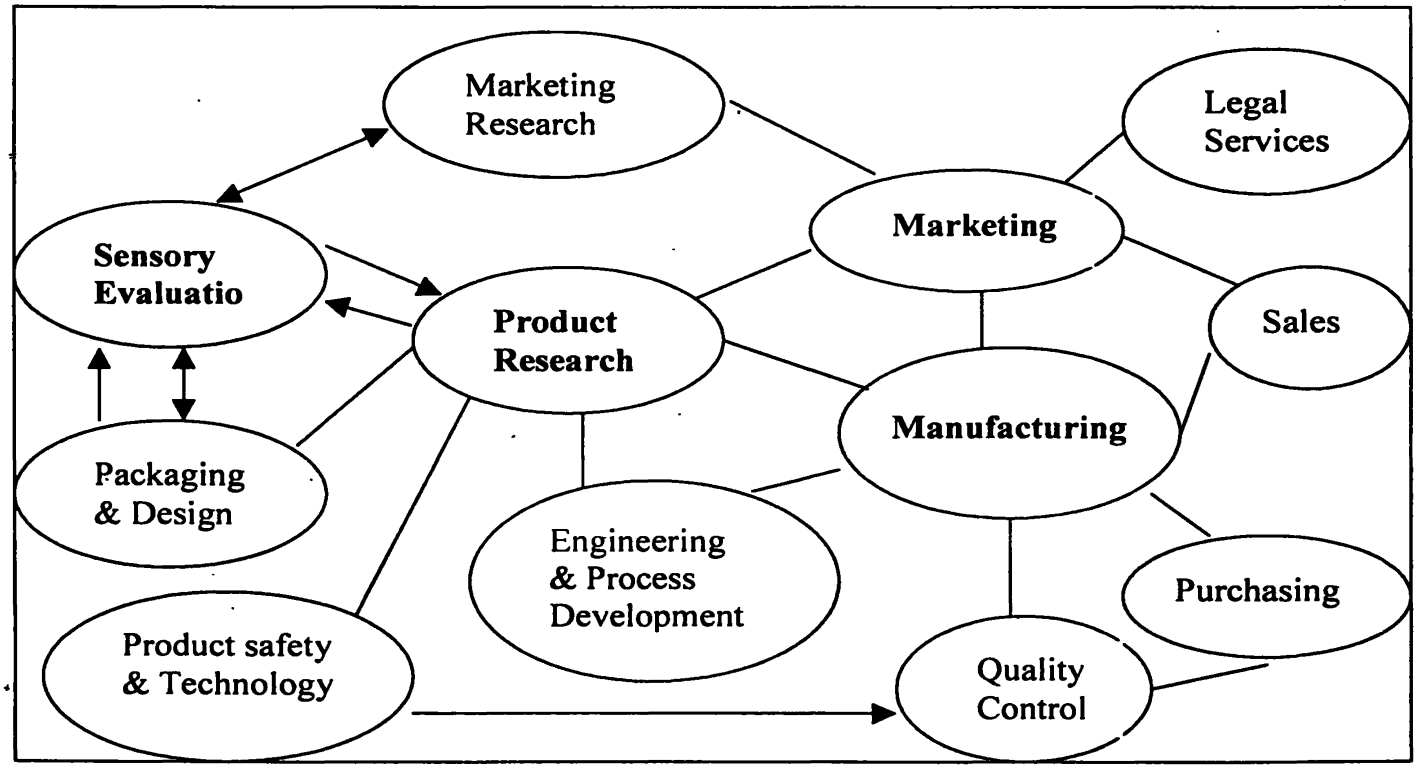


Fig.2.14. Interacting Departments of sensory evaluation

Their primary interaction is in support of product research and development. However, they may also interact with quality control, marketing research, packaging and design groups and even legal services over issues such as claim substantiation and advertising challenges.

2.8.3. Sensory Characteristics of Foods

There are various sensory characteristics of food such as appearance, colour, flavour, odour, taste, mouth feel and psychological factors.

2.8.3.1. Appearance

Surface characteristics of food products contribute to the appearance. The size, shape, colour of food and such characteristics as transparency, opaqueness, turbidity, dullness and gloss can be judged by appearance.

2.8.3.2. Colour

In addition to giving pleasure, the colour of food is associated with other attributes. Colour is used as an index to the quality of a number of foods.

2.8.3.3. Flavour

The flavour of food has three components: odour, taste and a composite of sensations known as mouth feel. Texture and consistency can be found out by mouth feel. The brittleness, tenderness and astringency are also texture characteristics, which can be identified by mouth feel.

2.8.3.4. Odour

The odour of food means immeasurably to the pleasure of eating. It is estimated that the olfactory sense of man has the capacity to distinguish 16 million odours.

2.8.3.5. Taste

Taste sensations that the taste buds register are categorized as sweet, salt, sour or bitter. Taste buds in the different areas of the tongue are not equally sensitive to all taste stimuli and at least some taste cells response to more than one stimulus. Taste buds near the tip of the tongue are more sensitive to sweet and salt and also the sides sensitive to sour and near the back to bitter.

2.8.3.6. Psychological Factors

In addition to those factors, psychological factors contribute to the acceptability of foods. Food is accepted, when there is pleasant association.

2.8.4. Requirements for conducting sensory tests

1) Trained panel members
2) Testing laboratory
3) Sample preparation and presentation
4) Techniques of smelling and tasting
5) Testing time
6) Design of the experiment and analysis of the result

2.8.5. Types of sensory tests

Different sensory tests are used for food evaluation, which can be grouped into four types.

1) Difference tests
2) Rating tests
3) Sensitivity tests
4) Descriptive tests

2.8.6. Limitations of Sensory evaluation

There are some limitations in sensory evaluation.

1) The results may be highly variable.
2) People with colds or other health problems temporarily lose their maximum effectiveness.
3) Emotional burdens may influence an individual's ability.

(Srilakshmi, 1997 and Lawies and Heymann, 1998)

2.9. Physico-chemical properties assessment

2.9.1. Moisture Content

Moisture content of foods varies greatly according to the food product. Water is a major constituent of most food products.

The ease of water removal from foods depends on how it exists in the food product. There are three states of water in a food product.

1) Free water: - This water retains its physical properties and acts as the dispersing agent for colloids and the solvent for salts.
2) Adsorbed water: - This water is occluded in cell walls or protoplasm and is held tightly to proteins.
3) Water of hydration: - This water is bound chemically to the food product.

2.9.2. Total Solids

The dry matter that remains after moisture removal is commonly called as total solids.

Percentage of total solids = 100 – (%moisture)

2.9.3. Methods use to determine moisture content

There are several methods, which are commonly used to determine moisture in a food sample.

1) Oven drying method
2) Distillation methods (Dean and Stark distillation method)
3) Chemical method (Karl Fischer titration)
4) Physical methods
    - Electrical methods
    - Refractometry
    - Hydrometry
    - Infrared analysis
    - Freezing point

2.9.4. Oven drying method

In this procedure, the sample is heated under specified conditions and the loss of weight is used to calculate the moisture content of the sample. The moisture content value is dependent on the type of oven used, conditions within the oven and the time and temperature of drying.

2.9.4.1. Removal of moisture

Free water is the easiest of the three forms of water to remove. Moisture removal is sometimes done as a two-stage process. Liquid products are commonly pre-dried over a steam bath and then dry in an oven. Products such as bread, field-dried grain are air dried first and then oven dried. Particle size, particle size distribution, sample size and surface area during drying influence the rate and efficiency of moisture removal.

2.9.4.2. Decomposition of other food constituents

Moisture loss from a sample during analysis is a function of time and temperature. For decomposition time is extended too much or temperature is too high. For example, carbohydrate decomposes at 100^0C according to the following reaction.

$$C_6H_{12}O_6 \longrightarrow 6C + 6H_2O$$

The water generated in carbohydrate decomposition is not the moisture that we want to measure. But there are certain other chemical reactions such as sucrose hydrolysis can result in utilization of moisture, which would reduce the moisture for measurement.

2.9.4.3. Temperature Control

Drying methods utilize specified drying temperatures and times, which must be carefully controlled. There may be variability of temperature depending on the type of oven used for moisture analysis. So, the most suitable type should be selected.

2.9.4.4. Calculations

Moisture and total solids contents of foods can be calculated as follows using oven drying procedures.

% Moisture (wt/wt) = (wt H2O in sample/ wt of wet sample) * 100

% Total solids (wt/wt) = (wt of dry sample/ wt of wet sample) * 100

(Nielson, 1998)

CHAPTER 03

Materials and Method

3.1. Materials

3.1.1. Materials for the determination of best antioxidant

Materials: -

- Scraped coconut
- SMS
- Citric acid
- Turmeric powder
- Pepper
- Glacial acetic acid
- Chloroform
- Saturated K_2I
- Distilled water
- Starch

Apparatus: -

Polypropelene
Sealer
Electronic balance
Refrigerator
Measuring cylinders (500ml, 100ml)
10 ml beaker
1 ml pipette

3.1.2. Materials for determination of residual SMS

Materials: -

- Young jackfruit
- SMS
- Standard I_2 solution
- Conc. HCl
- Distilled water

Apparatus: -

Round-bottomed flask
Heating mantel
Funnel
Condenser
Beaker
Electronic balance
Burette

3.1.3. Materials for preparation of Minimally processed Young Jackfruit Mallun

Raw materials: -

- Young jackfruit
- Scraped coconut
- Onions
- Garlic
- Green chilies
- Pepper turmeric
- Curry leaves
- Mustard
- Distilled water
- SMS

Apparatus: -

Electronic balance
Stainless steel knife
Cutting board
Stainless steel sauce pans
Measuring cylinder (500ml)
Sterilized bottles (jam)
Polypropelene
Sealer
Refrigerator

3.1.4. Materials for preparation of Dehydrated Young Jackfruit Mallun

Raw materials: -

- Young jackfruit
- Scraped coconut
- Onions
- Garlic
- Green chilies
- Pepper turmeric
- Curry leaves
- Mustard
- Distilled water
- SMS

Apparatus: -

Electronic balance
Stainless steel knife
Cutting board
Stainless steel sauce pans
Measuring cylinder (500ml)
Sterilized bottles (jam)
Polypropelene
Sealer
Refrigerator
Cabinet dryer
Desiccators
Muslin cloth
Thermometer
Trays

3.1.5. Materials for Physico-chemical Assessments

Materials: -

- Three 5 g samples of minimally processed young jackfruit Mallun
- Three 5 g samples of dehydrated young jackfruit Mallun

Apparatus: -

- Moisture dishes with lids (clean, dry)
- Cabinet dryer
- Electronic balance
- Desiccators

3.1.6. Materials for Sensory Evaluation

- Standard ballot papers
- Coded sample
- Glasses of portable water
- Cream-cracker biscuits

3.1.7. Materials for Shelf-life Evaluation

- Two coded samples of dehydrated and minimally processed young jackfruit Mallun
- Electronic balance

3.1.8. Materials for determination of Rehydration ratio

- Dehydrated young jackfruit Mallun sample
- Water
- Beaker
- Petri dish
- Electronic balance

3.2. Methodology

3.2.1. Determination of best antioxidant

50 g of scraped coconut was measured and 5 g of SMS was added to it and mixed. It was divided into 10 samples (5g samples) and packed. Then the samples were stored in refrigerator. The same procedure was followed for citric acid, turmeric and pepper. One sample was prepared without any antioxidant. Peroxide test was done everyday for each sample.

Peroxide test: -

5 g sample

↓

Add 30ml glacial acetic: $CHCl_3$ (3:2)

↓

Add 0.5ml-saturated K_2I

↓

Keep 2-3 minutes in dark

↓

Add 30ml-distilled water

↓

Add starch solution

↓

Observe colour change

5 g of sample was taken and 30 ml of glacial acetic: $CHCl_3$ (3:2) was added to it. Then 0.5 ml of saturated K_2I was added and the mixture was kept 2-3 minutes at dark. Then 30 ml distilled water and few drops of freshly prepared starch solution were added to it. The colour change was observed. If the coconut is rancid, blue colour can be seen in the solution.

3.2.2. Determination of residual SMS

Young jackfruit Mallun was prepared using 0.3% SMS solution. Then residual SMS was determined using Monier Willium's method.

6.35 g of Iodine and 9.77 g of KI_2 were dissolved in 50ml of water. When Iodine dissolves, it was transferred to a glass stopped one-liter volumetric flask, diluted to volume with water and mixed thoroughly. The solution was stored in dark brown glass stopped bottles away from light.

Monior-Willium method: -

First the following apparatus were set.

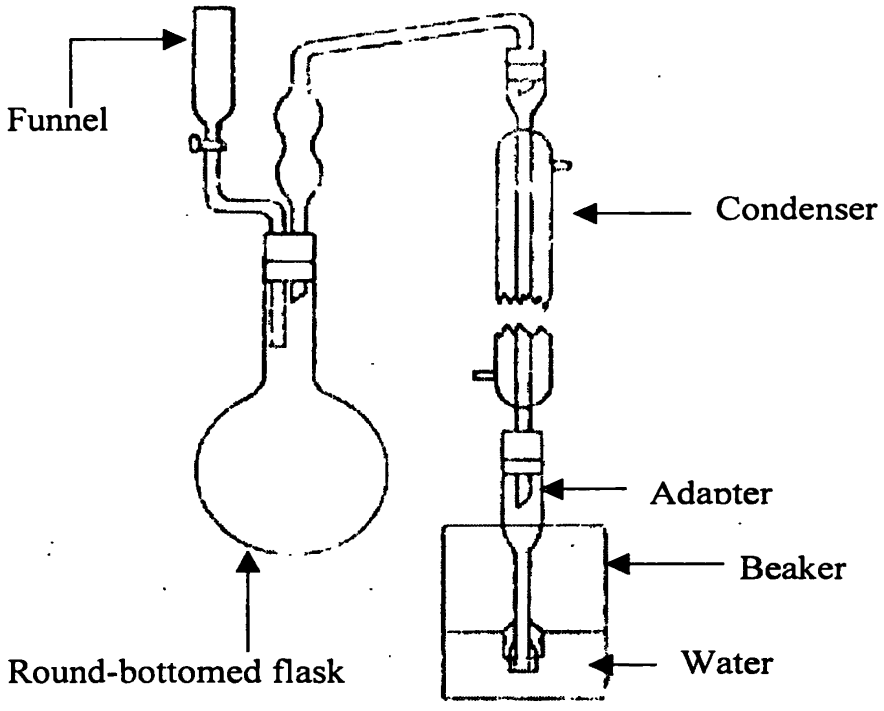
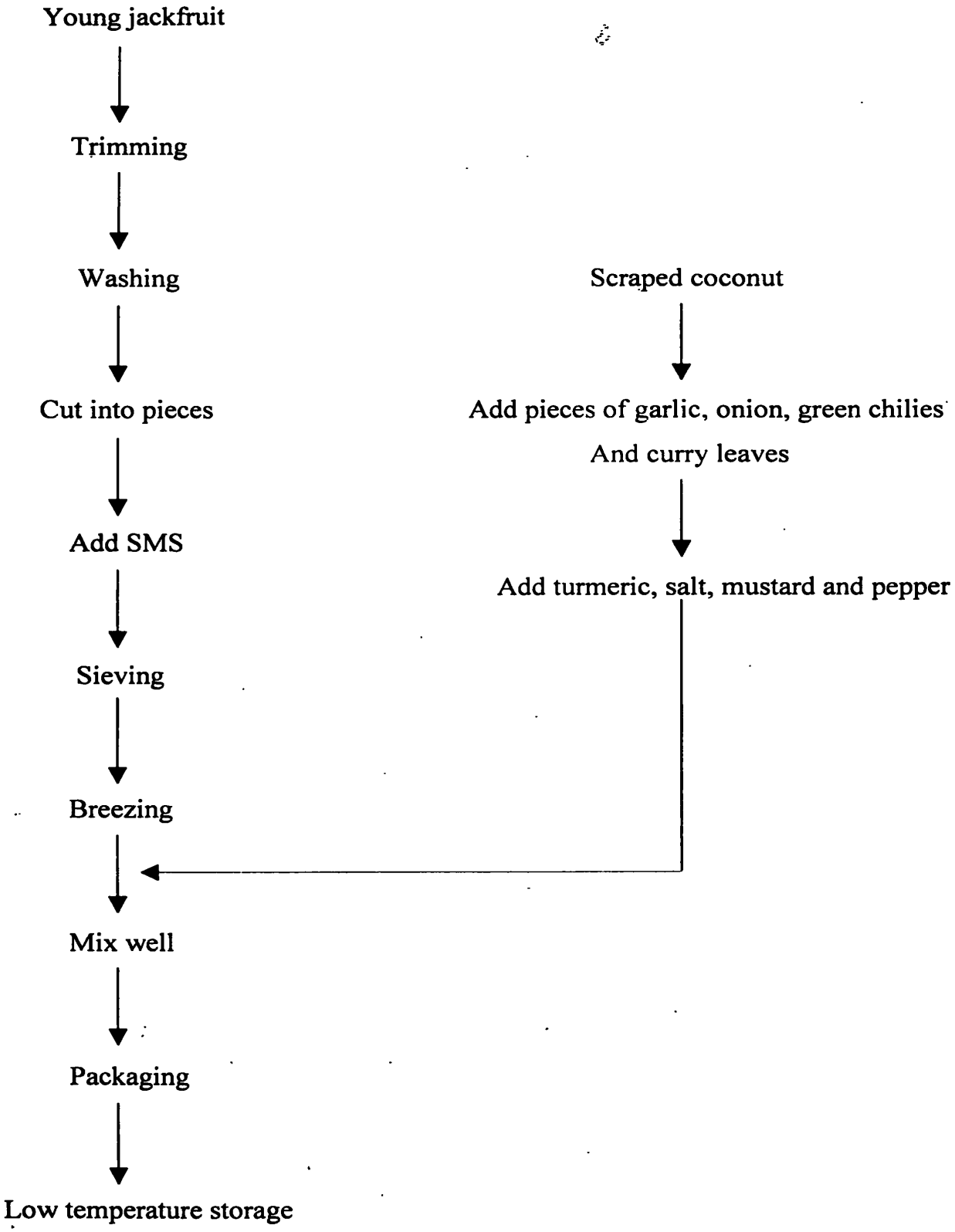


Fig.3.1. Apparatus of Monior- Willium method

200ml of water was boiled in the round-bottomed flask of the apparatus in the figure, cooled and 30 g of the sample was added. The apparatus were connected up and 20ml of conc.HCl was added through the funnel. Then round-bottomed flask was boiled quickly. The distillate was collected from the condenser in a larger beaker containing water, starch solution and a drop or more of iodine solution from a burette as the distillation proceeds. So the blue colour was just remained. Most of the SMS was usually evolved within 5 minutes boiling but the experiment was done the end point when the blue colour persists for 1 minute. The same procedure was repeated three times. Then the readings were recorded. (SLS 221:1985 UDC 663.85)

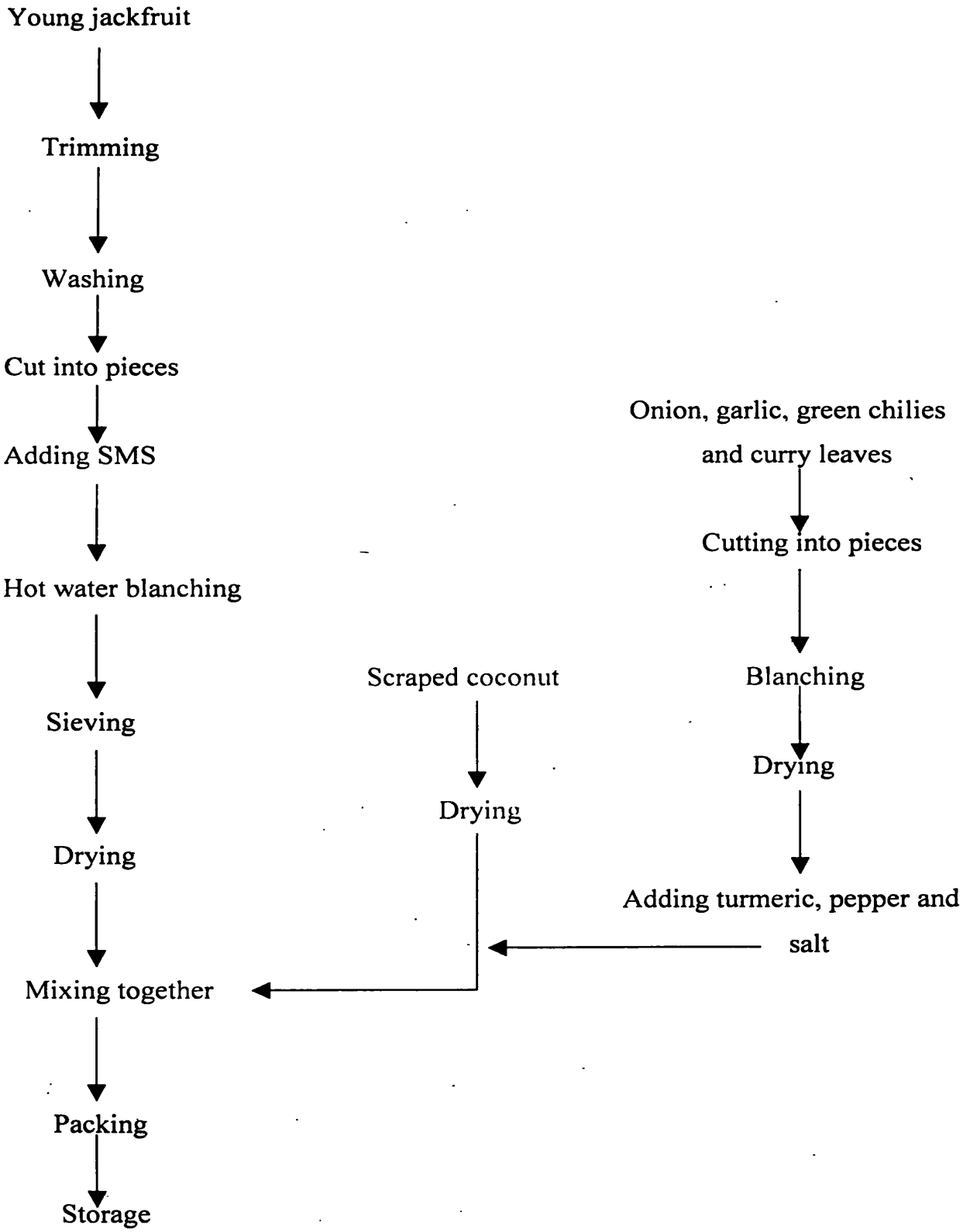
3.2.3. Preparation of Minimally processed young jackfruit Mallun



Young jackfruit was taken. Then it was trimmed, washed, cut into pieces and added SMS. Then the pieces were sieved and breezed. One pound of pieces were weighed.

4 owns of scraped coconut was weighed. 6-7 cloves of garlic, 2 oz of onion, 0.5 oz of green chilies and a sprig of curry leaves were cut into small pieces and added to scraped coconut. And also 0.5 teaspoon of turmeric, 2.5 teaspoon of salt, 3 teaspoon of mustard and 2 teaspoon of pepper were added. Then they were mixed well and packed. Then the product was stored under low temperature condition (refrigerator).

3.2.4. Preparation of Dehydrated young jackfruit Mallun



Young jackfruit was taken. Then it was trimmed, washed, cut into pieces and added SMS. Then the pieces were sieved and breezed. One pound of pieces were weighed. Then the pieces were blanched with hot water, sieved and dehydrated in the electric oven about 3 hours at65^{0}C. The pieces of 6-7 cloves of garlic, 2 oz of onion, 0.5 oz of green chilies and a sprig of curry leaves were dehydrated under same temperature. And also 4 oz of scraped coconut were dehydrated at 88^{0}C for about 45 minutes.

Dehydrated scraped coconut, pieces of curry leaves, pieces of garlic, pieces of onion, pieces of green chilies and dehydrated young jackfruit were mixed with 0.5 teaspoon of turmeric, 2.5 teaspoon of salt, 3 teaspoon of mustard and 2 teaspoon of pepper. Then the mixture was packed and stored in cool, dry place.

3.2.5. Physio-chemical assessments

Moisture dishes were cleaned and dried with the lids in an oven at 105^{0}C and cooled in a desiccator. Then they were weighed by using an electronic balance. 5 g of the sample of minimally processed young jackfruit Mallun was placed on previously weighed dish (W_1) and weighed again (W_2). Another two samples of this were placed on previously weighed dishes and weighed again. Then these three dishes were placed in an oven maintained at 105^{0}C for three hours and cooled in a desiccator to room temperature and weighed. Drying, cooling and weighing were repeated until a constant weight (W_3) was obtained.

The same procedure was followed for three dehydrated young jackfruit Mallun samples.

3.2.6. Sensory Evaluation

Sensory evaluation was carried out to compare the minimally processed and dehydrated young jackfruit Mallun samples. Five sensory characteristics (taste, colour, smell, appearance and overall acceptability) were evaluated with 30 untrained consumer's type panelists by giving standard ballot paper. The five point hedonic scale was used to evaluate the degree of liking for particular sensory attributes.

Both minimally processed and dehydrated young jackfruit Mallun samples were cooked about 5-8 minutes with portable water. The samples were coded using three digits random numbers. Coded samples, ballot papers, cream-cracker biscuits and glasses of portable water were given for each and every panelist. Collected data were statistically analyzed by using Kruskal-Wallis non-parametric Minitab software statistical package.

3.2.7. Shelf life Evaluation

Both dehydrated and minimally processed young jackfruit Mallun samples were prepared. (25 packets (5 g) of dehydrated Mallun samples and 10 packets (10 g) of minimally processed Mallun samples). Then the colour, flavour, smell and weight changes were measured day by day. The results were recorded.

3.2.8. Rehydration ratio of the dehydrated young jackfruit Mallun sample

5 g of dehydrated young jackfruit Mallun sample was weighted out. The sample was put into a beaker and about 40 ml of water was added. Then the beaker was covered with a petri dish and it was boiled in a water bath about 30 minutes. Then the excess water was removed a using blotting paper. Then the sample was weighted.

CHAPTER 04

Results and Discussion

4.1. Determination of Best Antioxidant

The colour change of freshly prepared starch solution was observed. If the coconut is rancid, the blue/ dark brown colour can be seen in the solution.

Table 4.1 Observations of Peroxide test

Time Duration	Sample 01	Sample 02	Sample 03	Sample 04
After 24 hrs	No change	No change	No change	No change
After 48 hrs	No change	No change	No change	No change
After 72 hrs	No change	No change	No change	No change
After 96 hrs	No change	No change	No change	No change
After 120 hrs	No change	No change	No change	No change
After 144 hrs	No change	Blue colour	No change	No change
After 168 hrs	Blue colour	Blue colour	No change	No change
After 192 hrs	Blue colour	Blue colour	No change	No change
After 216 hrs	Blue colour	Blue colour	No change	Blue colour
After 240 hrs	Blue colour	Blue colour	No change	Blue colour

Sample 01 - SMS added coconut sample

Sample 02 - Citric acid added coconut sample

Sample 03 - Turmeric added coconut sample

Sample 04 - Pepper added coconut sample

Among the two artificial antioxidants (SMS and Citric acid) and two natural ones (turmeric and pepper), were resulted good results. Among turmeric and pepper, turmeric was the best one. After 10 days, turmeric added coconut sample was not resulted a rancidity. Pepper added sample could be stored 8 days (192 hrs) without rancidity. So, the best antioxidant was turmeric for coconut. They were best than famous artificial antioxidants. It was better because, addition of these spices (turmeric and pepper) is not harmful for human health.

So, the two natural antioxidants (turmeric and pepper) were better with compare to artificial antioxidants.

4.2. Determination of Residual SMS

From the former studies, it was determined that the best SMS level for prevent browning in young jackfruit is 0.3%. (Priyadarshana, 2003) So, it was used and the residual SMS was determined by Monier-Willium method. End point reading was taken three times for accuracy of the experiment.

Table 4.2 Readings of the titration

	Burette reading (ml)
First reading	1.2
Second reading	1.3
Third reading	1.2

Residual SMS was determined by using SO_2 level in the sample in ppm.

SO_2 in ppm $= V * 0.016 / w * 10^{-6}$

1ml 0.05N I_2 = 0.016 g of SO_2

V – Needed iodine amount of the titration

W – Weight of the sample

Calculation: -

Average iodine amount of the titration = (1.2 + 1.3 + 1.2) / 3

= 1.233 ml

SO_2 in ppm = $1.233 * 0.016 * 10^{-6} / 30 * 10^{-3}$

= $0.0006578 * 10^{-3}$

= 65.78 ppm

According to the results the residual SMS level of the sample was about 66 ppm. Normal SMS level for Ready to Serve fruit drinks also 70 ppm. So, the residual SMS level is not harmful for human health. It is suitable for human consumption according to the SLS standards. (SLS 221:1985 UDC 663.85)

4.3. Preparation of Minimally processed young jackfruit Mallun

The final product after packaging was looked like a freshly prepared one. Because, all the ingredients were in fresh state. The colour, smell and appearance were good. The product was stored in refrigerator after packaging.

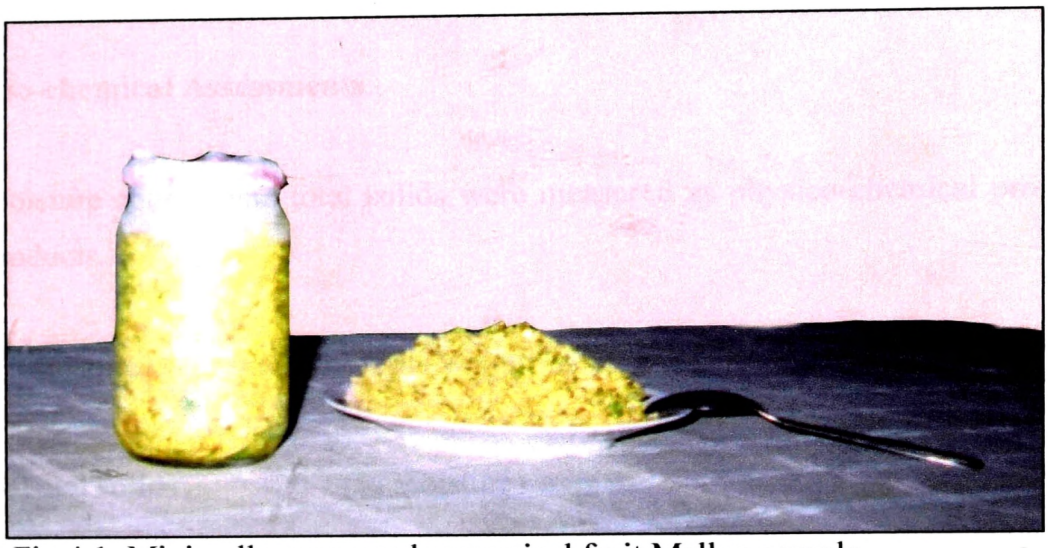


Fig.4.1. Minimally processed young jackfruit Mallun sample

4.4. Preparation of Dehydrated young jackfruit Mallun

The final product after packaging was not similar to minimally processed sample in colour and appearance. Some jackfruit pieces were turned in to brown colour, because has over drying. Colour of other pieces, smell of the product and appearance were good. The product was stored in cool, dry place.

Fig.4.2. Dehydrated young jackfruit Mallun sample

4.5. Physio-chemical Assessments

Moisture content and total solids were measured as physico-chemical properties in both products.

% Moisture = weight loss / weight of sample * 100

% Total solids = 100 – (% moisture)

Average moisture content of minimally processed sample = 75.38%

Average total solids of minimally processed sample = 24.62%

Average moisture content of dehydrated sample = 27.6%

Average total solids of dehydrated sample = 72.4%

Average moisture content of minimally processed sample was higher than the dehydrated sample. It was more than 75%. Because, most of the ingredients in that sample (young jackfruit, coconut, onion, green chilies, garlic and curry leaves) were in raw state. But all the ingredients in dehydrated sample were completely dehydrated. So, the average moisture content of that sample was lower than the other one.

4.6. Sensory Evaluation

If the probability value is higher than the normal probability value that is required for the test to be significant and reject H0. If the probability value is lower than the normal probability value, accept H0.

H0: There is no significant difference between the characteristics of two samples.

H1: There is a significant difference between the characteristics of two samples.

The results of sensory evaluation conducted to determine most appropriate characteristics of the samples are given below.

According to the revealed of Kruskal-Wallis test, there is no significant different between the colour of two samples. (P = 0.496)

According to the revealed of Kruskal-Wallis test, there is no significant different between the smell of two samples. (P = 0.546)

According to the revealed of Kruskal-Wallis test, there is no significant different between the taste of two samples. (P = 0.894)

According to the revealed of Kruskal-Wallis test, there is no significant different between the appearance of two samples. (P = 0.164)

According to the revealed of Kruskal-Wallis test, there is no significant different between the overall acceptability of two samples. (P = 0.456)

Table 4.3 Average ranks of the five characteristics

Character	Sample code	Average rank
1) Colour	254	29.1
	542	32.0
2) Smell	254	29.2
	542	31.8
3) Taste	254	30.2
	542	30.8
4) Appearance	254	33.5
	542	27.5
5) Overall acceptability	254	28.9
	542	32.1

According to the average ranks of the samples dehydrated sample (sample code 542) was better than the minimally processed sample among colour, smell, taste and overall acceptability. But the appearance was best in minimally processed sample.

4.7. Shelf life Evaluation

The weight, colour changes, flavour changes, smell and appearance were observed for both samples.

4.7.1. Minimally Processed sample

Table 4.4 Storage characteristics of minimally processed sample

Storage days	Weight	Colour	Flavour	Smell	Appearance
0	10.2 g	Good	Good	Good	Good
1	10.1 g	Good	Good	Good	Good
2	10.1 g	Good	Good	Good	Good
3	10.1 g	Good	Good	Good	Good
4	10.3 g	Good	Good	Good	Good
5	10.3 g	Some pieces were turned to brown	Good	Good	Not good
6	10.5 g	Some pieces were turned to brown	Good	Good	More watery
7	10.6 g	More pieces were turned to brown	Good	Good	More watery

According to the results best storage life of minimally processed young jackfruit Mallun is around 4-5 days. This is the normal shelf life of fresh-cut products. (Arthey and Ashurst, 2001)

4.7.2. Dehydrated sample

Table 4.5 Storage characteristics of dehydrated sample

Storage days	Weight	Colour	Flavour	Smell	Appearance
0	5.1 g	Good	Good	Good	Good
1	5.1 g	Good	Good	Good	Good
2	5.1 g	Good	Good	Good	Good
3	5.2 g	Good	Good	Good	Good
4	5.1 g	Good	Good	Good	Good
5	5.1 g	Good	Good	Good	Good
6	5.2 g	Good	Good	Good	Good
7	5.2 g	Good	Good	Good	Good
8	5.1 g	Good	Good	Good	Good
9	5.1 g	Good	Good	Good	Good
10	5.1 g	Good	Good	Good	Good
11	5.1 g	Good	Good	Good	Good
12	5.1 g	Good	Good	Good	Good
13	5.2 g	Good	Good	Good	Good
14	5.2 g	Some coconut pieces (2-3) Turn to light orange	Good	Good	Not good
15	5.1 g	Same as above	Rancid flavour	Good	Not good
16	5.2 g	Same as above	Rancid flavour	Rancid smell of coconut	Not good

According to the results best storage life of dehydrated young jackfruit Mallun is around 13-14 days in normal room temperature. After 14^{th} day, a rancid flavour and rancid smell was observed. So, after 14^{th} day the product is not good for human consumption. Till the 14^{th} day colour of coconut and young jackfruit pieces were good. Then some coconut pieces were turned to brown. Hence the appearance of the product was bad.

4.8. Reconstitution ratio of dehydrated young jackfruit Mallun sample

$$\text{Reconstitution ratio} = \frac{\text{weight of rehydrated sample}}{\text{weight of dried sample}}$$

$$= \frac{22.32\ \text{g}}{5.00\ \text{g}}$$

$$= 4.46 : 1$$

So, the Rehydration ratio of dehydrated sample was 4.46 to 1.

CHAPTER 05

Conclusion and Recommendations

5.1. Conclusion

- The two natural antioxidants (turmeric and pepper) were better with compare to artificial antioxidants. (SMS and citric acid)
- The minimally processed product contains 75.38% moisture and 24.62% total solids. The product can store for about 4-5 days.
- The dehydrated product contains 27.6% moisture and 72.4% total solids. This product can store for about 13-14 days. The reconstitution ratio for this product is 4.46.It can be considered as a pre-cooked natural product.
- Dehydrated sample (sample code 542) was better than the minimally processed sample among colour, smell, taste and overall acceptability. But the appearance was best in minimally processed sample.
- There is significantly high demand for the product due to the complex life style. The product would be successfully marketed at a reasonable price. It will be compatible with the living standard of busy lives of the people.

5.2. Recommendation

- Selection of another type of powerful antioxidant compound like Vitamin E, is recommended to extend the shelf life of the dehydrated young jackfruit Mallun sample.

References

Arthey, D. and Ashurt, (2001) Fruit Processing –Nutrition, Products and Quality Management, An Aspen Publication, 2nd Ed, 312p.

Cruess, W.V., (1958) Commercial fruit and vegetable products, McGraw-hill book Company, 884p.

Davidek, J., Velisek, J. and Pokorny, J. (1990) Chemical changes During Food Processing, Elsevier Science Publishers, 448p.

Desrosier, N.W., (1970) The Technology of Food Preservation, The AVI publishing Company, 3rd Ed, 493p.

Grimwood, B.E., Ashman, F., Jarman, C.G., Dendy, D.A.V., Little, E.C.S. and Timmins, W.H. (1975) Coconut Palm Products, Published by Food and Agriculture organization of the United Nations, 261p.

Gunasena, H.P.M. (1993) Documentary survey of Artocarpus heterophillus (jackfruit) in Sri Lanka, v.02.

Gunasena, H.P.M., Ariyadasa, K.P., Wickramasinghe, A., Herath, H.M.W., Wickramasinghe, P. and Rajakaruna, S.B. (1996) Manual on jak cultivation in Sri Lanka, Published by: Forestry information service, Forest department, 48p.

Kordylas, J.M. (1990) Processing and Preservation of Tropical and Subtropical Foods, Macmillan Education Ltd, 414p.

Lawles, H.T. and Heymann, H. (1998) Principles and practices, Sensory evaluation of food, 827p.

Luesecke, H.W.V. (1999) Drying and Dehydration of foods. Allied Scientific Publishers, 2nd Ed, 300p.

Nethsingha, C. and Paskaranathan, U. (1976) Spices and Essential oil bearing Plants. No.4, Turmeric- a literature survey, Published by Ceylon Institute of Scientific and Industrial Research and National Science council of Sri Lanka, pp.11-13.

Nielson, S.S. (1998) Food Analysis, An Aspen Publication, 2nd Ed. 630p.

Norman, J., (1990) The complete book of Spices- A practical guide to spices and aromatic seeds, Dorling Kindersley- London, 160p.

Potter, N.N. and Hotchkiss, J.H. (1996) Food Science, CBS publishers and Distributors, 5th Ed, 608p.

Priyadarshana, S.M.P.T., (2003) Development of fresh cut vegetables (Elabatu, banana blossom, immature jackfruit), Faculty of Applied sciences, Buttala.

Rajapaksha, U. (1998) Traditional food plants in Sri Lanka, Hector Kobbekaduwa Agrarian Research and Trading Institute, 529p.

Ranaweera, S. and Ranaweera, R. (2003) Food, Nutrition and Health, Published by Wasana publishers, 127p.

Rice, R.P., Rice, L.W. and Tindall, H.D. (1990) Fruit and Vegetable production in Warm climates, Published by The Macmillan Press Ltd.. 486p.

Rose, T.K. and Mitra, S.K. (1990) Fruits: Tropical and subtropical, pp838-649.

Specification for Synthetic / Artificial cordials (First Revision) SLS 221:1985, UDC 663-85, Sri Lanka Standard Institute, pp.11-12.

Srilakshmi, B. (1997) Food Science, New Age International (P) Limited publishers, 521p.

Vaclavik, V.A. and Christian, E.W. (1998) Essentials of Food Science, An Aspen Publication, 417p.

Appendix 01

THE BALLOT SHEET

Name: ..... Date: .....

Product: Instant Polos Mallun

You have given two different instant Polos Mallun samples, which are prepared by two methods.

Like extremely.....5
Like moderately.....4
Like slightly.....3
Dislike moderately.....2
Dislike extremely.....1

Please taste these samples and check how much you like or dislike each one by using above scale.

Sample code	Colour	Smell	Taste	Appearance	Overall acceptability

Comments:.....
.....
.....

Thank you!!!

Appendix 02

Analyzed results of Kruskal-Wallis statistical test

Kruskal-Wallis Test on Colour

Kruskal-Wallis Test on Colour

C1	N	Median	Ave Rank	Z
1	30	4.000	29.1	-0.64
2	30	4.000	32.0	0.64
Overall	60		30.5	

H = 0.41 DF = 1 P = 0.520
H = 0.46 DF = 1 P = 0.496 (adjusted for ties)

Kruskal-Wallis Test on Smell

Kruskal-Wallis Test on Smell

C1	N	Median	Ave Rank	Z
1	30	4.000	29.2	-0.58
2	30	4.000	31.8	0.58
Overall	60		30.5	

H = 0.33 DF = 1 P = 0.564
H = 0.36 DF = 1 P = 0.546 (adjusted for ties)

Kruskal-Wallis Test on Taste

Kruskal-Wallis Test on Taste

C1	N	Median	Ave Rank	Z
1	30	4.000	30.2	-0.13
2	30	4.000	30.8	0.13
Overall	60		30.5	

H = 0.02 DF = 1 P = 0.900
H = 0.02 DF = 1 P = 0.894 (adjusted for ties)

Kruskal-Wallis Test on Appearance

Kruskal-Wallis Test on Appearance

C1	N	Median	Ave Rank	Z
1	30	4.000	33.5	1.32
2	30	4.000	27.5	-1.32
Overall	60		30.5	

H = 1.73 DF = 1 P = 0.188
H = 1.93 DF = 1 P = 0.164 (adjusted for ties)

Kruskal-Wallis Test on Overall acceptability

Kruskal-Wallis Test on Overall acceptability

C1	N	Median	Ave Rank	Z
1	30	4.000	28.9	-0.69
2	30	4.000	32.1	0.69
Overall	60		30.5	

H = 0.48 DF = 1 P = 0.487
H = 0.55 DF = 1 P = 0.456 (adjusted for ties)

National Digitization Project

National Science Foundation

Institute : Sabaragamuwa University of Sri Lanka

1. Place of Scanning : Sabaragamuwa University of Sri Lanka, Belihuloya

2. Date Scanned : ...2017-09-21.....

3. Name of Digitizing Company : Sanje (Private) Ltd, No 435/16, Kottawa Rd, Hokandara North, Arangala, Hokandara

4. Scanning Officer

Name : ....S.A.C. Sandaruwan.....

Signature : .....

Certification of Scanning

I hereby certify that the scanning of this document was carried out under my supervision, according to the norms and standards of digital scanning accurately, also keeping with the originality of the original document to be accepted in a court of law.

Certifying Officer

Designation : LIBRARIAN.....

Name : T.N. NEIGHSOOREI.....

Signature : .....

Date : ....2017-09-21.....

Mrs. T.N. NEIGHSOOREI
(MSSc.PGD.ASLA,BA)
Librarian
Sabaragamuwa University of Sri Lanka
P.O.Box 02,Belihuloya,Sri Lanka
Tele:0094 45 2280045
Fax:0094 45 2280045

"This document/publication was digitized under National Digitization Project of the National Science Foundation, Sri Lanka"