Evaluation of Canned Papaya (*Carica papaya*) and Guava (*Psidium guajava* L.) Fruits in Sudan

By

Fardoos Yassin Abdalatif Saeed

B.Sc. (Honors) in food science and technology

Faculty of agriculture

University of Al- Zaiem Al-Azhari

2003

A dissertation

Submitted to the University of Khartoum in Partial Fulfillments of the Requirement for the Degree of Master of Science in Food Science and Technology

Supervisor

Dr. Hassan Ali Mudawi

Department of Food Science and Technology

Faculty of Agriculture

University of Khartoum

June 2007
Dedication

This study is dedicated with gratitude to

my

Mother

Father

Husband

Brothers and Sisters

All my friends and all whom I love

Fardoos
Acknowledgements

First and for most I'm grateful to Allah for giving me strength to fulfill this work.

I would like to express my sincere appreciation and deep gratitude with special respect to my supervisor Dr. Hassan Ali Mudawi for kindness, understanding and critical supervision during the whole research period.

I am also very grateful to Prof. Abd Elhaleem Rahma and Dr. Babker Elwasela. My greatest appreciation to Nada Mukhtar for printing this dissertation.

Thanks are extended to my best friends Nihad, Salwa, Gada for help in practical side of this research.

Finally I am grateful to every one who contributed with direction and assistance till the completion of this work.
ABSTRACT

The Papaya (*Carica Papaya*) and Guava (*Psidium guajava*) are widely grown in the Sudan, where the fruits are usually consumed in fresh form. Many producing areas in the country are known to have a surplus of production which could be wasted because of the seasonality of production, difficulties in marketing and the perishable nature of the products.

The objective of the research was an effort to preserve Papaya and Guava fruits by means of canning in forms of slices in syrup, and to determine the effect of canning method on some Papaya and Guava constituents.

White Guava was purchased from local market while papaya was brought from Eldamazin (production area). Canning was done by conventional method with double seaming and heated by steam. The effect of canning method on products quality was evaluated by chemical organoleptic analysis; there was considerable decrease in vitamin C for Papaya from 43.77 to 18.80, moreover, vitamin C decreased in Guava from 568.77 to 131.27. Acidity for Papaya from 0.2650 to 0.00115, whereas in Guava was dramatically decrease from 0.45 to 0.17; moreover, reducing sugars showed slightly decrease from 3.90 to 3.60 and 5.90 to 5.30 for Papaya and Guava, respectively. Total sugar revealed a significant increase
from 4 to 9.90 and 8.90 to 12.70 for Papaya and Guava, respectively. Papaya pH was increased from 5.90 to 6.20, whereas in Guava increased from 5.19 to 5.30. Furthermore, T.SS showed a highly increase from 3 to 11 and 6 to 12 for Papaya and Guava, respectively.

The effect of canning on products quality was also evaluated by organoleptic analysis. Papaya recorded color 8.1 out of 10 flavor 12 out of 20 and texture 14.7 out of 20. For Guava color 8.7 out of 10 flavor 16.5 out of 20 and texture 14.2 out of 20. According to these organoleptic results, the color, flavor and texture were well accepted by the panelists.
لا يوجد نص يمكن قراءته بشكل طبيعي من الصورة المقدمة.
# LIST OF CONTENT

Dedication .................................................................................................................. ii
Acknowledgements .................................................................................................. iii
English Abstract ...................................................................................................... iv
Arabic Abstract ....................................................................................................... vi
List of Contents ....................................................................................................... vii
List of Tables ........................................................................................................... ix
List of Figures .......................................................................................................... x

**CHAPTER ONE**

1.1 Introduction ........................................................................................................ 1
1.2 The Objectives .................................................................................................... 2

**CHAPTER TWO: LITERATURE REVIEW**

2.1 Papaya and guava fruits .................................................................................... 3
2.2 Production of papaya in Africa ......................................................................... 4
2.2.1 Culture ........................................................................................................... 4
2.2.1.1 Propagation ............................................................................................. 4
2.2.1.2 Cultivars ................................................................................................. 5
2.2.1.3 Harvesting and Handling ....................................................................... 5
2.2.2 Papain and Pectin ....................................................................................... 6
2.2.3 Utilization of Purified and Characterized Lipase From Papaya in Acceleration 6
   of “Ras Cheese” Slurry .........................................................................................
2.2.4 Chemical and Nutrient Composition of Papaya ........................................... 7
2.3 Guava Fruit ........................................................................................................ 9
2.3.1 Harvesting, Storage and Handling ............................................................... 10
2.3.2 Nutrient and Proximate Composition .......................................................... 10
2.3.3 Processed Product ....................................................................................... 12
2.3.4 Storage Stability of Canned Guava .............................................................. 14
2.4 Canning of Fruit ................................................................................................ 14
2.4.1 Invention and Beginning of Canning ............................................................ 14
2.4.2 Preparatory Operations ............................................................................... 15
2.4.2.1 Selection of Raw Material ................................................................. 15
2.4.3 Preparatory Treatments ............................................................................. 17
2.4.3.1 Cleaning and Washing ......................................................................... 18
2.4.3.2 The Removal of Unwanted Parts ......................................................... 19
2.4.3.3 Peeling ................................................................................................. 19
2.4.3.4 Slicing and Dicing ............................................................................... 20
2.4.3.5 Grading ............................................................................................... 20
2.4.3.6 Blanching or Scaling .......................................................................... 20
2.4.4 Canning Procedure .................................................................................... 21
2.4.4.1 The Container ..................................................................................... 21
2.4.4.2 Filling of Container ............................................................................. 22
2.4.4.3 Exhausting and Can-Closure ............................................................... 22
2.4.4.4 Heat Processing .................................................................................. 23
2.4.4.5 Cooling of Containers ................................................................. 25
2.4.4.6 Post canning operations ................................................................... 25
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1</td>
<td>Chemical composition of papaya</td>
<td>8</td>
</tr>
<tr>
<td>2-2</td>
<td>Some chemical constituents of guava fruit</td>
<td>13</td>
</tr>
<tr>
<td>4-1</td>
<td>Some chemical and physical parameters of papaya slices before and after canning</td>
<td>38</td>
</tr>
<tr>
<td>4-2</td>
<td>Some chemical and physical parameters of guava slices before and after canning</td>
<td>40</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1</td>
<td>Canning steps.</td>
<td>26</td>
</tr>
<tr>
<td>4-1</td>
<td>Some chemical and physical parameters of papaya slices before and after canning.</td>
<td>39</td>
</tr>
<tr>
<td>4-2</td>
<td>Ascorbic acid of papaya.</td>
<td>39</td>
</tr>
<tr>
<td>4-3</td>
<td>Some chemical and physical parameters of guava slices before and after canning.</td>
<td>41</td>
</tr>
<tr>
<td>4-4</td>
<td>Ascorbic acid of guava.</td>
<td>41</td>
</tr>
</tbody>
</table>
CHAPTER ONE
INTRODUCTION

In Sudan papaya (Carica-papaya) and guava (Psidium guajava L.) fruits are consumed in a fresh form. In production areas large amount of papayas and guavas that exceed the local consumption demands are lost due to the relatively, poor marketing in the production season, low price, lack and difficulties of transportation, lack of the storage facilities, low exporting and absence of processing. Preservation methods should be adopted to lengthen the shelf life of these fruits. Canning may be considered as one of the preservation tools that can be made for both fruits.

The preservation of papaya and guava fruits by canning is expected to have the following benefits: (i) the product become stable, not requiring refrigeration, and can be easily transported, thus making it possible for the consumers to have a varied and nutritive diet at all seasons of the year and at all geographical locations. (ii) Canning can increase papaya and guava shelf-life, reduce the transportation cost and improve the living standard of the farmers by improving the price of papaya and guava in the production area. (iii) A product of good quality of canned papaya and guava can be exported hence contribute in improving the national economy.
1.2 The Objectives

The present work is planned to achieve the followings:

1- Preservation of papaya and guava fruits by means of canning.
   The production of readily reconcilable papaya and guava slices in syrup is the main objective.

2- Determination of the effect of canning method on some papaya and guava constituents.
CHAPTER TWO

LITERATURE REVIEW

2.1 Papaya and Guava Fruits

The papaya is called \textit{(Carica-papaya)}, pawpaw \textit{(Family caricacea)}. It is a small tropical tree native to South America. It normally grows with a single un branched trunk which may reach 10m, in height but more commonly 4-5 m tall. The grown tree is covered by large palmately lobed leaves up to 75cm across and along, hallow petioles up to 100cm in length (Rice and Rice, 1987).

The fruit is a berry with a green rind, which changes to yellow in most cultivars when ripe. The inside flesh is yellow or occasionally pink, and seeds are black, located in central cavity in the fruit and surrounded by a gelatinous material. Small latex vessels extend throughout the tree and are particularly abundant in the fruit which has reached full size but has not yet begin to ripen. The latex contains a high percentage of papain which is a proteolytic enzyme used in meat tenderizing, brewing, tanning and textile manufacture (Rice and Rice, 1987).

The guava, \textit{Psidium guajava L., myrtacea} can be grown from humid tropics to the outer most subtropics with winter or summer rainfall. The fruit ripen about 5 months after flowering. Guava is seldom eaten fresh and has a
uniform flesh color (white, pink or salmon red). It is outstandingly well suited for export in number of canned foods which should find good market, because of their excellent flavor and high vitamin C contents.

2-2 Production of Papaya in Africa

Papayas production in Africa is mostly confined to planting of 2 or 3 trees around private homes or in villages. An exception to this is Tanzania where the plant is grown on large scale for papain (Rice and Rice, 1987).

2-2-1 Culture

2-2-1-1 Propagation

Propagation is primarily from seed, which germinates 2-4 weeks after planting if the soil is warm. To obtain plants of best quality seed should be obtained from superior plants. In the cultivar “solo” which is the most important commercial cultivar seed should be obtained only from hermaphrodite plants which have been self-pollinated or crossed with another hermaphrodite. If this procedure is followed, seeds will produce 67 percentage hermaphrodite off spring and 33 female off spring. Dioecious cultivars normally produce a 1:1 of male to female plants which will result in the production. Propagation by cutting is possible but only entire branches including the basal swelling should be used. Due to the non-branched growth habit of papaya the trees produce few cuttings and propagation by
cuttings is therefore impractical in commercial operation. Grafting of scion from desirable plants onto seedlings also is possible although this is not practical on a commercial scale. Batch budding in which a rectangle of bark containing a bud is placed on the stock in an identical size rectangle from which bark has been removed is the most successful technique used (Rice and Rice, 1987).

2-2-1-2 Cultivars

In Africa, papaya is mostly grown from open pollinated seeds of a known identity in many situations, this is preferable to growing selected cultivars since the papaya is sensitive to environmental changes and naturalized plant will probably be well suited to the local environments due to generation of natural selection pressure. There are however, a number of cultivars which breed fairly true and which are worthy of trial. The most common is “solo” a hermaphrodite trees and large, rounded fruits of female trees. Other cultivars of merit are “Bluestem” (hermaphrodite),”Graham” (Dioecious), “Fair child” (dioecious). “Hortus” cold “Honey cold” (Female, vegetatively propagated (Rice and Rice, 1987).

2-2-1-3 Harvesting and Handling

The fruit is harvested at the first signs of yellowing if it is to be sent to distant markets, it may remain on the tree a day or two longer if intended for
local markets. Papaya should be stored at relatively high temperature. Lower temperatures will cause chilling injury and fruit fail to ripen properly. Since the skin is extremely delicate very careful handling is necessary (Rice and Rice, 1987).

2-2-2 Papain and Pectin

These two products are both obtained from papayas. Papain is an enzyme used to tenderize meat. It is present in the milky sap of the plant and it is generally obtained by ‘tapping’ the green fruits. Thin cuts are made vertically down the fruits towards the tip and the milky latex which oozes out is scraped after it hardens. This is done in the early morning. The hardened latex after drying is the product, which is sold. Pectin is used in jam and jelly making, papayas contain up to 2 percent of pectin. This may be extracted from the by-products of canning (Williams, et al 1980).

2.2.3 Utilization of Purified and Characterized Lipase From Papaya in Acceleration of “RAS CHEESE” Slurry

The lipase enzyme from papaya (Carica-papaya) was purified by ammonium sulphate solution (40-50) and fractionated by gel filtration on sephadex G-100. Crude extracted lipase was used to accelerate cheese slurry ripening with concentration of 2.0 and 4.0 ml/100g. Crude slurries were incubated at 37°C and analysed for acidity, for 7 days. All slurries were
analysed for acidity, pH, moisture, soluble and total nitrogen total volatile fatty acids and flavor (El-Hofi and Ismail, 1998; El-Hofi and Ismail, 2000).

2-2-4 Chemical and Nutrient Composition of Papaya

Papaya is rich source of antioxidant nutrients such as carotenes, vitamins and flavonoids, the B vitamin, folate and pantothenic acid, and the minerals, potassium and magnesium, and fiber. Together, these nutrients promote the health of the cardiovascular system and also provide protection against colon cancer (http://whfood).

Table (2-1) shows the chemical composition of papaya whole ripe fruit. Expressed on fresh weight basis. The Table indicates that the moisture is 89.4%.
### Chemical Composition of Papaya

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Energy kcal</td>
<td>37</td>
</tr>
<tr>
<td>Total carbohydrate%</td>
<td>7.9</td>
</tr>
<tr>
<td>Protein %</td>
<td>1.3</td>
</tr>
<tr>
<td>Fat %</td>
<td>0.0</td>
</tr>
<tr>
<td>Crude Ash %</td>
<td>0.7</td>
</tr>
<tr>
<td>Crude fiber%</td>
<td>0.7</td>
</tr>
<tr>
<td>Calcium mg/100g</td>
<td>149</td>
</tr>
<tr>
<td>Iron mg / 100g</td>
<td>3.6</td>
</tr>
<tr>
<td>Phosphorus mg/100g</td>
<td>6.0</td>
</tr>
</tbody>
</table>

2.3 Guava Fruit

Guava (Presidium guajava L.) is a widely cultivated tropical fruit. It is of the richest sources of vitamin C and characterized by its pleasant flavor. Most guava is eaten fresh little is processed. The most important cultivated species are of the myrtle family.

The guava grows well in most tropical and subtropical soils. Plants can be propagated from seed and root cutting and by grafting, budding or air layering (mar cottage). The fruit of the common guava has a rough yellow skin and is a round, ovoid or pyriferim in shape. The varieties pyriferim (the pear-shape guava) and pomiferim (the round shape guava) represented two of the many variations that occur in (presidium guajava L.). The fruit has many small hard seeds from 153-664 per fruit located in the center of the flesh (Palaniswamy and Shanmugavelu, 1974). Seedless (tripoid) varieties have been developed, however, they produce small amount of misshapen fruit. The fruit color varies from white to deep pink. The flavor has been described as sweet, musky and highly aromatic (Popenoe 1920; Malo and Campbell, 1968; Biley and Bailey 1976).

Guavas are consumed in many different ways, they can be eaten whole, preserved, slices with cream and stewed, can be made into pies or
short cake, however, guavas are processed commercially into jellies, jams and juice.

2.3.1 Harvesting, Storage and Handling

Guavas are hand-harvested in baskets 2-3 times weekly during an 8-10 weeks harvest season. Firm, yellow, mature fruits without insect or fungus damage are selected for harvesting and processed immediately. Green ripe guavas are stored for 2-5 weeks at 8-10°C and at 85-90% humidity. Mature guavas do not keep and are usually transported rapidly to processing plant. Fully mature fruit should be refrigerated during shipment. Ideally, it would be best to ship firm, slightly under-ripe fruits and to finish ripening under control condition.

2.3.2 Nutrient and Proximate Composition

The nutrient and proximate composition of guava grown in several regions is shown in Table (2-2). Guavas are rich source of ascorbic acid, the skin and outer flesh contain most of the ascorbic acid. Ascorbic acid content reaches a maximum in green, fully mature fruit and starts to decline rapidly as the fruit ripens (El-Zorkani, 1968; Agnihotri and Goel, 1962).

Ascorbic acid values from other sources ranged from 11-1160 mg/100g fruit (Dedolph, 1966; Freash and Abbott, 1948; Agnihotri et al., 1962; Mukherjee and Dutta, 1967). Waddington and Cist (1942) prepared
four samples of dried flesh and found that their average is 4385mg ascorbic acid/100g dried fruit. Guavas are a fair source of calcium, phosphorus and vitamin A.

Proximate analysis of guavas showed that they contain between 74-87% moisture, and 13-26% dry matter, the moisture content is highest and quality of guava is generally lower in fruit harvested during the rainy season than in fruit harvested during spring and winter. Guavas contain 0.5-1.0% ash, 0.4-0.7% crude fat and 0.8-1.5% crude protein. Acidity of guavas is 0.33-0.99%, pH 4.7-5.4%, total sugar values 4.3-9.0% reducing and non-reducing sugars were present in equal quantities (Chan and Kwok, 1975).

Guavas are fair source of pectin. Pectin increases during ripening and declines rapidly in over-ripe fruit (Luh, 1971).

Values for total pectin range from 0.5-1.8%. Hydrolyzed guava pectin has been reported to contain 72% D-galacturonic acid, 12% D-galactose and 4% L-arabinose (Pruthi et al 1960). The presence of pectin methyl stearase was reported by Rieckehoff and Rios (1956) who found most of the activity of this enzyme associated with the peel.

Fang (1965) analyzed one sample from each of white pulp and pink-pulp guavas and found that they contained almost equal amounts of glycolic
and citric acids, and pink-pulped contain more malic and tartaric and lactic acid. A side from its high ascorbic acid content, the flavour of the guavas is its most distinguishing characteristic. Therefore, a comparison of the flavour between various cultivars can not be made. In a review and study for guavas aroma. Shiota (1978) reported the identity of 22 compounds (3 terpene hydrocarbon, 1 ketone, 4 aldehydes, 8 alcohol, and 6 esters). In addition to some of the compounds reported by Steven et. al. (1970), they found cinnamyl alcohol cinnamaldehyde, nerolidol and 2-hexanol. Cinnamyl acetate has the most guavas-like aroma.

The concentration of poly phenol was the highest in immature fruit and decrease with maturity. It is the first reported naturally occurring poly phenols in which arabinose forms the carbohydrate core and the acid moiety is linked to the vicinal hydroxyl group at the 3 and 4 position of arabinose.

2.3.3 Processed Product

Guava puree is prepared in the following manners:

Guavas are inspected and washed, the washed guava are processed at constant rate through a paddle pulpier fitted with 0.08-1.1mm screens. The final product is deaerated, pasteurized for 60 sec. at 90°C and rapidly canned in either type N or type H enameled cans. The canned product is inverted held for 3 min, and cooled with a water spray at 38°C -48°C.
### Table (2-2)

Some Chemical Constituents of Guava Fruit

<table>
<thead>
<tr>
<th>Source</th>
<th>Crude Fiber %</th>
<th>Crude Protein %</th>
<th>Crude Fat %</th>
<th>Reducing Sugar %</th>
<th>Total Sugar %</th>
<th>Total Soluble Solid %</th>
<th>pH</th>
<th>Ascorbic Acid %</th>
<th>Ca mg</th>
<th>Fe mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>C and K</td>
<td>3.80</td>
<td>1.20</td>
<td>0.55</td>
<td>3.30</td>
<td>6.70</td>
<td>12.00</td>
<td>4.50</td>
<td>386.00</td>
<td>17.00</td>
<td>1.85</td>
</tr>
</tbody>
</table>

C and K: Chan and Kwok (1975)
2.3.4 Storage Stability of Canned Guava

Gauhar and Durrani (1972) reported about the ascorbic acid retention of hand-peel and lye-peeled guava packed in 40% sugar syrup acidified with 0.5 citric acid. Their study indicated that canned guavas with increased acidity and brix values had greater ascorbic acid retention than other guava packs, and hand-peeled guavas retained more ascorbic acid than those peeled with lye. Ranganna (1974) reported that pink discoloration in canned guava was mainly due to thermal effects during processing.

2.4 Canning of Fruit

2.4.1 Invention and Beginning of Canning

Food canning is the procedure for preserving food by the combination of sealing in a hermetic container and heating to destroy spoilage and pathogenic microorganisms and inactivate enzymes.

Progress in canning has been continuous since about 1809, when Nicolas Appert discovered that food could be preserved rendering the product free of spoilage microorganisms and enzymes, if it is placed in sealed container and heated (Douk Worth, 1966).

Today’s canning plants are efficient industrial operation where a single line may produce more than 600 containers per minute of whole some
nutritious food. Manufacturing of heat processed canned foods can be divided into three operations:

1- Operations that prepare raw product for packing in container.

2- Operations involving the application of heat to “sterilize” rendering the product free of spoilage microorganism and enzymes.

3- Distribution of canned food product.

2.4.2 Preparatory Operations

Certain preparatory treatments such as cleaning, grading, peeling, slicing and blanching, although they may not all be required for each individual product are nevertheless generally common to each of the major methods of processing (Douk Worth, 1966).

2-4-2-1 Selection of Raw Material

Raw material for the processing industry should be in sound condition and of good overall quality. One general feature which is highly desirable in material passing through any mechanized process and food processing nowadays which is becoming increasingly more highly mechanized is uniformity, especially of size, shape and physical condition. Size grading is usually integral part of the process, irregularity of shape, though sometimes
unavoidable reduces the efficiency of mechanical operations such as peeling, and generally lead to a high rate of wastage (Douk worth, 1966).

A part from such purely mechanical consideration, the color, flavor and texture of the material and extent to which these may be modified by the process, are obviously factors of prime importance.

The severe heat-treatments used in canning and the normal practice of packing the material in syrup result in much greater changes. Pigment changes such as the conversion of chlorophyll to phaeophytin and the alteration and leaching of anthocyanin pigments, often necessitate the addition of artificial coloring matter. In such cases the color of the raw material is of relatively little importance. In other cases the presence of leuco-anthocyanins may lead to the formation of undesirable brown or reddish-purple compounds during heat processing. Heat processing, apart from causing qualitative changes in flavor, also usually reduces general intensity of flavor of the material. A full rich flavor is therefore generally desirable material for canning.

Textural considerations are also most important. The main requirement here is that the material should be capable of withstanding the processing treatment without tissue breakdown, while at the same time being free of undesirable tough and heat resistant skin or other tissue aggregate.
All the factors so far considered have a genetic base and to great deal depend on the selection of suitable varieties (Joslyn, 1970).

Growing conditions may also markedly influence the quality of material for processing and different batches of a given variety can show appreciable differences in performance. Careful inspection of the raw material is therefore always necessary and the processor must always be ready to modify his technique to suite the requirements of the particular patch of material passing through his plant at any given time.

Finally, a most important factor determining the suitability of material for processing is the stage of maturity at which it is harvested. Fruit for processing should normally be used at the “firm ripe” stage, when it is fully grown and well colored, but before it has become soft. There are, however, a number of exceptions to this broad generalization. For example, goose berries are better to be under ripe for canning. Black berries on the other hand should be fully ripe, the “soft ripe” stage, at which the flavor has reached its full development, may also be preferred, as in-case of peaches, in fruit which is to be frozen (Douk worth, 1966)

2.4.3 Preparatory Treatments

The preparation of material for processing is usually closely similar whatever method of preservation is subsequently applied, although the
sequence of operations varies considerably according to the individual requirements of particular commodities. Certain procedures however are very widely used and these will now be considered as operations (Joslyn, 1970).

2-4-3-1 Cleaning and Washing

Fruit as received at the processing factory are very commonly contaminated with soil and other foreign materials, and these must be removed if high quality product is to be obtained.

Washing is almost invariable introduced at some stage in preparation, and several methods, each suited to a particular range of commodities, are employed, simple soak in the water is not usually sufficient in itself, but it dose serve to loosen adhering soil which is then more easily removed during subsequent washing operation. More effective are various methods in which, the material is agitated while submerged in water or subject to water sprays (Douk Worth, 1966).

A more recent development, which works on similar principle to the Duo washer but which is capable of a greater output and is more efficient in operation is flotation washer. Sprays are used for example in so-called rod-washer-drum-type washers in which the drum is constructed of parallel rods with intervening space which allow suspended soil and other contaminants
of small size to be washed through rod-washer and suitable for a wide range of fruits (Douk worth 1966).

Washing may be the first operation to be carried out after the initial sorting of the material. In any case washing is generally required later in the process, especially after blanching, to remove appreciable amount of soluble constituents which may contribute towards the flavor and nutritive value of the material.

2.4.3.2 The Removal of Unwanted Parts

Parts which are commonly removed in preparation for processing include vines, pods, husks, cores, peels, eyes and any part of the material which in any way are damaged or otherwise unsuitable for inclusion. Many of the operations involved were originally, and in some cases still are carried out by hand, but a wide range of machinery is now available and in most modern processing factories, these operations are largely mechanized.

2.4.3.3 Peeling

Many fruit products require to be peeled in preparation for processing, and hand peeling the original method, has now been largely replaced by other speedier labor-saving techniques (Douk worth, 1966).
2-4-3-4  Slicing and Dicing

The cutting of material into pieces, whether as halves, segments, whole slices, strips or dices is a common feature in the processing of fruits. Canned and frozen products prepared in the form of pieces of uniform size present an attractive appearance to the consumer and are also highly convenient to use. Cutting operations are almost invariably mechanized and large range of machines is available, some designed for use with a specific product, others for more general application (Douk Worth, 1966).

2-4-3-5  Grading

In order to obtain a product of uniformly good quality, grading is most important at one or more points during the preparation of the material. Grading for appearance factor other than size is normally done by eyes, but size grading is readily mechanized (Joslyn, 1970).

2-4-3-6  Blanching or Scaling

Blanching or scaling involves short heat-treatment, the nature and purpose of which vary somewhat with the material and with the method of preservation to be employed. The use of blanching treatment for the softening of skins prior to peeling has already been mentioned. The reasons for blanching can be summarized as:
a) Help to clean the material, and reduce the load of microorganisms present on surfaces.

b) To remove intercellular gas, thus preventing the excessive build up of pressure in the can during heat processing.

c) To soften the tissues, and allowing a greater volume of material to be introduced into a pack of given size.

d) It inactive enzyme systems which cause quality deterioration.

e) It may help to “fix” color of material.

f) Finally, various other chemical treatments can be combined with blanching such as calcium salt which may some times be used to reduce the susceptibility of material to tissue break down during processing (Douk worth, 1966).

Blanching, therefore, is a most important stage in many processing operations. Fruit which is susceptible to enzyme darkening is normally blanched before canning. There are two main methods of blanching: water blanching and steam blanching.

2.4.4 Canning Procedure

2.4.4.1 The Container

Container should be capable of being hermetically sealed by a rapid and efficient process. Most popular container now used for this purpose is
the open-top or sanitary can-made of tinplated sheet steel. Glass container, however, provide a satisfactory alternative especially for juice. Problems associated with the packing of fruit are the corrosive and staining action of the acid material on the inner lining of the can and discoloring effect of traces of dissolved tin on anthocyanin pigment (Marion, 1979).

2-4-4-2 Filling of Container

The minimum amount of material to be packed in a given size of can, should be measured as filled weigh or as drained weigh. Filling can be considerably speeded up by using a machine called hand-pack filler. A typical machine of this type consists of circular revolving stainless steel table with a number of circular holes, each of a diameter slightly less than that of the can. Each can is positioned under a hole and is filled by scooping material into it from table as it moves round. The cans are then passed automatically to the syrup (Douk Worth, 1966).

2-4-4-3 Exhausting and Can-Closure

Exhausting is to remove air from the contents of the can and from head space immediately before closure. This prevents the build-up under pressure inside the can during heat processing and reduces internal corrosion which is accelerated by the presence of oxygen.
Steam-flow seaming is a method, in which the top of the can is sealed, after the head space has been flushed with blast of steam vacuum as applied to the head space. The sealing of the open-top can is an operation which involves a machine known as the double-seamer (Joslyn, 1970).

2-4-4-4 Heat Processing

The objective of heat processing is to destroy all the microorganisms, which may initially by present inside the container and which may be able to grow under the condition prevailing in the container, and to eliminate the organisms which are causing spoilage or give rise to food-poisoning. Heat processing also cooks the material (Marion, 1979).

Complete sterilization in the strict bacteriological sense is not normally practicable (commercial canning is normally practiced, there is severe heat treatment necessary would in any case usually over cook the material).

In practice, something less than absolute sterility perfectly acceptable provided that (*Clostridium botulinuim*) has been effectively destroyed. The sterilizing effect is determined by the temperature used, and by the period of exposure to this temperature but other factors have their effects on the severity of the heat treatment necessary to obtain commercial sterility. pH is the most important one, it determines whether any surviving organism will
be able to develop in heated with pH values below 3.7-4.5 - referred to as acid food-can be sterilized by short treatment at 100°C (212°F). Juice can be preserved by short pasteurization treatment at lower temperatures between 79-90°C (175-195°F). The pH 4-5 is the lower limit for the development of the spores of *Clostridium botulinum* and other spore forming bacteria, which are resistant to destruction by heat, and require more severe heat treatment at higher temperature to obtain commercial pack. pH values below 5.3 and greater than 4.5 (medium acid and low acid) are most susceptible to bacterial spoilage if an inadequate heat treatment has been applied. If the heat transfer properties of a given type of pack are known, it is possible to calculate the length of time for which the can should be subjected to a given temperature to obtain a given sterilizing effect (Marion, 1979).

Many different kinds of heat processing equipment are available for use with canned food. Either batch or continuous cooker operating at atmospheric pressure is normally used. Heating may be by hot water or by steam, and the can may remain still during processing or they may be agitated.

Aseptic canning, recent technique, in which the material is sterilized by a higher temperature, short time treatment in a heat exchanger before filling into sterile cans, is not generally suitable for a particular materials and
especially suitable for application of free-flowing liquid products (Marion, 1979).

2-4-4-5 Cooling of Containers

After heat processing, it is most important that the can should be quickly cooled to around 38-41°C (100–110°F) to avoid further cooking of content. This is done by immersion in cold water or by subjection to cold water sprays, and continuous cooler. Rapid cooling to low temperature retards the subsequent evaporation of cooling water left on the surface of the can and may lead to external corrosion (Douk Worth, 1966).

2-4-4-6 Post Canning Operation

These include can labeling, packing into cartons and quality testing and grading. It is necessary to carry out incubation test to confirm the effectiveness of sterilizing treatment. Bacterial spoilage during storage at 37-55°C may evidence bulging of the can ends as a result of the production of gas by viable organisms. Gas production is not always the result of bacterial growth. It may also result from the corrosion of the tin plate due to acid food content of the can (Douk worth, 1966).
Fig. (2-1) Canning Steps
CHAPTER THREE

MATERIALS AND METHODS

3.1 Chemical and Physical Analysis of Fresh Papaya and Guava

3.1.1 Materials

Papaya, white guava, chemicals and equipments that were used in this research are presented below:

3.1.1.1 Papaya and Guava

In this research, papaya was treated at green mature stage. It was purchased from Aldamazen.

White guava was purchased from local Market. The samples collected were kept in a refrigerator at 12°C until they were used.

3.1.1.2 Equipment

Blender, Refractometer, pH meter.

3.1.3 Methods of Analysis

Homogeneous samples were prepared and used in analysis.

3.1.3.1 Preparation of Samples

For the analysis of fresh papaya and guava fruit, the samples were peeled and the seeds were removed from papaya but not from guava. Then the fleshes of samples were blended to form homogenous samples.
3.1.3.2 pH

The pH was measured using digital pH-meter, the pH-meter was calibrated using standard buffer solution of pH 4 and 7.

3.1.3.3 Total Soluble Solids

The total soluble solids were measured using hand refractometer at room temperature (AOAC, 1970).

3.1.3.4 Titrable Acidity

Ten grams of homogeneous samples were diluted with distilled water to 250 ml, the solutions were titrated by using (0.1N) NaOH and using phenolnaphthalin as indicator according to the method described by Association of Official Analytical Chemist (AOAC, 1970).

3.1.3.5 Reducing Sugars

The weight of sample was taken on basis of T.S.S. Each sample was dissolved with a portion of water into two volumetric flasks (100 ml). One flask was treated with 6-5ml HCL conc. and heated in water bath to 70°C for 5 minutes, then the samples were cooled and completed to mark and then filtered by filter paper and neutralized with 0.1N NaOH to determine total sugars. The other flask was diluted with distilled water and filtered by filter paper to determine reducing sugars.
15 ml of sample were added to 10ml of canned fruits (25 ml for fresh fruits) of mixture of Fehling solutions (1:1), and then heated until the color changed to brown, then 3 drops of methylene blue indicator were added to sample and the titration was continued under the heater until the color changed to brown. The volume of samples was taken and from invert sugar table, the mg invert sugars per 100ml were given. Then total and invert sugars were calculated (AOAC, 1984).

3.1.3.6 Ascorbic Acid

It was deterrinate according to (Ruck, 1963). 30g of fruit tissue had been taken and blended with reasonable amount of 0.4% oxalic acid, then filtered by using Whatman No.1 filter paper, made up to 250ml with 0.4% oxalic acid, then 20ml of filtrate was taken into a beaker and titrated with dye 2,6-dichlorophenol-indophenol to faint pink color.

**Determination of dye strength**

Five ml of standard ascorbic acid solution was added in a beaker and titrated with dye solution to faint pink color.

\[
\text{Dye strength} = \frac{1}{\text{Titer}}
\]

3.2 Processing of Papaya and Guava Fruits

The following shows the methods, materials and equipments that were used in processing of papaya and guava fruits.
3.2.1 Materials

Materials and equipments used in canning of papaya and guava fruits:

3.2.1.1 Raw Material

Papaya, guava, sucrose and citric acid.

3.2.1.2 Equipments

Autoclave, sealing machine, oven, refractometer, digital balance and stainless steel knife.

3.2.1.3 Preparation of Fruits

Firm ripe fruit (papaya and guava) were washed with tap water, the papayas were peeled and the seeds were removed by stainless steel knife and sliced. For guava fruit the seeds were not removed.

3.2.1.4 Preparation of Syrup:

Sucrose was added to boiled distilled waters to make syrup with Brix 20. In this step, 3.0 mg citric acid were added for guava and 6.0mg for papaya.

3.2.1.5 Preparation of Containers

The containers used were tin plate containers which were sterilized before packing the product.

3.3 Canning of Papaya and Guava

The slices of fruits were blanched in boiling water for 2 minutes.
3.3.1 Filling and Closing

The blanched slices of fruits were filled in containers, and then the syrup was added before closing, the containers were put in exhausting chain to exhaust air from containers, and then using the double seaming machine was used for closing the containers.

3.3.2 Sterilization

The sealed cans were Autoclaved at 120°C for a process time of 45 minutes.

3.3.3 Cooling

After heat processing, the hot cans were quickly cooled to around 38-41°C using cooling water.

3.4 Analyses of Canned Fruits

3.4.1 Chemical and Physical Analysis

The papaya and guava products were blended to homogenous samples. Chemical and physical analyses of samples were carried out (total soluble solids, pH, viscosity, titrable acidity reducing sugars, ascorbic acid) using the same methods that used for analysis of fresh samples.
3.4.2 Microbiological Analyses

3.4.2.1 Preparation of Serial Dilutions

Ten grams of each sample were aseptically weighed and added to a conical flask containing 90ml of sterile 0.1% peptone solution and shaked well to give dilution \(10^{-1}\). One ml of dilution \(10^{-1}\) was transferred by using sterile pipette to a test tube containing 9ml of sterile diluents to give \(10^{-2}\), the serial decimal up to \(10^{-6}\) were prepared as described by Harrigan and Mccance (1976). Total viable count was carried out using the pour-plate method as described by Harrigan and Mccance (1976).

One ml of each dilution was transferred aseptically into sterile Petri dishes . To each plate 15ml of melted and cooled to 45°C plate count agar were added. The inoculums was mixed with medium and allowed to solidify. The plates were incubated at 37°C for 48 hours. By using a colony counter the viable bacterial colonies were counted and the results were expressed as colony-forming units (cfu) g.

3.4.2.2 Mould and Yeasts Count

According to kreger-van Rij (1984), PDA (Potatoes Dextrose Agar) was used for count of yeasts decimal of 0.1ml of suitable dilutions was transferred to diluted samples and was spreaded onto surface, inoculated and incubated at 28°C for 48-72 hours.
3.4.3 Sensory Evaluation

Quality of food product may be better understood as a measure of desirability of product and how many that products is closely related to consumer acceptance (Haron, 1998).

Ratio scoring (Ihekorny and Negoddy, 1985) was used to determine the degree of preference or acceptance of colour out of (10), flavor out of (20) and texture out of (20). The scoring: excellent (20-15) or (10-8.5), very good (14-13), or (8-7) good (12-10) or (6-5), fair (9-7) or (4-3), poor (6-4) or (2), very poor (3-1) or (1).

3.5 Statistical Analysis

The statistical analysis was carried out by using a computer program called statistical package for social scientist (SPSS).
CHEPTAR FOUR

RESULTS AND DISCUSSION

4.1 The Physical and Chemical Analyses of Papaya and Guava

4.1.1 Total Soluble Solids

The total soluble solids of papaya before and after canning were 3.0% and 11%, respectively whereas total soluble solids of guava before and after canning were 6.0% and 12% as shown in Table (4-1), Figure (4-1) and Table (4-2), Figure (4-3), respectively.

This result for guava is lower than the result obtained by Yahie (2002) as he found that the total soluble solids before and after canning were 12% and 14.50%, respectively.

It was noted that the total soluble solids in both fruits increased after canning and this may be due to the presence of fruits slices in syrup.

4.1.2 pH

The pH is related to fruit acidity. The pH-values of papaya and guava were measured before and after canning for both fruits. The results were presented in Table (4-1) and Figure (4-1). The pH-values of papaya fruit before and after canning were 5.9 and 6.2, respectively this result is in agreement with the information from (URL http://www.chem.uwimona).
The acid content of papaya is very low and the pH is generally between 5.5-5.9. pH-values for guava before and after canning were 5.19 and 5.3, respectively as shown in the Table (4-2) and Figure (4-3). The pH-values of guava is within the range shown by Chan and Kwok, (1975) who reported a range of 4.7-5.4 and this result is higher than the result obtained by Yahie (2002). He reported that the pH-values of guava before and after canning as 3.90 and 4.00 respectively from this data it was observed that the pH values for both fruits were slightly increased by canning.

4.1.3 Titrable Acidity

The importance of acidity of fruit is that it is used as a chemical index in determining harvest maturity. It also contributes to the taste and flavor in ripe fruits. The acidity of fruits expressed in terms of citric acid % or malic acid% (Lack shminarayana et al, 1970).

Titrable acidity of papaya and guava was determined before and after canning and the results are shown in Table (4-1) and Figure (4-1) and Table (4-2) and Figure (4-3), respectively. The titrable acidity of papaya slices before and after canning were 0.265 and 0.064, respectively.

The titrable acidity of guava slices before and after canning were 0.47 and 0.17, respectively.
This result is lower than the results obtained by Yahie (2002) who reported that the acidity of guava before and after canning were 6.00 and 4.50, respectively.

It was noted that the pH of both fruits decreased after canning and this may be due to the presence of fruit slices in syrup.

4.1.4 Total and Reducing Sugars

The principal free sugars present in the papaya fruit are sucrose, glucose and fructose (URL http://www.chem.uwimona). Mowlah and Itoo (1980) reported that the white guava contained 3.8% fructose, 3.0% glucose and 0.24% sucrose.

Total and reducing sugars in papaya and guava were determined before and after canning. Total sugars in papaya before and after canning were 4.00 and 9.90, respectively. Reducing sugars in papaya before and after canning were 3.90 and 3.60 respectively. The total sugars in guava before and after canning were 8.90 and 12.7 respectively. This result are higher than the results which were obtained by Yahie (2002) who reported that the total sugars of guava before and after canning were 6.00 and 7.10, respectively. The reducing sugars in guava before and after canning were 5.90 and 5.30, respectively. This result is higher than the result which was obtained by Yahie (2002) who found that the reducing sugars in guava
before and after canning were 3.53 and 2.10 respectively. The result shown in Table (4-1) and Figure (4-1) and Table (4-2) and Figure (4-3), respectively, indicate that the total sugars in both fruits were increased while reducing sugars were decreased.

4.1.5 Ascorbic Acid

The vitamin content of the fruit varies between cultivars. Papaya is a good source for vitamin C, while guava is a rich source. Ascorbic acid content was determined for papaya and guava fruits before and after canning. The results are tabulated in Table (4-1) and Figure (4-2) and Table (4-2) and Figure (4-4), respectively. Ascorbic acid content of papaya before and after canning was 43.77 and 18.80 mg/100g, respectively. The result is less than that obtained by (Harvey et al., 1975). Who indicated that the ascorbic acid in papaya before and after processing and concentration were 69.4 and 55.3 respectively.

For guava the ascorbic acid contents before and after canning were 568.77 and 131.27 mg/100g, respectively. This result is within the range shown by (Dedolph, 1966; French and Abbott.1948; Agnihortietal, 1960; Mukherree and Dutta(1967) who reported a range of 11-1160mg/100g ascorbic acid and this result was higher than the result obtained by Yahie (2002).
Table (4-1)

Some Chemical and Physical Parameters of Papaya Slices Before and After Canning

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>TSS %</th>
<th>Acidity</th>
<th>T. sugar</th>
<th>R. Sugar</th>
<th>Ascorbic Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papaya</td>
<td>Fresh</td>
<td>5.90±0.01155a</td>
<td>3.00±0.11547a</td>
<td>0.2650±0.00115a</td>
<td>4.00±0.11547a</td>
<td>3.90±0.11547a</td>
</tr>
<tr>
<td></td>
<td>Canning</td>
<td>6.20±0.11547a</td>
<td>11.00±0.11547b</td>
<td>0.0640±0.00115b</td>
<td>9.90±0.11547b</td>
<td>3.60±0.11547a</td>
</tr>
</tbody>
</table>
Figure (4-1): Some Chemical and Physical Parameters Of Papaya Slices Before and After Canning

Figure (4-2): Ascorbic acid of Papaya
### Table (4-2)

Some Chemical and Physical Parameters of Guava Slices Before and After Canning

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>TSS %</th>
<th>Acidity</th>
<th>T. sugar</th>
<th>R. Sugar</th>
<th>Ascorbic Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fresh</strong></td>
<td>5.19 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.00 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.47 ± 0.02133&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.90 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.90 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>568.77 ± 6.2667&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Canning</strong></td>
<td>5.30 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.00 ± 0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.17 ± 0.02133&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.70 ± 0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.30 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>131.27 ± 10.82533&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Figures (4-3): (Some Chemical and Physical Parameters Of Guava Slices Before and After Canning

Figure (4-4): Ascorbic acid of Guava
He was reported that the ascorbic acid in guava before and after canning were 36 and 20 mg/100g respectively. A substantial loss in vitamin C was observed in the high temperature applied during canning.

4.2 Microbiological Test

Microbiological test for the presence of thermophilic bacteria, yeast and molds was carried out for assurance of heat processing. The result indicated no growth of any type of microorganism in cans. This indicated the efficiency of the heat treatment applied.

4.3 Sensory Evaluation

Ten panelists evaluated the colour, flavor and texture of canned papaya and guava fruits as shown in appendix (1) and (2). The scores for the papaya were as follows: color (8.1) out of (10), flavour (12) out of (20), and texture (14.7) out of (20).

For guava colour (8.7) out of (10), flavour (16.5) out of (20) and texture (14.2) out of (20).
CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The objective of this research was to preserve papaya and guava fruits by canning in form of slices syrup, to determine the effects of canning on the quality of the processed product. To achieve this objective a number of analyses were conducted, these are: total soluble solids, pH, Titrable acidity, total and reducing sugars and ascorbic acid.

It was found that the total soluble solids were increased. This is attributed to the presence of slices in syrup. The acidity was decreased, this may also be attributed to presence of slices in syrup. Most of the vitamin C (ascorbic acid) was lost in processed products. This attributed to high temperature used in canning process.

Sensory evaluation was used to determine the acceptance of the panelist for canned products. In ratio scoring was used to determine the effect of canning on colour, flavour and texture of products. It was found that the color and flavor for guava is perfect, the texture is V. good for papaya the colour and texture is V. good and flavour is good.
5.2 Recommendations

It is recommended that:

(1) To have future studies on the chemical composition and nutritive value of fresh and processed papaya fruits. It is also needed to isolate papain enzyme and study its effect on meat tenderness.

(2) Intensive and integrated work is required to test other preservation methods.

(3) More studies should be carried out with addition of artificial colour and flavor.

(4) The shelf life of the canned products should be studied under different storage conditions in order to determine the most suitable methods for storage and packing.

(5) The effect of canning on quality of products should be determined using advanced equipments and techniques. Such as high performance liquid chromatography (HPLC) and gas liquid chromatography, this will give more accurate qualitative and quantitative values.
REFERENCES


HARVEY T.CHAN J.R; MARGRETT .H.H. KUO; CATHRINE G. CAVALETTO ;T.O.M. NAKAYAMA and JOHN E.BREKKE, (1975). Papaya puree and concentrate changes in ascorbic acid,
carotenoids and sensory Quality during processing. Journal of Food Science v (40) 701-703.

http://musalit.inibap/by index.


APPENDICES
Appendix (1):
Ratio Scoring for Papaya

<table>
<thead>
<tr>
<th>Rep</th>
<th>Colour</th>
<th>Flavour</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>B</td>
<td>9</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>D</td>
<td>9</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>E</td>
<td>7</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>F</td>
<td>8</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>G</td>
<td>8</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>H</td>
<td>8</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>I</td>
<td>10</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>J</td>
<td>8</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>81</td>
<td>120</td>
</tr>
<tr>
<td>Mean</td>
<td>8.1</td>
<td>12</td>
<td>14.7</td>
</tr>
<tr>
<td>Degree</td>
<td>V. good</td>
<td>V. good</td>
<td>V. good</td>
</tr>
</tbody>
</table>

Guide Line to Evaluation

- Color: 10
- Flavor and Texture: 20
- Perfect: (10-8.5)
- Perfect: (20-15)
- Very good: (8-7)
- Very good: (14-13)
- Good: (6-5)
- Good: (12-10)
- Fair: (4-3)
- Fair: (9-7)
- Poor: (2)
- Poor: (6-4)
- Very poor: (1)
- Very poor: (3-1)
Appendix (2):
Ratio Scoring for Guava

<table>
<thead>
<tr>
<th>Rep</th>
<th>Colour</th>
<th>Flavour</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8</td>
<td>17</td>
<td>16</td>
</tr>
<tr>
<td>B</td>
<td>18</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>E</td>
<td>9</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>F</td>
<td>5</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>G</td>
<td>8</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>H</td>
<td>6</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>I</td>
<td>10</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>J</td>
<td>8</td>
<td>19</td>
<td>14</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>87</strong></td>
<td><strong>165</strong></td>
<td><strong>142</strong></td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>8.7</strong></td>
<td><strong>16.5</strong></td>
<td><strong>14.2</strong></td>
</tr>
<tr>
<td><strong>Degree</strong></td>
<td>Perfect ex.</td>
<td>Perfect ex.</td>
<td>V. good</td>
</tr>
</tbody>
</table>

**Guide Line to Evaluation**

- Colour: 10
- Flavour and Texture: 20
- Perfect: (10-8.5)
- Perfect: (20-15)
- Very good: (8-7)
- Very good: (14-13)
- Good: (6-5)
- Good: (12-10)
- Fair: (4-3)
- Fair: (9-7)
- Poor: (2)
- Poor: (6-4)
- Very poor: (1)
- Very poor: (3-1)
Appendix (3):

Ratio Scoring

<table>
<thead>
<tr>
<th>Colour</th>
<th>Flavour</th>
<th>Texture</th>
<th>Colour</th>
<th>Flavour</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Guide Line to Evaluation**

Colour: 10
- Perfect: (10-8.5)
- Very good: (8-7)
- Good: (6-5)
- Fair: (4-3)
- Poor: (2)
- Very poor: (1)

Flavour and Texture: 20
- Perfect: (20-15)
- Very good: (14-13)
- Good: (12-10)
- Fair: (9-7)
- Poor: (6-4)
- Very poor: (3-1)