PHYSICO-CHEMICAL PROPERTIES AND SENSORY ATTRIBUTES OF JAM, JELLY AND JUICE OF DIFFERENT GUAVA VARIETIES

A THESIS

BY

MD. NAZMUS SHAKIB
Student ID: 1805083
Session: 2018-2019
Semester: January-June, 2019

MASTER OF SCIENCE
IN
AGRICULTURAL CHEMISTRY

AGRICULTURAL CHEMISTRY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
UNIVERSITY DINAJPUR-5200

JUNE 2019

PHYSICO-CHEMICAL PROPERTIES AND SENSORY ATTRIBUTES OF JAM, JELLY AND JUICE OF DIFFERENT GUAVA VARIETIES

A THESIS

BY

MD. NAZMUS SHAKIB
Student ID: 1805083
Session: 2018-2019
Semester: January-June, 2019

Submitted to the

AGRICULTURAL CHEMISTRY

Hajee Mohammad Danesh Science and Technology University, Dinajpur

In Partial Fulfillment of the Requirement for the Degree of

MASTER OF SCIENCE (MS)
IN
AGRICULTURAL CHEMISTRY

DEPARTMENT OF AGRICULTURAL CHEMISTRY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
UNIVERSITY, DINAJPUR-5200

JUNE 2019

PHYSICO-CHEMICAL PROPERTIES AND SENSORY ATTRIBUTES OF JAM, JELLY AND JUICE OF DIFFERENT GUAVA VARIETIES

A THESIS

BY

MD. NAZMUS SHAKIB
Student ID.: 1805083
Session: 2018-2019
Semester: January-June, 2019

Approved as to style and content by

.....	.....
Md. Shazadur Rahman	Prof. Dr. Md. Jahidul Islam
Supervisor	Co-supervisor

.....

Prof. Md. Dr. Abdul Hakim
Chairman of the Examination Committee
and
Chairman,
Department of Agricultural Chemistry

DEPARTMENT OF AGRICULTURAL CHEMISTRY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

JUNE 2019

DEDICATED
TO MY
BELOVED PARENTS

ACKNOWLEDGEMENTS

The author like to acknowledge the immeasurable grace and profound kindness of almighty "Allah" the supreme ruler of the universe, who enabled the author to make his dream a reality, a successful completion of the present piece of work and submission of this thesis.

The author expresses his deepest gratitude, sincere appreciation and heartfelt indebtedness to his reverent teacher and research Supervisor Md. Shazadur Rahman,Assistant Professor, Department of Agricultural Chemistry, for his constant guidance, meaningful suggestion, encouragements, immense help throughout the investigation and preparation of this manuscript. His constructive criticisms and unfailingly patient and enthusiastic encouragement made the completion of this venture possible for me.

The author also wishes to express his immense gratitude and deep sense of respect to his respected Co-Supervisor Professor Dr. Md. Jahidul Islam, for his valuable advices, scholastic guidance, incisive criticisms and all out assistance for completion of this thesis.

The author finds great pleasure to express his warmest gratitude, special appreciation to Professor Dr. Md. Abdul Hakim, Professor Dr. Bikash Chandra Sarker, for their helpful suggestions, co-operations, encouragements, inspiration during the courses if the research work.

The author is also expressing his cordial appreciation to all laboratory and office staffs of the Department of Agricultural Chemistry, HSTU, Dinajpur who directly or indirectly help to this complete this work.

Finally, the author expresses his boundless gratitude, deep sense of respects, indebtedness, ever gratefulness to his beloved parents, sister and other relatives for their great sacrifice, endless prayers, blessing and support to the completion of this study.

The Author

ABSTRACT

The experiment was conducted in the laboratories of the Department of Agricultural Chemistry and Food Processing and Preservation, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during July, 2018 to December, 2018 to find out the physico-chemical properties and sensory attributes of jam, jelly and juice of different guavavarieties. The guava varieties were bauranga (BAU-2), THAI -4 and local red. The guavas were collected from horticulture center, Dinajpur. The experiment was laid out in complete randomized design (CRD) with three replications.The guavas were carefully chosen in order to obtained the optimum maturity because its pectin contain depends on maturity. Sugar, citric acid, pectin, xanthamgum, sodium benzoate and relevant materials required for the experiment were received from the laboratory stocks.Among thevarietiesin fresh condition THAI-4 contained highest amount of ascorbic acid (107.67 mg/100 g), BAU-2 and local red contained102.5mg/100 g and 96mg/100 g respectively. Preserved products namely jam, jelly, and juice were developed from each variety.Compositional analysisshowed thatjam and jelly contained higher amount of total soluble solid, non-reducing sugar, ascorbic acid (vit-c) and lower amount of pH, acidity, reducing sugar.On the other hand, juice contained higher amount of moisture, non-reducing sugar, ascorbic acid (vit-c) content and lower amount of total soluble solid, pH, acidity, reducing sugar. The highest value of ascorbic acid was observed (38.59ml/100 g) in THAI-4 jam, (20.33ml/100 g) in BAU-2 jelly and (20.33ml/100 g) BAU-2 juice.The varieties standard formulation and the products (jam, jelly and juice) were evaluated for their physico-chemical properties and sensory attributes by a panel of 20 testers.The result revealed that the color, appearance, taste and flavor of jam, jelly and juice was significantly different among the varieties. The overall results revealed that jam and jelly prepared from BAU-2 was highly acceptable and juice prepared from THAI-4 was more acceptable than the other varieties.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

Guava is one of the most common fruits in Bangladesh. It is a native of South America. It is believed to be introduced in India early in the 17th century, it belongs to family Myrtaceae and genus Psidium contains about 150 species (Hayes, 1970). At current the major guava producing countries are USA, Cuba, Brazil, Taiwan, Mexico, Peru, China, Malaysia, India, Pakistan, Thailand and Bangladesh. The fruit of guava is very familiar for its delicious taste, high nutritive value and rich source of vitamin C. The fruit is available throughout the year at comparatively cheaper rate to people. So, it is known as 'poor men's apple'.

It is considered as one of the most important tropical fruit trees in the world, enriching the diet of hundreds of millions of people with its special characteristic odor and high nutritive value. They are often included among super fruits, as they are rich in dietary fiber, pectin, vitamin A and C, folic acid, potassium, copper and manganese and contain fair amount of calcium, phosphorus and iron (Morton, 1987).

This fruit contains rich source of vitamin C (260 mg/100g of fruit) and pectin which has industrial use for jelly production (Bose and Mitra, 2011). Guava is also good source of vitamin A, Bi, B2 and minerals like Iron, Calcium and Phosphorus (Sadhu and Chattopadhyay, 2001). Guava contains 84.2% water, 9.68% total soluble solids, .50% ash, 4.45% reducing sugar, 5.23% non-reducing sugar, 1.25% acid, and 560 mg/100g vitamin C. However, the composition of guava varies significantly with variety, stage of maturity and season. Its fruits also contain considerable amount of β-carotene, Thiamine, Riboflavin and Niacin. Therefore, for the nutritional security guava considered as an ideal food.

Guava stands fifth in production among the most important fruit crops of Bangladesh and can be grown in all over the country. According to the Bangladesh Bureau of Statistics (BBS, 2013)Ministry of Agriculture, Government of the People's Republic of Bangladesh Yearbook of Agricultural Statistic, the annual production of guava is about 181950 m. tons in an area of about 12542 ha at 2009-2010. In 2011-12 the guava production is

190074 m. tons within 12112 ha. Its cost of production is also low because its requirements for fertilizer, irrigation and plant protection are not much. Guava performs equally in tropical as well as in subtropical regions. Its trees are quite hardy and adaptable to a wide range of climatic condition and environmental stresses.

It is a shallow-rooted shrub or small tree spreading up to 3-10 m in height. It can be grown easily on a wide variety of soils from heavy clay to light sandy. The pH of soils with pH 6.5-7.5 are more suitable for its cultivation but it can withstand the soil pH ranging from 4.5 to 8.5.The characteristics of wide adaptability of guava tree helped it to sustain even in adverse conditions. However, the winter season guava is considered best for the adequate yield and improved fruit quality. For quality fruit production, the optimum temperature should be 23-28^{o}C. It can withstand extreme humid and dry conditions, but yield less and poor quality fruits, if there is decrease in humidity along with high temperature. The crop improvement through selection, introduction and hybridization was attempted in India and many other countries to develop high quality fruit varieties in terms of fruit size, high TSS, good sugar-acid blend, good aroma, attractive skin, flesh color, free core, soft seeds, keeping quality, stable juice color, high vitamin C and good pectin content (Boora 2012).

Although guava grows throughout the country it is confined in some areas where guava is cultivated for commercial purposes. At the time of harvesting season, a market glut is occurred in the guava producing areas. Careless and improper handling of fruits reduce the market value and keeping quality, ultimately causing enormous losses to both growers and consumers. In Bangladesh, due to lack of marketing, storage facilities the growers bound to sell their produce at throw away prices and huge quantity of guava spoiled. As estimated by Lashely (1984) an approximately 30 - 50% fruit goes waste during post-harvest handling, storage and ripening. This post- harvest loss is highly prominent in guava because of its high perishability. Once it fully ripe, the fruit becomes soggy and its edibility and marketing quality deteriorates rapidly.

Because of their perishable nature, guava disposes off immediately after harvesting in the local market and a very small quantity is sent to distant markets. The spoilage could be prevented during the glut season at the producing centers by converting them into new categories of processed products. Such efforts will help the development of processing

industries in the growing areas of the countries. Moreover, this will stimulate an increase in production and bring better return to the guava growers.

Guava is mainly used as dessert in many countries of the world. It can be used in preparing jam, jelly, candy, marmalade and juice. Guava jelly is well known to all and it can be caned in sugar syrup or made into fruit butter. Its juice is used for the preparation of sherbets and ice cream. Guava contains vitamin C, 2 to 5 times more than that of fresh orange juice.

Guava has been extensively studied in terms of pharmacological activity. The high vitamin C and polyphenol content of guava exhibits strong ant oxidative properties and also boost the functioning of the immune system of the body. Oxidative stress is found to play a contributory role in pathogenesis of ageing, inflammation and cancer. Free radicals have also been implicated as playing a role in etiology of various cardiovascular diseases, neurodegenerative diseases such as atherosclerosis, stroke, asthma, Alzheimer's disease and may also facilitate mutagenesis and tumor promotion and progression (Allen and Tresini 2000).In our body, protection against free radicals is provided either by antioxidant enzymes or by non-enzymatic antioxidants supplied through our diet which include thiols, vitamin C, vitamin E, vitamin A, some metals and polyphenols like isoflavones, gallic acid, quercetin, kaemferol etc. According to Misra and Seshadri (1968) phenolic compounds such as myricetin, apigenin, ellagic acid and anthocyanins are also present at high levels in guava fruits. Thus guava is at top among tropical fruits when it comes to disease fighting antioxidants.

This fruit have some nutritional benefits. Guava is rich in soluble dietary fiber. It is helpful in protecting the colon mucus membrane from toxins that may cause cancer. Guava is a great source of antioxidant. Guava is a great source of vitamin A helpful in maintaining a healthy mucus membrane. It also helpful in protecting the skin. Guava is also a source of vitamin E and K. They are also rich in minerals such as magnesium, copper and manganese. Fresh guava fruit is a very rich source of potassium. It contains more than potassium than other fruits like banana weight per weight.

Jam is a product made by boiling fruit pulp with sufficient amount of sugar to reasonable thick consistency, firm enough to hold the fruit tissue in position. It can be prepared from one or more kinds of fruits.

Jelly is a semi-solid product prepared by boiling a clear, strained solution of pectin-containing fruit extract, free from pulp, after the addition of sugar and acid. A perfect jelly should be transparent, well-set, but not too stiff, and should have the original flavor of fruit. It should be of attractive color and keep its shape when removed from the molds.

Juice is a drink made from the extraction or pressing of natural liquid containing fruit and vegetables. It can also refer to liquids that are flavored with concentrate or other biological source. It can be prepared from one or more kinds of fruits.

The objectives of the proposed research are

1. To determine the nutritional composition of fresh guava varieties.
2. To prepare guava product from each variety and study the nutritional composition of the preserved guava products.
3. To determine sensory attributes and find out the maximum acceptable variety to prepare products.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The literatures were reviewed on the following aspects to proposed research work:

2.1 Characteristics of guava

Guava (payara) a berry like fruit of any of various myrtaceous trees or shrubs of the genus Pisidium. It originated in tropical America (Mexico to Peru), where it still occurs in the wild. Guava is often called the "apple of the tropics". Portuguese introduce the plant to the Indian subcontinent by the early 17th century. Guava grows well in most climates in the tropics and subtropics. Being a hardy plant, guava is not much affected by the extremes of temperature. It does not however, tolerate frost. The optimum temperature for growth ranges from 23 to 28^{o}C (Samson 1980).

Guava fruit is a berry. The fruits are mostly round in shape. Some varieties are ovate or pear shaped. The fruit consists of fleshy pericarp and seed cavity with a number of small seeds. Numerous stone cells occur in the fleshy part of the fruit. These stone cells impart gritty texture to the flesh. The skin color of mature guava fruit is greenish yellow. The flesh color is normally white or cream. In some varieties it is pink. The flavor of mature guava fruit has been described as sweet, musky and highly aromatic (Wilson 1980; Singh 1988).

Guava is quite hardy, prolific bearer and highly remunerative even without much care. Now-a-days, guava is receiving importance as a promising dry land horticultural crop in Bangladesh. The information pertaining to cultivation practices of guava for high yield is available.

2.2 Morphology

Guava (*Psidium guajava* L.) is a fruit crop cultivated in the tropics and some sub-tropical regions (Gautam *et al.,* 2010; Rodríguez *et al.,* 2010). The fruit tree has been cultivated for a long time, and its distribution has been promoted by man, birds and other animals (Pommer and Murakami 2009). The tree has a good potential to grow on wastelands, including soils with high p^{H} levels (Gautam *et al.,* 2010), explaining its wide distribution. The fruit is a fleshy, pyriform or ovoid berry that can weigh up to 500 g (Orwa *et al.,* 2009) and varies greatly depending on the genotype and the environment (Babu *et*

*al.,*2007; Patel *et al.,* 2011). The fruit requires about 120 days to mature after flowering (Crane and Balerdi 2005). The skin color of ripe fruits varies from light green to yellow, while the pulp may be red, white, yellow or pink (Ecocrop 2015; Orwa *et al.,* 2009). The flavor ranges from sweet to highly acidic, while the aroma may be strong and penetrating, or even mild and pleasant (Mehmood *et al.,* 2014).

A mature tree will produce from 54 to 100 kg of fruit per year, with two seasons of production – one in which there is a major crop, and another with a minor second crop (Nyambo *et al.,* 2005). There are probably more than 400 guava cultivars around the world, but only a few are under common cultivation (Pommer and Murakami 2009). The cultivated cultivars are widely diverse regarding tree size, bearing habit, and yield, as well as fruit size, shape, ripening season and quality in terms of nutrient composition (Pommer and Murakami 2009; Sharma *et al.,* 2010).

Guava shape ranges from round, ovoid, to pear-shaped, and with an average diameter and weight ranging from 4-10 cm and 100-400 g respectively (Mitra, 1997). Classified as a berry, guava is composed by a fleshy mesocarp of varying thickness and a softer endocarp with numerous small, hard yellowish-cream seeds embedded throughout it (Malo and Campbell, 1994; Marcelin *et al.,* 1993). Guava pulp contains two types of cell-wall tissues: stone cells and parenchyma cells. Stone cells are highly lignified woody material responsible for a characteristic sandy or gritty feeling in the mouth when the fruit is consumed; due to their nature, they are resistant to enzymatic degradation. They account for 74% of the mesocarp tissue, while the endocarp is rich in parenchyma cells, which give it a softer texture. (Marcelin *et al.,* 1993). Exterior skin color ranges from light green to yellow when ripe and its pulp may be white, yellow, pink, or light red.

Unripe guava fruit are hard in texture, starchy, acidic in taste and astringent, due to its low sugar and high polyphenol content. Once it ripens, the fruit becomes very soft, sweet, non-acidic, and its skin becomes thin and edible (Malo and Campbell, 2004; Mitra, 1997). Many guava cultivars exist today; however, they can be broadly classified as pink or white. Seedless cultivars are available in many countries, which have a great potential to become popular in the US in the future (Yadava, 1996).

Figure 2.1: Guava tree (THAI-4)

2.3 Physical properties of guava

Guava bears mainly two crops in a year i.e., winter and rainy season crop. The fruits of rainy season crop are larger in size than winter season as reported by various workers (Pandey and Singh, 1998; Singh *et al.,* 2008). They further observed that the total soluble solids, total sugar, acidity, pectin and ascorbic acid content were higher in winter guava fruits than that of rainy season fruits.

The guava includes about 150 species, but only a few have horticultural value. There are generally two kinds of guava. The common guava (*P. guajava*), the most important species is Cattley Guava (P. cattlecianum), which is also grown commercially. The plant is a shallow rooted sharb or small tree (3 to 10m), branching close to the ground and often producing sukers from the roots. The leaves are opposite, oblong, elliptic and hairy beneath. Flowers are bisexual, white and 2.5 cm in diameter, borne on new growth from mature branches, either singly or in clusters of two or three. The multisided, glucose fruits are a fleshy berry.

The common guava has the scientific name *Psidium guajava* and is a part of the myrtly and eucalyptus family. The tree is small, with copper-colored bark. It has leaves with many veins, and white or cream colored flowers. The fruit of the common guava varies in size and shape, but it is usually 4-8 centimeters (11/2-3 inches) long. As the guava ripens, the outside skin changes color from green to light green or yellow. The flesh of the fruit may be white, yellow, pink or red. Inside the fruit are many stone-like seeds.

Another kind of guava is the Cattley guava, also called strawberry guava or Cherry guava. It is quite different from the common guava and has the scientific name *Psidium Caffleianum*. The leaves of the Cattley guava are smaller, shinier and darker green than those of the common guava. The fruit is also small, rarely growing to more than 4 centimeters (11/2 inches) long. It is usually red or radish purple. Inside are several large, nut-like seeds. Both kinds of guava trees usually bear their fruit during the hot, rainy season. Some of the important varieties are known by the name of the places where these are grown commercially. Thus Swarupkathi is from Barisal, Mukundapury from Brahmanbaria and Kanchannagar from Chittagong.

Guava cultivars display a great diversity in the tree size, bearing habit and yield, as well as in fruit size, flesh and skin color, taste and flavor and ripening season. There are three main types of guava: processing-type cultivars produce strong acidic fruit with colored flesh, dessert-type produce less acidic fruits with mostly white flesh and attractive skin color, while dual purpose-types produce less acidic fruits that are a compromise between processing and dessert requirements [Mamunur Rashid and Muhammad Nurul Amin].

Guava cultivars display a great diversity in the tree size, bearing habit and yield, as well as in fruit size, flesh and skin color, taste and flavor and ripening season. Kazi, introduce in Thailand, is the only standard variety that has been released by the Bangladesh Agricultural Research Institute. It produces fruit weighing up to 500 g or even more. All other varieties have fruit weights ranging from 100 to 200 g.

Ullah *et al.*,(1992) conducted an experiment at RaRa, Akbarpur Moulavibazar on physico-chemical characteristics on the fruits of nine guava cultivars. From the experiment it was found that Kazi peyara was very large in size and weight (9.5cm ×8.59cm and 446.3g respectively) among the varieties. Weight of rest of the fruits ranged from 68.8 to 165.5g and size varied from 4.95cm, 4.66cm to 6.75×6.35cm.Number of seeds per fruit ranged from 222.2 to 426.8 minimum number of seeds was in Kanchan nagar and maximum number was in Kashi peyara. Percent edible portion was the highest in Kazi peyara (98.23%) and lowest in Syedi (96.65%).

Azad *et al.,* (1987) conducted an experiment on physico-chemical characteristics of fruit of some guava varieties at BARI. The data indicated that Kazi peyara produced significantly bigger fruits than other varieties.

Haque (1992) carried out an experiment at BAU, Mymensingh on the vitamin C and mineral constituents of eleven guava varieties of Bangladesh. Among the varieties, Kazi and Thai were varying large in size and weight (424.77g and 388g), respectively. It is due to their genetical character. Soil fertility, management practices and environment also influenced fruit size.

Shanker (1967) studied the ripe fruit of five guava varieties and found that fruit weight ranged from 81.0g in seedless to 163.0g Allahbad Safada, seeds per fruit were 4 in. seedless, 230 (Luchknow-49), to 521 (hafsi) in other fruit seeded variety.

2.4 Chemical Composition of guava

Yusof (1990) carried out an experiment of physico-chemical character ranged from touristic of some guava varieties of Malaysia stated that moister content of the fruits ranged from 79.2 to 85.9%.

Verma and Shrivastava (1965) reported that guava fruits are rich source of pectin. The total pectin content of guava fruit ranged from 0.5 to 1.8 percent and it was found to be influenced by variety.

Phandis (1970) worked on improvement of guava in India and reported that guava contained .48% ash, whereas in another experiment Wilson (1980) found 0.66% ash in guava. This difference might be due to varietals characteristics.

Phandis (1970) observed that sadar guava contained acidity 2.45% Yusof (1990) carried out an experiment and stated that titratable acidity ranged from 0.26 to 0.52% in guava.

According to Chang *et al.,* (1971) the guava fruit contains citric, malic, glycolic, tartaric and lactic acids, first two being predominant ones. The content of organic acids has been reported to vary significantly in guava cultivars.

Gangwar (1972) reported that, the fresh ripe fruits of winter season had TSS (13°Brix), total sugar (9.4 per cent), acidity (0.48 per cent), pectin (1.16 per cent) and ascorbic acid (268.0 mg/100 gm) and were superior over rainy season fruits in quality.

Pandey and Singh (1998) studied the chemical composition of fruits of four important varieties (Sardar, Allahabad Safeda, Apple color and Sangam) of guava and observed that the fruits contained 12.10 to 14.20% total soluble solids, 149-250 mg/100 g ascorbic acid, 6.38 to 6.98% total sugar and 0.40 to 0.59% acidity, respectively.

Rathore (1975) worked on the season on growth and chemical composition of guava fruits and stated that the acidity of guava fleshed ranged from 0.33 to0.99%.

Nag (1998) carried out an experiment at the Bangladesh Agricultural Universityand observed the highest ash content in Swaruopkathi (90.475%) followed by Kazi peyara (.46) and Mukundopuri (.48%), respectively at the mature stage.

Steven *et al.,* (1970) stated that there were 22 compounds which play a predominant role in flavor and odor of guava fruit.

Misra and Sheshadri (1968) reported that the guava fruit contains significant amount of polyphenols and its concentration decreases with the maturity of fruit.

Ullah *et al.,* (1992) carried out an experiment and found that TSS of fruit juice in the mesocarp varied from 7.1% in the Kazi peyara to10.2%in Gu-oo8and in endocarp 10.7% in Kazi piara to 13.9% in Gu-008.

Palaniswami and Shanmugavelu (1974) while conducting an experiment in India with 11 varieties of guava that total soluble solid (TSS) varied from 4.0% in Lucknow-49 to 12.5% in smooth green and red fleshed fruits.

Chundawat *et al.,* (1976) reported that non reducing sugars and reducing sugars varied significantly among cultivars and from season to season. Non reducing sugar content was recorded to be higher in rainy season crops than winter season crop. A reverse trend in reducing sugars was found in winter season fruits.

Adrees *et al.,* (2010) estimated the nutritional quality of different fresh guava fruit varieties and observed that the total sugar content varied from 4.33 to 6.36 per cent. According to Singh *et al.,* (2013) the total sugar 8 content of fresh guava fruit of L-49 was found to be 4.3 per cent.

Table 2.1. Chemical composition of Guava (*Psidium guajava*)

Nutritional value per 100 g (Raw)	
Energy	285 KJ
Carbohydrates	14.32 g
Sugars	8.92 g
Dietary fiber	5.4 g
Fat	0.95 g
Protein	2.55 g
Vitamins	
Vitamin A	31 µg
Beta-Carotene	374 µg
Thiamine (B1)	0.067 mg
Riboflavin (B2)	0.04 mg
Niacin (B3)	1.084 mg
Pantothenic acid (B5)	0.451 mg
Vitamin B6	0.11 mg
Folate (B9)	49 µg
Vitamin C	228.3 mg
Vitamin K	2.2 µg
Minerals	
Calcium	18 mg
Iron	0.26 mg
Magnesium	22 mg
Manganese	0.15 mg
Phosphorus	40 mg
Potassium	417 mg
Sodium	2 mg
Zinc	0.23 mg
Other constituents	
Lycopene	5204 µg

Source: USDA Nutrient Data base, 2016

2.5 Nutritional composition of guava

The guava significantly contributes to the nutrition of the people of this country. Guava contains nutritional value five times more than orange. The guava is a good source of Vitamin C and fibers in the pacific. The guavas may differ in their nutritional composition depending on the growing conditions, season, maturity stage and variety. The pink fruits were found to contain more vitamin C than other varieties. The outer flesh of the fruit content more vitamin C than inner pulp. Vitamin C was decreased after ripeness had been attained. Similar to most other fruits, guava has low fat and protein and high moisture content. The guava is an exceptionally rich source of ascorbic acid and a fair source of vitamin A, calcium, phosphorus, pantothenic acid, riboflavin, thiamin, niacin and pectin (Wilson 1980).

Das *et al.,*(1995); Kundu *et al.,*(1995); Ghosh and Chattopadhyay (1996) reported that ripe guavas contain 77.9 – 86.9% moisture, 12.3 – 26.3% dry matter, 0.51 – 1.02% ash, 0.10 – 0.70% crude fat, 0.82 – 1.45% crude protein and 2.0 – 7.2% crude fiber. According to the national nutritional database of United States Department of Agriculture (USDA), the major nutritional components of fresh guava fruit per 100 g are: sugars 8.92 g; vitamin C 228.3 mg; vitamin A 624 IU; vitamin E 0.73 mg; vitamin K 0.0026 mg; lycopene 5.2 mg (in red fleshed cultivars only); potassium 417 mg; phosphorus 40 mg; magnesium 22 mg and calcium 18 mg (Singh and Yahia 2011).

Carbohydrates are the main component of guava and their composition also depends on the guava variety. Of the total carbohydrate content, about 60% are sugars, with a predominance of fructose (59%) followed by 35% glucose and 5% sucrose (Yusof 2003).

Guavas are a rich source of pectin. Pectin content of guava increases during ripening and declines rapidly in over-riped fruits. Total pectin content of guava was found to vary from 346-396 mg/100g for unripe fruit and 705-804 mg/100g for fully ripened guavas (Jagtiani *et al.,*1988).

Tanwar *et al.,* (2014) reported 0.6 per cent ash content in fresh guava fruit. Kumar (2015) analysed Punjab Pink and Allahabad Safeda varieties of guava and found that ash content was higher in Punjab Pink variety by 37.20 per cent. The value of ash content was recorded as 0.54 per cent in Allahabad Safeda and 0.6 per cent in Punjab Pink.

El-Buluk *et al.,* (1997) stated that ascorbic acid was increased significantly with fruit maturity. Yamdagni (1987) also found the similar result with the cultivars sardar, Allahabad Safeda and Banarasi Surkha.

Esteves *et al.,* (1984) carried out an experiment and stated that vitamin C was increased in all the cultivars during ripening and decreased during senescence.

Phandis (1970) analyzed the guava fruit to find out its composition and reported that the fruit contained 260mg vitamin C per 100g fruit, which differed with the variety, stages of maturity, ripening and season.

The pink flesh color found in some varieties of guava has been attributed to the presence of lycopene. Pink guava shows valuable nutraceutical properties in terms of high antioxidant activity as well as vitamin C and lycopene. Padula and Rodriguez-Amaya (1986) found that the red species of guava contains between 44.8 and 61.0 mcg/g of total carotenoid, of which 76-86% is lycopene.

El-Ahmady *et al.,*(2013) studied the chemical composition of the essential oil of guava fruits by gas–liquid chromatography/mass spectrometry (GLC/MS) and identified forty five compounds, accounting for 93.7% of the fruit. The dominant compounds found in fruit oil were β caryophyllene (17.6%) and limonene (11.0%).

2.6 Guava Phytochemicals

2.6.1 Phytochemicals

Phytochemicals may be defined as biologically active compounds present in foods, nutritive or non-nutritive, which prevent or delay chronic diseases in humans and animals. They may also be defined as food ingredients which provide health benefits beyond their nutritional value (reviewed by Ho *et al.,* 1992). The importance of phytochemicals has grown in recent years due to consumers increased awareness of health beneficial effects. The main phytochemicals found in guava are ascorbic acid, antioxidant-containing dietary fiber, carotenoids, and polyphenolics.

2.6.2 Ascorbic Acid and Other Antioxidant Vitamins

The main phytochemicals found in guava are ascorbic acid, antioxidant-containing dietary fiber, carotenoids, and polyphenolics. Guavas are considered an outstanding

source of ascorbic acid (AA), three to six times higher than the content of an orange and after acerola cherries it has the second highest concentration among all fruits. The AA content in guava varies from 60 to 100 mg/100 g in some cultivars, and from 200 to 300 mg/100g in others, while higher reports range from 800 to 1000 mg/100g. Mitra (1997) mentions that AA content is more influenced by the fruit's variety than by its ripening stage and storage conditions. Within the fruit, AA is concentrated in the skin, followed by the mesocarp and the endocarp (Malo and Campbell, 1994).Guava was also found to contain alphato-copherol (vitamin E) at nearly 1.7 mg/100g (Ching and Mohamed, 2001), which is an important fat-soluble dietary antioxidant.

2.6.3 Dietary Fiber

Dietary fiber in fruits and vegetables has been associated with a reduction in colon and other cancer risks. Soluble fiber content is generally associated with a reduced risk of cardiovascular disease.

In a study done to a number of tropical fruits guava showed the highest content of total and soluble dietary fibers with values of 5.60 and 2.70g/100g respectively (Gorinstein *et al.*,, 1999). Total and soluble fiber present in guava is extraordinarily high in concentration as compared not only to tropical, but all fruits and vegetables. Fiber from guava pulp and peel was tested for antioxidant properties and found to be a potent source of radical-scavenging compounds, presumably from the high content of cell-wall bound polyphenolics (2.62-7.79% w/w basis) present in each fiber isolate (Jimenez-Escrig *et al.*,, 2001).

2.6.4 Carotenoids and Lycopene

Carotenoids are yellow, red, and orange pigments abundant in a wide variety of fruits and vegetables. Due to their antioxidant properties, carotenoids have shown beneficial health effects in cancer inhibition, immuno-enhacement, and prevention of cardiovascular diseases (Wilberg and Rodriguez-Amaya, 1995). The most important carotenoids which provide oxidative protection are α-carotene, β-carotene, lutein, lycopene, zeaxanthin, and β-cryptoxanthin (VERIS, 2000). A well-established function is the vitamin A antioxidant activity of some of carotenoids, including α-carotene, β-carotene, β-cryptoxanthin. Carotenoids are a class of structurally related 40-carbon compounds (two 20-carbon tails) which consist of eight repeating isoprene units (Van de Berg *et al.,* 2000). Lycopene, the

major carotenoid presents in guava (Mercadante *et al.,* 1999), is a 40-C open chain hydrocarbon containing 11 conjugated and 2 non-conjugated double bonds arranged linearly (Figure 2.2). Currently, High Performance Liquid Chromatography (HPLC) is the preferred procedure for carotenoid analysis.

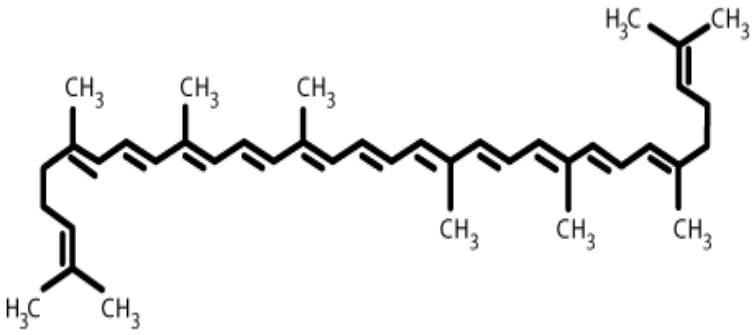

Figure 2.2: Chemical structure of lycopene

Lycopene has received considerable attention recently due to diverse in-vivo and in-vitro studies reporting the effect of dietary lycopene in reduction in the risk of prostate cancer and coronary heart disease (Rao and Agarwal, 1999). Lycopene has reported a superior antioxidant activity in relation to lutein or β-carotene, due to its conjugated double bonds (reviewed by Lin and Chen, 2003).

Lycopene content in guava 'Beaumont' variety has been found to be about 5-7 mg/100g fruit. Mercadante and partners (1999) isolated sixteen carotenoids from guava, of which thirteen were reported as guava carotenoids for the first time. In another study made to Brazilian guavas, the β-carotene concentration in ripe fruits ranged from 0.3 mg/100g to 0.5 mg/100g; while the lycopene concentration ranged from 4.8 mg/100g to 5.4 mg/100g (Wilberg and Rodriguez-Amaya, 1995).

2.6.5 Guava Polyphenolics

Polyphenols are the most abundant phytochemicals in our diets, and fruits are the main contributors (Jimenez-Escrig *et al.,* 2001). Gorinstein *et al.,* (1999) conducted a comparative study between several tropical and subtropical fruits and found guava to be among the top three investigated for concentrations of gallic acid (.374 mg/100g), total phenolics (4.95 mg/100g), and the highest total and soluble dietary fiber of the fruits investigated. Guava are somewhat unusual in their flavonoid polyphenolic content as

well, with significant levels of myricetin (55 mg/100g) and apigenin (58 mg/100g) present in edible tissues, but do not contain the more commonly found flavonoids quercetin and kaempferol (Miean and Mohamed, 2001) that are abundant in other fruits and vegetables. Misra and Seshadri (1967) identified procyanidins, or condensed tannins in both white and pink cultivars, concentrated in the skin and seeds, but very little in the pulp. Also, free of ellagic acid was isolated in both varieties (0.2 mg/100g in pink, 0.05 mg/100g in white). In the whole guava, total phenolics are concentrated on the peel, followed by the pulp (Bashir and Goukh, 2002). For processed products, though, location of polyphenolics does not matter since the entire fruit with peel is fed into a pulper.

Although limited information is existent, it has been confirmed that guava polyphenolics decrease and undergo considerable changes during maturation and subsequent ripening (Mowlah and Itoo, 1982; Itoo *et al.,* 1987; Bashir and Goukh, 2002). According to work conducted by Itoo *et al.,* (1987) immature, underdeveloped guava contains approximately 65% condensed tannins of its total polyphenols, which decrease dramatically as the fruit grows and develops. According to Mowlah and Itoo (1982) in both pink and white varieties both "nontannin phenolic' (simple phenolics, monomeric anthocyanins, catechins, and leucoanthocyanins) and "tannin phenolics" (hydrolysable and condensed tannins) decrease during ripening. However, at full-ripeness non-tannin phenolics (76 and 80% of total phenolics for pink and white respectively) contents are higher than tannin phenolic (24 and 20%). The decrease in astringency during guava ripening has been attributed to an increase in polymerization of condensed tannins to form an insoluble polymer and hydrolysis of a soluble/astringent arabinose ester of hexahydroxydiphenic acid, a precursor of ellagic acid (Goldstein and Swain, 1963; Misra and Seshadri, 1967; Mowlah and Itoo, 1982; Itoo *et al.,* 1987).

Confirming these results, an increase in free ellagic acid during ripening has been reported (Goldstein and Swain, 1963; Misra and Seshadri, (1967). Currently, limited information on individual polyphenolic compounds found in ripe fruits is existent.

2.7 Health benefits of guava

Huang *et al.,* (2011) studied that lyophilized pulp of guava in diabetic rats induces significant hypoglycemic effects probably due to its antioxidant activity of compounds present in the pulp. Guava fruit consumed for 12 weeks resulted in lowering of blood pressure by an average 8%, decreased total cholesterol by 9% decreased triglycerides by

almost 8% and increased HDL cholesterol by 8% (Singh *et al.,* 1993). The effects were attributed to the high potassium and soluble fiber content of the fruit.

Singh *et al.,* (1992) studied that nutrient intakes including saturated and total fat were significantly decreased; whereas carbohydrates, total and soluble fiber and vitamins and mineral intakes were significantly increased after 12 weeks of guava substitution. There was a significant net decrease in serum total cholesterol (9.9%), triglycerides (7.7%) and blood pressure (9.0/8.0 mm Hg) with a significant net increase in high-density lipoprotein cholesterol (8.0%).

Lakshmi and Sudhakar (2009) found out that ethanol extract of *Psidium guajava* exhibits anti-stress and adaptogenic activity thus may be useful in the treatment of several disorders caused by stress by its immune stimulating, immune modulating properties and also by enhancing the homeostatic mechanisms.

Lin and Yin (2012) analyzed the content of phenolic acids and flavonoids in extracts of guava fruit (*Psidium guajava* L.) and examined the renal protective effects of guava aqueous extract (GAE) and ethanol extract (GEE) in diabetic mice. The study revealed that GAE had more caffeic acid, myricetin, and quercetin; and GEE had more cinnamic, coumaric and ferulic acids. GAE or GEE supplied in diet at 2% for 12 weeks significantly reduced glucose and blood urea nitrogen levels and increased insulin level in plasma of diabetic mice ($p<0.05$). These findings support that guava fruit protects kidney against diabetic progression via its antioxidative, anti-inflammatory and anti- glycemic effects.

Guava leaf infusion is taken as a quick remedy for stomach complaints such as constipation and dysentery in Ghana, Senegal and Nigeria (Jaiarj *et al.,* 1999). Wei *et al.,* (2000) found in a clinical study with 62 infants with infantile rotaviral enteritis, the recovery rate was 3 days in those treated with guava, and diarrhea ceased in a shorter period than controls. It was concluded in the study that guava has good curative effect on infantile Rota viral enteritis".

Rodriguez *et al.,* (2001) stated that pectin chemicals in guava were shown to bind to *E. coli*, preventing its adhesion to the intestinal wall and thus preventing infection and resulting diarrhea. Yang *et al.,*(2009) investigated the antimicrobial effects of guava fruits, leaves and juice on the survival and growth of seven Escherichia coli strains and found that the guava products (fruit, juice and leaf extracts) significantly reduced survival

and growth of the tested foodborne pathogen strains indicating that guava extracts are a potential antimicrobial agent to ensure food safety.

More and more evidences suggest that high consumption of guava is strongly associated with reduced risk of developing chronic diseases such as cancer, diabetes, Alzheimer's disease, cataracts, and age-related functional decline (Conway, 2002). Although guava possesses enormous health benefits, a major drive in the research and development of guava as functional food is far behind than other exotic fruits (Heinrich *et al.,* 1998).

2.8 Ripening stage of guava

Mitra and Bose (1990) reported that the components responsible for flavor are the ester components which have the higher concentration (44.94%) in ripe fruits and the lowest (33.38%) in mature one.

Yamdagni (1987) worked on the guava fruit cultivars sardar, Allhabad Safeda and Banarasi Surkha and they divided the fruit into different ripening stages viz. i)Green mature ii) Colour break iii) Deep Yellow color and iii) over ripe stages.

Scientist divided the ripening process into a set of stages. They defined the stages on the basis of the eminent external changes at the onset and during the progress of ripening in the color of skin. Reyes and Paul (1995) divided the ripening period into the following color stages-i) Mature green ii) Quarter yellow iii) Half yellow.

2.9 Postharvest Physiology

Ripening and factors associated with it in climacteric fruits is regulated by ethylene synthesis. Ethylene (C_2H_4) is a naturally-produced, gaseous growth regulator associated with numerous metabolic processes in plants (Mullins *et al.,*, 2000). It is produced from L-methionine via 1-aminocyclopropane-1-carboxylic acid (ACC) synthase in a complex signal transduction pathway, which is still widely researched today (Salveit, 1998; Mullins *et al.,*, 2000). All plants produce ethylene, but only climacteric fruits and wounded or stressed tissue produce sufficient amounts to affect other tissues. In climacteric fruits, ethylene stimulates its own biosynthesis at the start of ripening, enhancing its production until reaching saturation levels (Salveit, 1999). Stresses such as chill injury, heat shock (Cisneros-Zevallos, 2003) or disease (Mullins *et al.,* 2000), can

induce ethylene production and therefore enhance fruit ripening, and the factors associated with it.

Studies evaluating respiratory patterns of guava demonstrated a climacteric response as increased carbon dioxide corresponded to increased ethylene production (Akamine and Goo, 1979; Mercado-Silva *et al.,* 1998; Bashir and Abu-Goukh, 2002).

Guavas have a rapid rate of ripening, therefore a relatively short shelf life ranging from 3 to 8 days depending on the variety, harvest time, and environmental conditions (Reyes and Paull, 1995; Basseto *et al.,* 2005). Ethylene production and respiration (CO_2 production) increases after the first day of harvest, at the start of ripening. Guava reaches its climacteric peak between day 4 and 5 post-harvest (mature-green harvested fruits) and then declines (Akamine and Goo, 1979; Bashir and Abu-Goukh, 2002).

As a guava ripens, total soluble solids and total sugars increase in both the peel and pulp, whereas titratable acidity declines after reaching its climacteric peak of respiration. In general, climacteric fruits undergo considerable changes in sugar content during ripening, where starch and sucrose are broken down into glucose (Bashir and Abu-Goukh, 2002). Moisture loss in guava, especially in tropical climates, can also be substantial resulting in up to 35% weight loss (Mitra, 1997) that corresponds to loss of postharvest quality and consumer acceptability. Ascorbic acid content is at its maximum level at the mature-green stage and declines as the fruit ripens in both white and pink

Guavas (reviewed by Bashir and Abu-Goukh, 2002), and may also be a function of postharvest handling. Lycopene synthesis in pink guavas is enhanced during ripening. In the case of tomatoes, once lycopene is accumulated, the respiration rate decreases (Thimann, 1980). Total fiber content decreases significantly during ripening, from 12 to 2g/100g, and it is hypothesized that is closely be related to the activity of certain enzymes (El-Zoghbi, 1994). Abu-Goukh and Bashir (2003) studied the activities of some cell wall degrading enzymes in both pink and white guava and showed that pectinesterase (PE) activity increased until reaching its climacteric and latter decreased, whereas polygaracturonase (PG) and cellulase increased as the fruit ripened in correspondence to fruit softening. Increase in polyphenoloxidase (PPO) activity was also reported with ripening and a decrease in polyphenolics, which be the responsible for the reduction of astringency (Mowlah and Itoo, 1982).

Visually, the ripeness level of guava can be characterized by its skin color ranging from a dark green when unripe to a bright yellow or yellow-green at full ripeness. However, determination of ripeness can be misleading for some varieties and may be combined with a simple test for specific gravity, by placing fruit in water to determine if it sinks (unripe) or floats (ripe) to obtain a clearer picture of the degree of fruit ripeness (Reyes and Paull, 1995). Objective determination of skin color has also been used to predict ripeness, with L*, a* and hue angles of 65.93, 15.92, and 110.92° respectively indicating a mature, yellow fruit (Mercado-Silva *et al.,* 1998). In combination with fruit texture, these simple assays can provide an adequate estimation of the stage of fruit ripeness.

2.10 Postharvest Treatments

2.10.1 Guava Postharvest Handling and Storage

Mitra (1997) studies on post-harvest physiology and storage on tropical and subtropical fruits. He showed in his food that tropical and subtropical fruits are becoming increasingly important food items in countries where they are produced and also in an increasing number of importing countries in non-tropical areas. His book deals with the post-harvest storage. Physiology and conservation of all of the economically important tropical and subtropical fruits. It should be of particular interest to all horticultural researchers' fruits. It should be particular interest to all horticultural researchers' exports and imports within the interest concerned with tropical and subtropical fruits.

Reyes and Paull (1995) reported less disease incidence in mature green guavas stored at 15°C as compared with fruit that were quarter- and half-yellow under the same conditions. Additionally, 15°C was determined to be an optimum holding temperature prior to processing, since it allowed gradual ripening of mature-green fruit while delaying deterioration of quarter-yellow and half-yellow fruit. Fruit stored at 5°C did not ripen and developed skin bronzing after two weeks in storage, as a consequence of chill injury.

2.10.2 Quarantine Heat Treatments

Various thermal and chemical quarantine treatments exist for fresh tropical fruits entering the US established by US Department of Agriculture-Animal and Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ). They are set to ensure disinfestations from pests, insects, larvae, eggs or fungus for fresh produce importation from other countries and other US states or territories. During the past years, there has

been an increasing interest in the use of thermal treatments as a measure of control, due to consumer demand to ameliorate the use of chemicals. Currently, there are three methods to heat commodities: hot water, vapor heat, and hot air (reviewed by Lurie, 1998). Hot water dips are effective for both fungal pathogen control and for

disinfestations of insects, needing a longer time for the latter one, since the internal core of the fruit and not just the surface needs to be brought up to the required temperature. Procedures have been developed to disinfest a number of tropical and subtropical fruits from various species of fruit fly (reviewed by Paull, 1994). The USDA-APHIS-PPQ treatment manual includes treatment schedules that must be followed to import fruit into the US. In the case of mango, this includes a 46°C hot water dip that disinfects mangoes with possible fruit fly contamination. Currently, no established treatment schedule exists for guava by the US government (USDA-APHIS, 2004).

Guava is major host for many nephritic fruit fly species, including the Caribbean Fruit fly, *Anastrepa suspensa*, which has been present in Florida for several years. Local guavas therefore, cannot be exported from Florida to other citrus-producing states, somewhat limiting their market as fresh fruit (Gould and Sharp, 1992). Gould and Sharp(1992) conducted studies to determine the suitability of hot-water (HW) immersion as a quarantine treatment to disinfest pink guavas of Caribbean fruit flies and to assess its effect on overall fruit quality. As compared to other tropical, such as mangos, a shorter immersion time was required to kill larvae in guava due to the size of the fruits used (approx. 90g). The storage temperature was apparently more important than a HW treatment to retain fruit quality. Guavas held at 24 ºC ripened within 7 days and guavas held at 10 ºC ripened within 11 to 18 days regardless of the length of the HW treatment. Probity statistical analysis estimated probity 9 (99.9968%) mortality at 31 min at 46.1 + 0.5 ºC for quarantine security, which did not affect fruit quality. This has been one of few studies done on guava HW treatment application. Further investigations are needed in order to obtain a quarantine schedule for guava.

2.10.3 Shelf-life Extension Treatments

Various treatments exist to extend the shelf-life of horticultural commodities. Storage under modified atmosphere (MA), packaging (MAP) or coating in polymeric films (cellulose or carnouba-based emulsions) have been shown to be effective on many commodities, including guava. In most cases, respiration and ethylene production are

reduced, delayed or inhibited, inhibiting ripening and characteristics associated with it (Mitra, 1997). Other shelf-life extensors which act directly on ethylene binding sites are called ethylene inhibitors or ethylene blockers. Some compounds employed as ethylene inhibitors for both floricultural and horticultural commodities include: carbon dioxide, silver thiosulfate (STS), aminoethoxyvinylglycine (AVG). 2,5-norbornadiene (2,5-NBD), and diazocyclopentadiene (DACP) (Blankenship and Dole, 2003). 1- Methylcyclopropene is an ethylene blocker which is gaining popularity because of its action in a broad range of produce and its practicality of use.

2.11 Guava and its preserved products

Guavas are best when consumed fresh. But due to their highly perishable nature, mature fruits can only be stored for a limited period at room temperature (Singh and Pal 2008). The fruit is sensitive to low temperature (Wills *et al.,* 1983) and susceptible to infection by decay causing fungi making its transport and storability difficult. So to extend the shelf life and make the fruit available throughout the year, the fruits are often processed into juice, nectar, pulp, jam, jelly, slices in syrup, fruit bar or dehydrated products. It is also used as an additive to other fruit juices or pulps (Leite *et al.,* 2006). Two types of wines viz. guava juice wine and guava pulp wine are also prepared from guava fruits (Bardiya *et al.,*1974). The selection of a guava variety for processing depends on the characters like pulp, sugar, acids, pectin and vitamin C.

2.11.1 Guava jelly

Jelly is one of the major products prepared from the guava fruits. For the preparation of jelly, slightly under ripe fresh guava fruits are used. The fruits are cut into small pieces or slices and boiled with equal amount of water for 30-45 minutes at low flame. The material is filtered through a strainer/ muslin cloth and clear juice obtained which is used for the preparation of jelly.

Desrosier (1963) reported that gel formation occurs only without certain range of hydrogen ion concentration, the optimum acidity figure for jelly being pH 3.2. The gel strength falls slowly on decreasing and rapidly on increasing the pH value. Beyond pH value 3.4 jelly formation occurs at the usual soluble solid range. The optimum concentration so sugar is about 67.5%, it is however possible to make jellies with high content of pectin and acid containing less than 60% sugar. Too high concentration of

sugar results also in a jelly of stick consistency. The quality of pectin necessary to form a gel depends largely on the quality of pectin. One percent should be sufficient to produce a firm jelly.

El-Mubarak *et al.,* (1977) observed that by using 100 grade pectin solution from citrus waste/kg pulp Guava good setting and flavor of jam manufacture from guava.

Parashkova (1982) conducted that, fruit jelly manufacture with low sugar content preserved well. The aroma and flavor of fresh fruit due to shorter heating time. The effect of 0.30 to 50.35% NaCl to the jellies produced from the sugar solution and syrups with citric acid resulted in 25% reduced composition of jelling agents, the physical and sensory properties of jellies as well as their resistance to the unfavorable action of acids at high temperature remained unchanged.

Singh and Chandra (2012) developed the fruit jelly using various level of guava extract and carrot juice and found that the jelly prepared with guava extract and carrot juice ratio of 75:25 was found to be superior to those prepared with other ratios. It was also found that there was a decrease in most of the physico-chemical and sensory qualities during the storage of jelly.

Donchonka *et al.,*(1983) observed that at pH 6.0the strength of jam/jelly was 4 kpa; increasing citric acid concentration resulted in increased jelly (strength) at pH 3.2the strength was 40.0 kpa and at pH (2.8 it was 53.2 kpa) pH values in the range 2.8-3.2 are considered optimum for maximum strength of jelly.

2.11.2 Guava jam

Jam is a fruit preserve with a stable shelf-life that depends on high sugar content (68-72%) combined with the fruit acidity that prevents microbial invasion and growth. A good jam is, in fact, a complex product that requires precise balance between sugar level, acidity and pectin content of fruit boiled together to produce a gel on cooling (Egan *et al.,*1981). Guava jam is made from chopped or crushed guava by cooking it with sugar, pectin and acids, to improve consistency and acidity of the final product (Sidhu 2006). Menezes *et al.,*(2009) observed that higher yields and firmer guava jam were obtained with increasing addition of ascorbic acid and reduction in fruit/sugar ratio.

Shah *et al.,* (1975) studied that single strength guava juice retained higher amount of ascorbic acid (35%) than guava juice with 25% added sugar. Jawaheer *et al.,* (2003) investigated effects of storage of fresh fruits and the processing into jam and juice followed by storage, on the ascorbic acid content. Results showed that the postharvest storage of the fruits resulted in a loss of 28% of ascorbic acid for white and 25% for red fleshed over six days. During the juice making process, the highest percentage of loss of ascorbic acid was due to peeling (6%) followed by exhausting (4.5%). Processing led to an overall decrease of 20.4% for juice and 62.5% for jam. The average ascorbic acid content of juice (76.2 mg/100 g fruit) was significantly higher than the average ascorbic acid content of jam (35.6 mg/100 g fruit).

Asghar *et al.,* (2015) analyzed the jam made from apple and bale pulp at different levels of concentration and found a significantly decrease in the vitamin C and total phenolic contents after processing.

Hegde *et al.,* (2007) studied the lycopene content in processed tomato products namely tomato jam, pickle, pulp and squash. Tomato jam (32 mg/100g) had the highest lycopene content followed by pickle (30 mg/100g), squash (15 mg/ 100g) and least in tomato pulp (10 mg/ 100 g). Thermal processing and tissue matrix destruction might have led to increased lycopene content. Sato *et al.,* (2006) observed that thermal processing may be responsible for rupture of fruit membranes, release of lycopene from red guava, enhancing its bioavailability and intensifying the red color of processed food.

Mazur *et al.,* (2014) studied the effects of ripeness and cultivar on chemical composition of strawberry fruits and their suitability for jam production and found that the quality parameters and chemical composition of fruits of the strawberry cultivars were significantly affected by ripeness of the fruits. The degradation of phenolic compounds and ascorbic acid during jam processing was generally low compared to the changes that occurred during storage. The differences in ripeness of the fruits were quite small but it affected the changes that occurred in the jams during storage .Concentrations of anthocyanin's and ascorbic acid decreased the most in jams made from the least ripe fruits. Further, stability of phenolic compounds and color was affected by the cultivar.

2.11.3 Guava juice

Guava juice is known to be a great thirst quencher as well as extremely rich source of vitamin C and iron (Dhillon 2013). It may be prepared from fresh fruits or stored pulp. Juice from fresh fruit is extracted by squeezing guava pieces through a hydraulic filter press. Juice could be made from pulp by diluting it with water adding sugar and citric acid and then filtering. It could further be processed and utilized in the form of concentrates, beverages and other products. The fully ripe guavas are cut into small pieces followed by addition of 0.2 g citric acid and 250 ml water/kg. The mix is cooked while stirring constantly, strained through a muslin cloth and juice is collected.

Pandey and Singh (1999) evaluated recipes for commercial preparation of guava RTS beverage. The recipe containing 10% pulp and 11% TSS with 0.25 % acidity was found most ideal and storage stability of the product was found 4 months at ambient temperature.

Kadam *et al.,*(2012) prepared guava juice RTS using 12% of guava fruit pulp and pasteurized at 85ºC for 3 min with the addition of sugar (12%) and citric acid (2.8g/l) and adjusted the remaining volume with water. Nectar was made using 20% guava pulp, 15% sugar, 2.5g/l citric acid and 65% water. It was found that the ascorbic acid content (mg/100g) decreased with increase in the dilution varying as 8.086 mg/100g in guava nectar and 2.56 mg/100g in guava RTS.

Pasupuleti and Kulkarni (2014) studied the effect of lycopene fortification on the quality characteristics of pink flesh guava beverage. Incorporation of lycopene in the form of tomato puree to the guava pulp resulted in increase in lycopene from 760 µg/100 g to 2010 µg/100 g and enhanced the nutritive value. Guava beverage having 6 % tomato puree had acceptable color, flavor and overall quality.

Ordóñez-Santos and Vázquez-Riascos (2010) studied the effect of processing and storage time on the vitamin C and lycopene contents. The production of nectar from fresh guava reduced vitamin C to 37% and lycopene to 38% of that of the whole fruit. The reduction of lycopene and vitamin C in guava nectar is attributed mainly to the dilution effect generated by addition of water in the product. Pulping increased lycopene content by 77.5% and Vitamin C content was significantly reduced by 28.3%. Hypothesis of possible increase of lycopene during the pulping of

the guava fruit, is the increase in free lycopene at the expense of protein-bound lycopene, because it may be partly due to the disruption of cell membranes by homogenization and heat treatment leading to the cleavage of protein-carotenoid complexes and hence to increased extractability of carotenoids. However, heat treatment might stimulate the transformation of some carotenoids into lycopene. The loss of vitamin C in the pulping of the guava fruit is greater than the loss of 11% and 20.4% that have been observed during the production of guava juice. These losses of vitamin C are probably due to oxidation.

2.12 Some other product prepared from guava

Chandu and Prasad (2006) developed guava pulp candy by optimizing amount ofbutter and sugar. Fresh, firm, fully matured guava was obtained and cut into pieces. The guava pieces were boiled in water to soften the pieces. The seeds were removed with the help of sieves and guava pulp was mixed with sugar, butter and milk powder to make a candy mixture. The concentrated candy mixture was spread on the pre-greased trays with butter and cooled to 25^{o}Cand cut into cubes and then wrapped in butter paper.

Madan and Dhawan (2005) prepared candies from carrot following three different methods. First type of candy was made by pricking the carrots followed by blanching and then dipping in sugar syrup till 68 per cent concentration was achieved for 3-4 days followedby drying at 55^{o}C. Using second method candies were prepared by pricking the carrots followed by blanching and soaking in jiggery syrup till the concentration is raised to 68^{o}B.Syrup is drained and candies are dried at 55^{o}C. Third type of candy wasprepared in thesimilar way except an additional step that included soaking of dried candies again in 70 percent concentrated sugar syrup for 30 minutes and dried to 50^{o}C till candies becomes non-sticky.

Kaikadi *et al.,* (2006) used pre-treated bar fruits for candy preparation. The fruits were dipped in sugar syrup of 40 per cent concentration for a day and dipped in 50 per cent sugar syrup for another day. Fruits were then placed in sugar syrup of 60 per cent concentration for a day followed by dipping in 70 per cent sugar syrup for 7 to 8 days. The candies were dried in shade after washing under running tap water.

Singh *et al.,*(2013) developed guava nougat, a sugar confectionery product from guava to utilize its nutritional qualities. The most acceptable recipe for the product had combination of 550 g sugar, 75g butter, 125 g milk powder, 35 g cashew nut and 90 g glucose. The guava nougat was thus found to have T.S.S (69.93^0Brix), acidity (0.064 % C.A), total sugar (74.77 %) and ascorbic acid (160.4 mg/100g).

Patel and Amin (2015) formulated different milk ice-creams fortified with pink guava pulp and concludedthat the ice-cream prepared using cow milk and guava pulp and using coconut milk and guava pulp contained higher nutrient, followed by buffalo milk. Ice cream from cow milk and guava pulp had higher amount of ascorbic acid content 196.28 mg %, energy 172.31 kcal, moisture 62.6 g %, fat 5.16 g %, protein 3.33 g %, iron 0.9 mg %, calcium 132.82 mg % and CHO 28.11 g % and coconut milk and guava pulp ice-cream contained higher amount of energy 215.48 kcal, fat 10.83 g %, iron 1.57 mg %, ascorbic acid 185.17 mg %, calcium 65.17 mg %, CHO 26.08 g %, protein 3.41 g % and moisture 61.84 g %. Ice- cream prepared from cow milk and guava pulp obtains higher acceptability than other samples.

The literature was reviewed regarding the physical, chemical and nutritional composition of guavas, their health benefits and development and quality evaluation of the preserved products developed from guavas to analyze the quantum of work done under the above mentioned areas. The studies conducted on guava fruit, its processing and health aspect showed that guava is a rich source of a wide variety of nutrients and has a long history of being used for a number of physiological disorders. Guava fruit, jam, jelly and juice as well as its preserved product are freely consumed for their great taste and nutritional benefits.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The investigation was conducted in the laboratory of the Department of Agricultural chemistry and Food and Process Engineering-1, Hajee Mohammad Danesh Science and Technology University, Dinajpur during July, 2018 to December, 2018.

3.1 Materials and equipment required

3.1.1 Materials

Three varieties of experimental material (guava) were taken for this research. Bauranga (BAU-2), THAI-4, Local red collected from horticulture center, Dinajpur. The guavas were carefully chosen in order to obtained the optimum maturity because its pectin contain depends on maturity. Sugar, citric acid, pectin, xanthamgum, sodium benzoate and relevant materials required for the experiment were received from laboratory stocks.

Bauranga(BAU-2) Local red

THAI-4

Fig 3.1: Fresh guava sample

3.1.2 Solvents and reagents

a) Pectin
b) Citric acid
c) 1N Hcl
d) 0.1N NaOH
e) Sodium benzoate
f) Xanthamgum
g) Meta-phosphoric acid (3%)
h) Standard ascorbic acid solution
i) Dye solution
j) Fehlings solution
k) Methylene blue
l) Natural lead acetate solution

3.1.3 Instruments and equipment's

a) Blender
b) Electric heater
c) Analytical balance
d) Volumetric flask
e) 250 ml conical flask
f) Burette
g) Pipette
h) Potentiometer
i) Whatman filter paper no.4

3.2 Jam preparation

Ingredient

i. Juice with pulp----450 g
ii. Sugar----------550 g
iii. Pectin---------- 5 g
iv. Citric acid-------- 5 g

Procedure

Ripe firm fruit

↓

Washing

↓

Cutting into small pieces

↓

Boiling

↓

Peeling

↓

Extract the juice and pulp

↓

Boiling (juice and pulp)

↓

Addition of sugar

↓

Addition of citric acid

↓

Color added

↓

Judging the end point

↓

Filling hot into sterilized bottle

↓

Cooling

↓

Capping

↓

Storage

(at ambient temperature)

Fig 3.2 Flow chart for jam (Guava) preparation

3.3 Jelly preparation

Ingredient

i. Juice-------- --450 g
ii. Sugar----------550 g
iii. Pectin---------- 5 g
iv. Citric acid----- 5 g

Procedure

Ripe fruit
↓
Washing
↓
Cutting into thin slides
↓
Boiling with water
↓
Extract juice
↓
Pectin test
↓
Boiled
↓
Addition of sugar
↓
Addition of citric acid and Color
↓
Judging the end point
(By drop)
↓
Removal of scum or foam
↓
Filling hot into sterilized bottle
↓
Cooling
↓
Capping
↓
Storage
(at ambient temperature)

Fig 3.2 Flow chart for jelly (Guava) preparation

3.4 Juice preparation

Ingredient

i. Juice----------750 g
ii. Distilled water--------400 g
iii. Sugar----------100 g

Procedure

Ripe fruit
↓
Washing
↓
Cutting into thin slides
↓
Boiled
↓
Extract juice
↓
Mixing with stained syrup solution
(Sugar+Distilled water+Sodium benzoate+Citric acid+Xanthamgum)
↓
Heated just to Boiled
↓
Homogenization
↓
Bottling
↓
Crown corking
↓
Pasteurization (90^0c for 15 min)
↓
Cooling
↓
Storage

Fig 3.3 Flow chart for juice (Guava) preparation

3.5 Chemical analysis

The fresh sample of matured guava, guava jam, Jelly and juice were analyzed for moisture, Vitamin-C (ascorbic acid), Titrable acidity, total soluble solid, pH, reducing sugar, non- reducing sugar and total sugar as per the method as of Ranganna (1992).

3.5.1 Moisture content

5 gm fruit was taken in crucible and placed in an oven at 80°C for72 hours until constant weight attained. Percent moister content was calculated using following formula:

$$\%Moisture = \frac{IW-FW}{IW} \times 100$$

Where,

IW = Initial weight of guava

FW= Final weight of oven dried peel

3.5.2 Vitamin C content

The reagents used for the estimation of vitamin C were as follows:

i) Meta phosphoric acid (3%)

ii) Standard ascorbic acid solution

iii) Dye solution

Standardization of dye solution: 5 ml standard ascorbic acid solution was taken in a conical flask and 5 ml meta phosphoric acid (HPO_3) was added to and shaken. A micro burette was filled with dye solution then the ascorbic acid solution was treated by dye solution using phenolphthalein as an indicator, till the end point (light pink color) is reached. The pink color will persists at least for 15 seconds.

Dye factor was calculated using the following formula:

$$Dye\ factor = \frac{0.5}{Titre}$$

Preparation of sample: 20 gm sample was taken in a blender and homogenized with 3% meta phosphoric acid and then the blended material was filtered. The filtrate was transferred to a 250 ml volumetric flask and the volume was made up to the mark with meta phosphoric acid.

Titration: 5 ml of meta phosphoric acid extract was taken in a conical flask and titrated with standard dye solution, using phenolphthalein as an indicator. The end point will be light pink color which persists at least for 15 seconds. Vitamin C content was calculated by using the following formula:

$$Vitamin\ C\ content = \frac{T \times D \times V_1}{V_2 \times W} \times 100$$

Where

T = Titration

D = Dye factor

V_1 = Volume made up

V_2 = Volume of extract taken for estimation

W = Weight of sample taken for estimation

3.5.3 Titrable acidity:

50 gm sample was taken in a blender and homogenized with distilled water, the blended materials were then filtered and transferred to a 250 ml volumetric flask and the volume was made up to the mark with distilled water. 5 ml solution was taken in a conical flask and titrated with 0.1N NaOH solution using phenolphthalein as an indicator. The end point shows colorless to pale pink and will stand 15 seconds. The titration was done for several times for accuracy.

Percent Titrable acidity was calculated using the following formula:

$$\text{Titrable acidity} = \frac{T \times N \times V_1 \times E}{V_2 \times W \times 100} \times 100$$

Where,

T = Time

N = Normality of NaOH

V_1 = Volume made up

E = Equivalent weight of acid

V_2 = Volume of sample taken for estimation and

W = Weight of sample

3.5.4 Total soluble solids (TSS)

Total soluble solids of extracted juice were estimated by using Abbe refractometer. A drop of guava juice placed on prism of refractometer on its prism. Percent TSS was obtained directly from the scale of refractometer.

3.5.5 pH

Reagent:

Buffer solution of pH 4

Buffer solution: A buffer solution may be defined as a solution which maintains a nearly contain pH value respite the addition of substantial quantities of acid and base. Generally it consists of mixture of an incompletely dissociated acids and its conjugated base. Buffer solution of any known pH may be used.

Potentiometer

Procedure

An electrolytic cell composed of two electrodes (calomel electrode and glass electrode) was standardized with buffer solution of pH 4. Then the electrodes were dipped into the test sample (guava juice, jam and Jelly). A voltage corresponding to the pH of the solution indicated by the instrument

3.5.6 Sugar

The sugar content in a food sample is estimated by determining the volume of the unknown sugar solution required to completely reduce a measured volume of Fehling's solution.

Preparation of Fehling's solution

Reagents

1. Fehling's solution (A): Dissolve 69.28 g of copper sulphate ($CuSO_4.5H_2O$) in water, dilute to 1000 ml and if necessary, filter through No. 4 Whatman paper.
2. Fehling's solution (B): Dissolve 346 g of Rochelle salt (potassium sodium tartrate, $KNaC_4H_4O_6.\ 4H_2O$) and 100 g NaOH in water and make up to 1000 ml.
3. Methylene blue indicator: Dissolve 1 g of methylene blue in 100 ml of water.
4. 450% Neutral lead acetate solution: Dissolve 225 g of neutral lead acetate in water and dilute to 500 ml
5. 22% Potassium oxalate solution: Dissolve 110 g potassium oxalate ($K_2ClO_4.\ H_2O$) in water and dilute to 500 ml. An excess of lead acetate in the sugar solution will result in an error in the titration. Determine the exact amount of potassium oxalate solution necessary to precipitate the lead from the lead acetate solution. To obtain this value, pipette 2-ml aliquots of the lead acetate solution into each of six 50-ml beakers containing 25 ml water. To the beakers add 1.6, 1.7, 1.8, 1.9, 2.0 and 2.1 ml potassium oxalate solution respectively. Filter each through a 41H Whatman paper and collect the filtrate in a 50-ml conical flask. To each of the filtrates, add a few drops of potassium oxalate solution. The correct amount of potassium oxalate required is the smallest amount which, when added to 2 ml of lead acetate solution, gives a negative test for lead in the filtrate. In the presence of lead, the filtrate gives white precipitate with HCl or yellow precipitate with potassium chromate solution. The equivalent volume should be marked on the bottle and employed when the solution is used in sugar determinations.
6. Standard invert sugar solution: Weigh accurately 9.5 g of sucrose into a 1-litre volumetric flask. Add 100 ml water and 5 ml conc HCI. Allow to stand for 3 days at 20-25° C or 7 days at 15° C for inversion to take place, and then make up to mark with water. This solution is stable for several months.

Pipette 25 ml of the standard invert solution into a 100-ml volumetric flask and add about 50 ml water. Add a few drops of phenolphthalein indicator and neutralize with 20% NaOH until the solution turns pink. Acidify with 1 N HCl adding it dropwise until one drop causes the pink color to disappear. Make up to mark with water (1 ml = 2.5 mg of invert sugar)

Standardization of the Fehling's Solution

Mix equal quantities of Fehling's solutions (50 ml of A and 50 ml of B). Accurately pipette out 10 ml of the mixed solution into a 250-ml conical flask. Add 25 to 50 ml of water. Take the standard invert sugar solution prepared by inversion of sucrose in a 50-ml burette. Add to the mixed Fehling's solution almost the whole of the standard invert sugar solution (18 to 19 ml) required to effect the reduction of allthe copper, so that not more than 1 ml will be required later to complete the titration. Heat the flask containing the cold mixture over a hot plate or burner covered with asbestos filled wire gauze. When the liquid begins to boil, keep it in moderate ebullition for 2 min. Without removing from the flank, add 3 drops of methylene blue indicator solution and complete the titration in a further 1 minute, so that the reaction mixture boils altogether for 3 min without interruption. The end point is indicated by the decolourization of the indicator. Note the volume of the sugar solution required for completely reducing 10 ml of Fehling's solution. The equivalent volume should be 20.37 ± 0.05 ml. Small deviations front the tabulated factors may arise front variations in the individual procedures or composition of the reagents. If the variation is too wide, adjust the concentration of the Fehling's solution such that the equivalent volume of neutralized sugar solution for 10 ml of Fehling's solution is 20.37 ± 0.05 ml.

$$\text{Factor for Fehling's solution} = \frac{\text{titre} \times 2.5}{1000}$$

Preparation of Sample

Fruit juices: Weigh 25 g of filtered (Whatman No. 4) juice and transfer to 250-ml volumetric flask. Add about 100 ml of water and neutralize with 1N NaOH. Add 2 ml of lead acetate solution. Shake and let it stand for 10 min. Add the necessary amount of potassium oxalate solution to remove he excess of lead, make up to volume with water, and filter.

Fruit jellies and jam: Place 50 g of the blended (jam, jellies) in a 500-ml husker and add 400 ml of water. Neutralize the solution with 1N NaOH using phenolphthalein indicator. Boil gently for 1 hr with occasional stirring. Add boiling water to maintain the original level. Cool and transfer to a 500-ml volumetric flask. Make up to volume and filter through No. 4 Whatman paper. Pipette a 100-ml aliquot into a 500-ml volumetric flask. Add 2 ml of neutral lead acetate solution and about 200 ml of water. Let it stand for 10 min, then precipitate the excess of lead with potassium oxalate solution. Make up to mark and filter.

3.5.6.1 Reducing Sugar

Procedure:

Standard method of titration: Pipette 10 ml of mixed Fehling's solution into each of two 250-ml conical flasks. Fill the 50-ml burette with the solution to be titrated. Run into the flask almost the whole volume of sugar solution required to reduce the Fehling's solution, so that 0.5 ml to 1.0 ml is required later to complete the titration. Alix the contents of the flask, heat to boiling and boil moderately for 2 min. Then add 3 drops of the methylene blue solution, taking care not to allow it to touch the side of the flask. Complete the titration within 1 min by adding 2 to 3 drops of sugar solution at 5 to 10 sec intervals, until the indicator is completely decolorized. At the end point, the boiling liquid assumes the brick-red color of precipitated cuprous oxide, which it had before the indicator was added. Note the volume of the solution required.

3.5.6.2 Non-reducing sugars

Pipette 50 ml of the clarified solution into a 250-ml conical flask. Add 5 g of citric acid and 50 ml of water. Boil gently for 10 min to complete the inversion of sucrose, then cool. Transfer to a 250-ml volumetric flask and neutralize with 1N NaOH using phenolphthalein as indicator. Make up to volume. For inversion at room temperature, transfer 50 ml aliquot of clarified and deluded solution to a 250-ml flask. Add 10 ml of HCI (1+1) and allow to stand at room temperature (20° C or above) for 24 hr. Neutralize with cone NaOH solution and make up to volume.

Take an aliquot and determine the total sugars as invert sugars.

CALCULATION

$$a = \%\ \text{Reducing sugar} = \frac{\text{ml of invert sugar} \times \text{dilution} \times 100}{\text{titre} \times \text{volume of the sample} \times 100}$$

$$\text{b} = \%\ \text{total sugar as} = \text{Calculate as in (a)making use of the titre value}$$

obtained in the determination of total sugars

c = % Total invert sugars-% Reducing sugars originally present × 0.95

d = % Reducing sugars + % Sucrose

$$\%\ \text{Reducing sugars} = \frac{\text{factor} \times \text{dilustion} \times 100}{\text{titre} \times \text{volume of the sample}}$$

3.6 Subjective (sensory) evaluation of jam, jelly and juice

An informal sensory evaluation of jam, jelly and juice containing three varieties were evaluated initially for color, appearance, taste and flavor by a panel of 20 tasters. All the tasters were the M.S. students of the Dept. of Agricultural Chemistry.

For statistical analysis of sensory data, three varieties of jam, jelly and juice were further subjected to sensory evaluation. In this case, 9-point hedonic rating test was performing to assays the degree of acceptability of these products. Three pieces from each variety lot presented to 20 panelists as randomly coded samples. The taste panelists were asked to rate the sample on a 9-point hedonic scale for color, flavor, texture and overall acceptability with the ratings of: 9 = Like extremely, 8 =Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like nor dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2 = Dislike very much and 1 = Dislike extremely.

3.7 Data analysis

The results were evaluated by Analysis of Variance and Duncan Multiple Range Test (DMRT) procedures of the Statistical Package for the Social Science (SPSS).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

Guava is considered as a super fruit because of its high nutritive value, pleasant flavor, high palatability and availability in abundance at moderate price. It is a rich source of vitamin C, dietary fiber, minerals, polyphenols and carotenoids. Guava is generally consumed fresh but due to its highly perishable nature, it is often processed into nectar, jam and jelly to extend its shelf life and make the fruit available throughout the year. The present study was undertaken with the aim to develop preserved products from different varieties of white and pink fleshed guava and determine the nutritional composition of the guava varieties and their products. The results of the study are presented and discussed under the following subheadings:

4.1 Chemical constituents of fresh guava

Table 4.1 Chemical constituents of fresh guava

Variety	Moisture (%)	Total soluble solid (TSS)	pH	Acidity (%)
THAI-4	87.80±0.954a	11.70±0.425b	4.70±0.233b	0.92±0.011a
BAU-2	82.33±0.882b	9.20±0.264c	5.20±0.173b	0.84±0.009b
Local red	81.66±0.882b	14.57±0.581a	5.80±0.120a	080±0.055b
CV%	3.38	20.398	10.454	7.121

The mean difference is significant at the 0.05 level

Table 4.2 Chemical constituents of fresh guava

Variety	Reducing sugar (%)	Non-reducing sugar (%)	Ascorbic acid (Vitamin C) (mg/100 ml
THAI-4	5.49±0.149a	4.14±0.144ab	107.67±1.090a
BAU-2	5.34±0.086b	4.52±0.118a	102.50±1.760b
Local red	5.08±0.204b	3.94±0.144b	96.00±0.622c
CV%	5.534	7.790	5.19

The mean difference is significant at the 0.05 level

The chemical components of fresh guava are more or less similar to that reported by US department of Health Education and Welfare (1972). The department reported that guava

contain 80.61 moisture, 0.4% pectin, 4.5% reducing sugar,3.5% non- reducing sugar, 8.9% total sugar, 0.7% total ash, 1.28% acidity, 19%TSS. The small variation may be due to the inefficient measurement or instrumental error. In component guava in this study may be due to the varietal difference, soil nutrients and composition of the growing area and or inefficient measurement or instrumental error.

Fig 4.1 Pulp and juice extraction

4.2 Chemical composition of guava jam

Table 4.3 Chemical constituents of guava jam with different varieties

Variety	Moisture (%)	Total soluble solid (TSS)	pH	Acidity (%)
THAI-4	22.83±0.052a	65.50±0.289b	3.76±0.040b	0.57±0.011a
BAU-2	20.84±0.058b	66.00±0.577b	4.32±0.092a	0.32±0.017b
Local red	19.20±0.069c	68.17±0.601a	4.44±0.040a	0.32±0.023b
CV%	7.522	2.172	7.861	31.703

The mean difference is significant at the 0.05 level

4.2.1 Moisture

The percentage of moisture content of guava depends on guava variety and tropical area. Table 4.3 showed that, the highest value of moisture content (22.83%) was observed in THAI-4 and lowest value of was recorded (19.20%) in local red.

4.2.2 Total soluble solid (TSS)

The highest value of total soluble solid (68.17^0Brix) was found in local red and lowest value (65.5^0Brix) was found in THAI-4. This result was similar to Moyle (1962) and recommended that jam contains total soluble solids of 67 to 70 percent. Most of the Food laws of the world provide for a minimum percentage of 66 percent total solids and a minimum fruit content of 45 percent. Jams of total solids below 66 percent will be subjected to spoilage by yeast and moulds due to high water activity content and will have very poor setting.

4.2.3 pH

Results of this research was exposed that the pH varies from variety to variety. Table 4.3 showed that, the highest pH value (4.44) was obtained in local red and the lowest pH value was recorded (3.76) in THAI-4. This is an agreement with the findings of Ahmed (2007) and recommended that the pH of prepared guava jam was almost 3.4.pH affects the setting of the jam. The pH of the jam should be kept in the range of 3.2 to 3.4.pH above 3.4 may lead to failure of the jam to set while a pH value of less than 3.0 leads to bleeding of the Jam. The small variation may be due to the inefficient measurement or instrumental error.

4.2.4 Acidity

Acidity of this research was varied from (0.57% to 0.32%). In the table 4.3, the result showed that the highest acidity value was recorded (0.57%) in THAI-4, hence the lowest value was calculated (0.32%) in local red. This is an agreement with the findings of Ahmed (2007) who has reported that the acidity of prepared jam was (0.50%). Acidity of a fruit depends on ripening stage. Lower ripening cause's higher acidity and it decrease exponentially after ripening. Citric acid is the most popular acid used in jam manufacture and is added when the mixture reached 64% total soluble solids.

Table 4.4 Chemical constituents of guava jam with different varieties

Variety	Reducing sugar (%)	Non-reducing sugar (%)	Ascorbic acid (Vitamin C) (mg/100 ml
THAI-4	21.37±0.131b	35.85±0.060b	38.59±0.269a
BAU-2	23.30±0.086a	37.50±0.202a	32.55±0.075b
Local red	18.20±0.260c	34.61±0.274c	28.65±0.063c
CV %	10.715	3.578	13.061

The mean difference is significant at the 0.05 level

4.2.5 Reducing sugar

The highest value of reducing sugar (23.3%) was observed in BAU-2 and lowest value (18.2%) was recorded in local red. This is an agreement with the findings of Moyle (1962) who reported that jam contains 20 to 28 percent reducing sugar. Norman (1970) Report that during the process of boiling sucrose solution in the presence of acid, hydrolysis occurs, in which reducing sugars are formed (dextrose and levulose). Sucrose is converted into reducing sugars, and the product is known as inverted sugar. The rate of inversion is influenced by the temperature, the time of heating and the pH value of the solution.

4.2.6 Non-reducing sugar

The percentage of non-reducing sugar depends on guava variety and stage of ripening. According to the research non-reducing sugar was varied from (37.50% to 34.61%). The highest non reducing sugar was (37.50%) found in BAU-2, whereas the lowest non reducing sugar (34.61%) was observed in local red according to the table 4.4. The sucrose

– invert sugar ratio is very important in jam manufacture otherwise crystallization will occur during storage.

4.2.7 Ascorbic acid

According to the research ascorbic acid was varied from (38.59ml/100 g to 28.65ml/100 g). The highest value of ascorbic acid (38.59ml/100g) was observed in THAI-4 and lowest value (28.65ml/100g) observed in local red. El-Buluk *et al.,* (1997) stated that ascorbic acid was increased significantly with fruit maturity.

4.3 Chemical composition of guava jelly

Table 4.5 Chemical constituents of guava jelly with different varieties

Variety	Moisture content (%)	Total soluble solid(TSS)	pH	Acidity (%)
THAI-4	27.30±0.144a	65.00±0.289b	3.80±0.083b	0.52±0.028a
BAU-2	25.50±0.132b	67.00±0.577a	4.37±0.075a	0.32±0.011b
Local red	24.03±0.075c	67.00±0.577a	4.50±0.075a	0.31±0.020b
CV%	5.572	1.884	8.045	27.452

The mean difference is significant at the 0.05 level

4.3.1 Moisture

The moisture content of a sample is very important to prepare product that depends on its variety and tropical area. In this research, the highest value of moisture content (27.30%) was observed in THAI-4 and lowest value of moisture content (24.03%) was recorded in local red. Our results were in agreement with the finding of Singh and Chandra (2012) who reported that moisture content in guava jelly is almost (27%).

4.3.2 Total soluble solid (TSS)

Total soluble solid of this research was varied from (67^0Brix to 65^0Brix). Table 4.5 showed that the highest value of total soluble solid (67^0Brix) was found in local red and lowest value (65^0Brix) found in THAI-4.Singh and Chandra (2012) reported that the total soluble solid of mixed fruit jelly was is about (68.10^0Brix) that was similar to our results.

4.3.3 pH

Results of this research was exposed that the pH varies from variety to variety. The highest pH value (4.5) was obtained in local red and the lowest pH value was recorded (3.8) in THAI-4. This is an agreement with the findings of Singh and Chandra (2012) who has reported that the pH of guava jam was (3.61 to 4.15). pH value also depends on ripening stage of guava.

4.3.4 Acidity

Acidity of this research was varied from (0.52% to 0.31%). In the table 4.5, the result showed that the highest acidity value was recorded (0.52%) in THAI-4, hence the lowest value was calculated (0.31%) in local red. Acidity was responsible for making jelly because high acid conditions result in a tough gel structure, or destroy the structure by action of hydrolysis of the pectin. Low acidity yields weak fibers, unable to support the liquid, and the gel slumps.

Table 4.6 Chemical constituents of guava jelly with different varieties

Variety	Reducing sugar (%)	Non-reducing sugar (%)	Ascorbic acid (Vitamin C) (mg/100 ml
THAI-4	22.85±0.265b	40.65±0.052b	36.37±0.331a
BAU-2	25.55±0.046a	43.31±0.217a	34.02±0.151b
Local red	19.63±0.317c	35.50±0.190c	28.65±0.063c
CV%	11.429	8.664	10.430

The mean difference is significant at the 0.05 level

4.3.5 Reducing sugar

The highest value of reducing sugar (25.55%) was observed in BAU-2 and lowest value (19.63%) was recorded in local red. This is an agreement with the findings of Rasheda Khatun (2011) who recommended that the percentage of reducing sugar was (29.17%) that was similar to our results. The addition of sugar influences the pectin-water equilibrium established and destabilizes the pectin. The higher the concentration of sugar, the less water supported by the acidity of the substrate.

4.3.6 Non-reducing sugar

The percentage of non-reducing sugar depends on guava variety and stage of ripening. According to the research non-reducing sugar was varied from (43.31% to 35.5%). The highest non reducing sugar was found (43.31%) in BAU-2, whereas the lowest non reducing sugar was observed (35.5%) from table 4.6. This result was almost similar to the finding of Rasheda Khatun (2011).

4.3.7 Ascorbic acid

According to the research ascorbic acid was varied from (36.37ml/100 g to 28.65ml/100 g). The highest value of ascorbic acid was observed (38.59ml/100 g) in THAI-4 and lowest value observed (28.65ml/100 g) in local red guava. Pandey and Singh (1998) observed that ascorbic acid (vitamin C) content of guava squash decreased continuously during storage at room temperature.

4.4 Chemical composition of guava juice

Table 4.7 Chemical constituents of guava juice with different varieties

Variety	Moisture content (%)	Total soluble solid (TSS)	pH	Acidity (%)
THAI-4	93.4±0.661a	12.50±0.288a	3.15±0.057b	0.56±0.017a
BAU-2	92.53±0.433a	13.00±0.173a	4.44±0.040a	0.323±0.026b
Local red	91.72±0.098b	13.17±0.601a	4.35±0.092a	0.32±0.034b
CV%	1.057	5.182	15.874	31.373

The mean difference is significant at the 0.05 level

4.4.1 Moisture

Juice extract from fresh sample depends on the percentage of moisture content. In this research, the highest value of moisture content (93.4%) was observed in THAI-4 and lowest value of (91.72%) was recorded in local red. This is an agreement with the findings of Rasheda Khatun (2011) and recommended moisture content was almost similar to our results.

4.4.2 Total soluble solid (TSS)

Total soluble solid of this research was varied from (13.17^0Brix to 12.5^0Brix). Table 4.7 showed that, the highest value of total soluble solid (13.17^0Brix) was found in local red and lowest value (12.5^0Brix) was found in THAI-4. Harnanan *et al.,* (1980) reported that ready-to-serve beverage of guava fruits with 20 percent pulp, 12 percent total soluble solids.

4.4.3 pH

Results of this research was exposed that the pH varies from variety to variety. The highest pH value was (4.44) obtained in BAU-2 and the lowest pH value (3.15) was recorded in THAI-4. Nidhi *et al.,* (2007) analyzed the bel-guava ready-to-serve beverage and squash and reported that pH decreased in both the beverages with the increase in storage duration.

4.4.4 Acidity

Acidity of this research was varied from (0.56% to 0.32%). In the table 4.7, the result showed that the highest acidity value (0.56%) was recorded in THAI-4 guava; hence the lowest value (0.32%) was calculated in local red. This is an agreement with the findings of Harnanan *et al.,* (1980) and recommended that 0.4 percent acidity was ideal recipe for ready- to- serve beverage.

Table 4.8 Chemical constituents of guava juice with different varieties

Variety	Reducing sugar (%)	Non-reducing sugar (%)	Ascorbic acid (Vitamin C) (mg/100 ml
THAI-4	4.41±0.063a	14.95±0.259c	19.36±0.196b
BAU-2	4.15±0.075a	24.18±0.092a	20.33±0.176a
Local red	4.19±0.350a	17.44±0.110b	17.50±0.133c
CV%	7.930	21.985	6.675

The mean difference is significant at the 0.05 level

4.4.5 Reducing sugar

The highest value of reducing sugar was observed (4.41%) in BAU-2 and lowest value was recorded (4.15%) in local red. This is an agreement with the findings of Rasheda

Khatun (2011) and recommended that was similar to our results. The higher the concentration of sugar, the less water supported by the acidity of the substrate.

4.4.6 Non-reducing sugar

The percentage of non-reducing sugar depends on guava variety and stage of ripening. According to the research non-reducing sugar was varied from (20.18% to 14.95%). The highest non reducing sugar was found (20.18%) in BAU-2, whereas the lowest non reducing sugar was observed (14.95%) THAI-4 guava of the table.

4.4.7 Ascorbic acid

According to the research ascorbic acid was varied from (20.33ml/100 g to 17.5ml/100 g). In the table-4.8, showed that the highest value of ascorbic acid (20.33ml/100 g) was observed in BAU-2 and lowest value (17.5 ml/100 g) was observed in local red. Shah *et al.,* (1975) studied that single strength guava juice retained higher amount of ascorbic acid (35%) than guava juice with 25% added sugar.

4.5 Sensory analysis

Sensory attributes like color, appearance, taste, flavor and overall acceptability of prepared jam, jelly andwere evaluated by using 20 experienced panelists. Mean score for sensory evaluation of jam, jelly and juice was given in table (4.9, 4.10, 4.11).

Fig 4.2 prepared jam, jelly and juice from guava

Table 4.9 Sensory characteristics of prepared jam

Variety	Color	Appearance	Taste	Flavor	Overall acceptability
THAI-4	6.33±0.34b	6.66±0.33ab	6.66±0.33ab	7.00±0.557a	7.33±0.33ab
BAU-2	8.00±0.33a	7.88±0.33a	7.56±0.176a	7.67±0.33a	7.67±0.577a
Local red	6.33±0.309b	6.33±0.577b	6.67±0.34b	6.67±0.33a	6.33±0.176b
CV%	13.47	11.34	11.34	10.99	10.99

* The mean difference is significant at the 0.05 level. Uses Harmonic Mean Sample Size = 20.00

4.5.1 Color

Color is the important factor which determines the acceptability of any product, which has the highest impact as far as market success of product. The highest color BAU-2 jam (8.00), BAU-2 jelly (7.75) and THAI-4 juice (7.66) was excellence. This is due to the varietal difference, soil nutrients and composition of the growing area. It is explicit that the effect of composition of guava extract to carrot juice ratio and storage periods on color score was significant (Selvamuthukumaran *et al.,* 2007).

4.5.2 Appearance

The sensory analysis of guava jam, jelly and juice for appearance (ANOVA) showed that there was significance difference among the variety. The BAU-2 jam (7.88), BAU-2 jelly (7.67) and THAI-4 juice (7.33) was excellent for their genetic, moisture, softy characteristics. Sensory quality of jam, jelly, juice attributes of color, taste, flavor, mouthfeel and overall acceptability were evaluated. Nine points Hedonic rating test method as recommended by Joshi (2006) was used for the purpose of sensory evaluation.

Table 4.10 Sensory characteristics of prepared jelly

Variety	Color	Appearance	Taste	Flavor	Overall acceptability
THAI-4	7.33±0.34ab	6.67±0.34ab	7.33±0.577ab	6.33±0.34b	7.34±0.34a
BAU-2	7.75±0.577a	7.67±0.34a	7.67±0.34a	8.00±0.34a	7.78±0.577a
Local red	6.33±0.34b	6.33±0.577b	6.33±0.34b	6.33±0.577b	6.33±0.34b
CV%	10.99	11.34	11.99	11.53	10.99±0.34b

* The mean difference is significant at the 0.05 level. Uses Harmonic Mean Sample Size = 20.00

4.5.3 Taste

Taste is the important factor which determines the acceptability of any product, which has the highest impact as far as market success of product. The sensory analysis of jam, jelly and juice for taste (ANOVA) showed that there was significance difference among the variety. The BAU-2 jam (7.56), BAU-2 jelly (7.67) and THAI-4 juice (8.00) was excellent. This is due to the varietal difference, soil nutrients and composition of the growing area.

4.5.4 Flavor

Raab and Oehler (1999) showed that ingredients like sugar, eggs, nuts salt and other fruits added to improve the flavor. The sensory analysis of jam, jelly and juice t for flavor (ANOVA) showed that there was significance difference among the variety. The BAU-2 jam (7.67), BAU-2 jelly (8.00) and THAI-4 juice (7.45) was excellent.

Table 4.11 Sensory characteristics of prepared juice

Variety	Color	Appearance	Taste	Flavor	Overall acceptability
THAI-4	7.66±0.34a	7.33±0.577a	8.00±0.34a	7.45±0.34a	7.33±0.577a
BAU-2	6.33±0.34ab	6.33±0..34ab	7.33±0.34a	7.33±0.577ab	7.25±0.34a
Local red	6.00±0.57b	6.00±0.34b	6.33±0.17b	6.33±0.34b	6.33±0.34b
CV%	15.00	15.00	10.99	10.99	11.53

* The mean difference is significant at the 0.05 level. Uses Harmonic Mean Sample Size = 20.00

4.5.5 Overall acceptability

Overall acceptability includes many implications, which is the important parameter in organoleptic estimation. The BAU-2 jam (7.67), BAU-2 jelly (7.78) and THAI-4 juice (7.33) was highly acceptable. Guava jelly with attractive taste and aroma by blending it with red grape cultivars which was found to be highly acceptable (Aggarwal *et al.,* 1997).

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

Three guava varieties namely bauranga (BAU-2), THAI-4 and local red taken from Horticulture Centre, Dinajpur. The guavas were carefully chosen in order to obtained the optimum maturity because its pectin contain depends on maturity. Sugar, citric acid, pectin, xanthamgum, sodium benzoate and relevant materials required for the experiment were received from the laboratory stocks. Preserved products namely jam, jelly, and juice were developed from each variety. Compositional analysis of jam showed that the highest moisture content was observed 22.83% (THAI-4), total soluble solid 68.17^0 Brix (local red),pH value 4.44 (local red), acidity 0.57 (THAI-4), reducing sugar 23.3% (BAU-2), non- reducing sugar 37.5% (BAU-2) and ascorbic acid 38.59ml/100g (THAI-4). Hence the lowest moisture content was observed 19.20% (local red), total soluble solid 65.5^0Brix (THAI-4), pH value 3.76 (THAI-4), acidity 0.32 (local red), reducing sugar 18.2% (local red), non-reducing sugar 34.61% (local red) and ascorbic acid 28.65ml/100g (local red). Compositional analysis of jelly showed that the highest moisture content was observed 27.3% (THAI-4), total soluble solid 67^0 Brix (local red),pH value 4.5 (local red), acidity 0.52 (THAI-4), reducing sugar 25.55% (BAU-2), non- reducing sugar 43.31% (BAU-2) and ascorbic acid 36.37ml/100g (THAI-4). Hence the lowest moisture content was observed 24.03% (local red), total soluble solid 65^0Brix (THAI-4),pH value 3.8 (THAI-4), acidity 0.31 (local red), reducing sugar 19.63% (local red), non- reducing sugar 35.5% (local red) and ascorbic acid 28.65ml/100g (local red). Compositional analysis of juice showed that the highest moisture content was observed 93.4%(THAI-4), total soluble solid 13.17^0 Brix (local red), pH value 4.44 (BAU-2), acidity 0.56 (THAI-4), reducing sugar 4.41% (THAI-4), non- reducing sugar 24.18% (BAU-2) and ascorbic acid 20.33ml/100g (THAI-4). Hence the lowest moisture content was observed 91.72% (local red), total soluble solid 12.1^0Brix (THAI-4),pH value 3.15 (THAI-4), acidity 0.32 (local red), reducing sugar 4.15% (BAU-2), non- reducing sugar 14.95% (THAI-4) and ascorbic acid 17.5ml/100g (local red). The varieties standard formulation and the products (jam, jelly and juice) were evaluated for their physico-chemical properties and sensory attributes by a panel of 20 testers. The result revealed that the color, appearance, taste and flavor of jam, jelly and juice was significantly different with the varieties. The overall

results revealed that jam and jelly prepared from BAU-2 was highly acceptable and juice prepared from THAI-4 was more acceptable than other varieties.

The findings of the present study may help in developing commercial processing technology for preparation of guava products and it helps to find out the most acceptable variety for preparation of jam, jelly and juice.

REFERENCES

REFERENCES

Abu-Goukh A and Bashir H A (2003) Changes in pectic enzymes and cellulose activity during guava fruit ripening. Food Chem., 83, 213-218.

Adrees M, Younis M, Farooq U and Hussain K (2010) Nutritional quality evaluation of different guava varieties. Pak J Agri Sci **47(1)**: 1-4.

Aggarwal P, Padda G S and Sidhu J S (1997) Standardization of jelly preparation from guava: grape blends. J Food Sci Technol 34: 335-36.

Akamine E and Goo T (1979) Respiration and ethylene production in fruits of species and cultivars of *Psidium* and species of Eugenia. J. Amer. Soc. Hort. Sci. 104, 632-635.

Allen R G and Tresini M (2000) Oxidative stress and gene regulation. Free Radic Biol Med 28: 462-469.

Asghar N, Imran M, Mushtaq Z, Ahmad R S, Khan M K, Ahmad N, and Ahmad U (2015) Characterization and Functional Product Development from Bael (Aegle Marmelos L. Correa) Fruit Pulp. Journal of Food Processing and Preservation 34: 234-39.

Azad A K, A Haque and A K M Abdullah (1987) Physico-chemical characteristics of fruits of some guava varieties Bangladesh Journal of Agril. Res., 12(2): 53-49.

Babu KD, Patel R K and Yadav DS (2007) Comparative evaluation of guava selections under North Eastern region of India. Acta Horticulturae (735):99-103

Bardiya M C, Kundy B S and Tauro P (1974) Studies on fruit wines - guava wine. Haryana J Hort Sci 3: 140.

Bashir H A and Abu-Goukh A (2002)Compositional changes during guava fruit ripening. Food Chem., 80, 557-563.

Basseto E, Jacomino A P, Pinheiro A L and Kluge R A (2005) Delay of ripening of 'Pedro Sato' guava with 1-Methylcyclopropene. Postharvest Biol. Technol., 35, 303-308.

BBS (2013) Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of statistics, Statistics Division, ministry of Agriculture. Govt. of the people's Republic of Bangladesh.

Blankenship S and Dole J (2003)1-Methylcyclopropene:A Review. Postharvest Biol. Technol., 28, 1-25.

Boora R S (2012) Improvement in guava (*Psidium guajava* L.) - A review. Agri Rev 33: 34149.

Bose T K(2011) Fruits of India, Tropical and Subtropical. 1st edn, Naya Proksash, Calcata – 6 India. P. 278.Caribbean fruit fly (diptera: tephritidae). J. of Economic Entomology. 1992, 85'

Chandu N and Prasad M (2006) Development of guava candies. J Food Sci Technol 43: 210-12.

Chang H T, Brekke J E and Chang T (1971) Non-volatile organic acid in guava. J. Food Sci. 36(3):237.

Ching L and Mohamed S (2001) Alpha-tocopherol content in 62 edible tropical plants. J. Agric.

Cisneros-Zevallos L (2003) The use of controlled postharvest abiotic stresses as a tool for enhancing the nutraceutical content and adding-value of fresh fruits and vegetables. J. Food Sci., 68, 1560-1565.

Conway P (2002) Tree Medicine: A Comprehensive Guide to the Healing Power of Over 170 Trees. Judy Piatkus (publishers) Ltd. pp 2173-177

Crane J H and Balerdi CF (2005) Guava growing in the Florida home landscape. Horticultural Sciences Department Document HS4, Florida Cooperative Extension Service Institute of Food and Agricultural Sciences, University of Florida:1-8

Chundawat B S, Gupta O P, and Singh H K (1976) Variations in physico-chemical quantities of rainy and winter season guava (*P. guajava* L.) fruits. Haryana J Horti Sci **5**: 154-59.

Das B C, Chakraborty A, Chakraborty P K, Maiti A, Mandal S and Ghosh S (1995) Comparative performance of guava cultivars under red and laterite soils of West Bengal. Hort J 8: 141-46.

Desrosier N W (1963) The technology of Food Preservation the AVI publishing company 2nd Ed. Westport, U.S.A 2(5): 40-279.

Dhillon W S (2013) Fruit production in India. Narendra Publishing House, Delhi, India. Pp 263-78.

Donchonko L V, N S Karpovich, I I Uvarova and O P Mironova (1988) Effect of acidity of strength of Jam / Jelly. Pzvestiya vysshikh unhebnykh Zavedenil, Pishchevaya Tekhnologiya. USSR, 1:108.

Ecocrop (2015) Ecocrop database. FAO, Rome, Italy.

Egan H, Ronald S K and Pearson S R (1981) Chemical Analysis of Foods. 8th Edition Longman Scientific and Technical.

El-Ahmady S H, Ashour M L and Wink M (2013) Chemical composition and antiinflammatory activity of the essential oils of *Psidiumguajava* fruits and leaves. J Essent Oil Res 25(6): 475-81.

El-Buluk R, Babiker, E E E and El- Tiany A H(1997) Changes in sugar, ash and minerals in our guava cultivars during ripening. Plant Foods for Human Nutrition, 49 (2): 147-154.

El-Buluk R, E E E Babiker and A H El- Tiany(1996) Changes in sugar, ash and minerals in our guava cultivars during ripening. Plant Foods for Human Nutrition, 49 (2): 147-154.

El-Mubarak, A Bahi El-Din, I Maqbul and A M Ali (1977) Optimization of citrus waste as a source of pectin in jam making. Sham bat, Sudan, 9: 55-59.

El-Zoghbi (1994) M Biochemical changes in some tropical fruits during ripening. Food Chem., 49, 33-37.

Esteves – MIF-Chitavra , AB Chitavra and De Mb- Paula(1984) Characteristics of fruits of six guava (*Psuidium guajava* L) cultivars during ripening. Anais do VII

congress porasilero de-Furitivultura., 2: 477-489.*Food Chem*. 2001, 49, 3101-2105.fortified with pink guava pulp. Int J Dairy Sci 10 (5): 219-27.

Gangwar B M(1972) Biochemical studies on growth and ripening of guava. Indian Food Packer, 26(5): 13-15.

Gautam NN, Singh K, Singh B, Seal S, Goel A, Goel V (2010) Studies on clonal multiplication of guava (*Psidium guajava* L.) through cutting under controlled conditions. Australian Journal of Crop Science 4 (9):666

Ghosh S N and Chattapadhyay N (1996) Performance of some guava cultivars under rainfed semi-arid region of West Bengal. Hort J 9: 121-27.

Goldstein J and Swain T (1963) Changes in tannins in ripening fruits. Phytochemistry. 2, 371-383.

Gorinstein S, Zemser M, Haruenkit R, Chuthakorn R, Grauer F, Martin-Belloso O and Trakhtenberg S (1999) Comparative content of total polyphenols and dietary fiber in tropical fruits and persimmon. J. Nutr. Biochem. 10, 367-371.

Gould W P and Sharp J L(1992) Hot-water immersion quarantine treatment for guavas infested with Caribbean fruit fly (Diptera: Tephritidae). Journal of economic Entomology, 85(4), 1235-1239.

Haque H H(1992) Vitamin C and mineral constituents of guava varieties of Bangladesh. M. Sc. Thesis, Dept. of Agril. Chemistry, BAU, Mymensingh.

Harnanan S W, Bains G C and Kripal K(1980) Studies on processing of pink and white-fleshed guava varieties for pulp. Punjab Hort. J, 20: 179.

Hayes W B(1970) Fruit Growing in India, Kitabistan, Allahabad.1235-1239.

Hegde S R, Vijayalakshmi D, Prasad D T and Raghotham K (2007) Development of tomato products and their nutrient composition. J Dairy Foods Home Sci 26(2): 94-97.

Heinrich M, Ankli A, Frei B, Weimann C and Sticher O (1998) Medicinal plants in Mexico: Healers' consensus and cultural importance. Soc Sci Med 47(11): 1859-71.

Ho C, Lee C and Huang M (1992)Phenolic compounds in food and their effects on health I.; American Chemical Society: Washington, DC.

Huang C S, Yin M C and Chiu L C (2011) Antihyperglycemic and antioxidative potential of *Psidium guajava* fruit in streptozotocin-induced diabetic rats. Food Chem Toxicol 49(9): 2189-95. International: New York, New York, 1997.

Itoo S, Matsuo T, Ibushi Y and Tamari N (1987)Seasonal changes in the levels of polyphenols in guava fruit and leaves and some of their properties. J. Japan. Soc. Hort. Sci., 56, 107-113.

Jagtiani J, Chan H T and Sakai W S (1988) Tropical fruit processing. Academic Press Inc., New York 2: 9-43.

Jaiarj P, Khoohaswan P, Wongkrajang Y, Peungvicha P, Suriyawong P, Saraya M S and Ruangsomboon O (1999) Anticough and antimicrobial activities of *Psidium guajava*Linn. leaf extract. J Ethnopharmacol 67(2): 203-12.

Jawaheer B, Goburdhun D and Ruggoo A (2003) Effect of processing and storage of guava into jam and juice on the ascorbic acid content. Plant Foods Hum Nutr 58(3):1-12

Jaydeep Singh and Suresh Chandra (2012) Preparation and evaluation of guava-carrot jelly. Intl. J. of Food. Ferment. Technol. 2(2): 197-200.

Jiménez-Escrig A, Rincón M, Pulido R and Saura-Calixto F (2001) Guava fruit (Psidium guajava L.) as a new source of antioxidant dietary fiber. J. Agric. Food Chem. 49, 5489-5493.

Joshi VK(2006) Sensory Science: Principles and Application in Food Evaluation. Agrotech Publish Academy, Jaipur (India).

Kadam D M, Kaushik P and Kumar R (2012) Evaluation of guava products quality. Int J Food Sci Nutr Eng **2(1)**: 7-11

Kaikadi M A, Chavan U D and Adsule R N (2006) Studies on preparation and shelf-life of Ber candy. Bev Food World 33: 49-50.

Kumar H (2015) Development and quality evaluation of guava candy. MSc. Thesis. Punjab Agricultural University, Ludhiana, India.

Kundu S, Ghosh S N and Mitra S K (1995) Physico-chemical characters of twelve guava cultivars in the laterite tract of West Bengal. Indian Food Packer 49: 11.

Lakshmi B and Sudhakar M (2009) Screening of *Psidium guajava* leaf extracts for antistress activity in different experimental animal models. *Pharmacogn Res.* 1(6): 359.

Lashely D(1984) Advances in post-harvest technology and new technologies in food. Proc. Seminar. St. Augistine (Trinidad Tbago) pp. 173-183.

Leite K M S C, Tadiotti A C, Baldochi D and Oliveira O M M F (2006) Partial purification, heat stability and kinetic characterization of the pectin methyl esterase from Brazilian guava Plauma cultivars. Food Chem 94: 565–72.

Lin C Y and Yin M C (2012) Renal protective effects of extracts from guava fruit (*Psidium guajava* L.) in diabetic mice. Plant Foods Hum Nutr 67(3): 303-08.

Lin C H and Chen B H (2003) Determination of carotenoids in tomato juice by liquid chromatography. J.of Chromatography. 1012, 103-109.

Lurie S (1998) Postharvest heat treatments. Postharvest Biol. Technol. 14, 257-269.

Madan S and Dhawan S S (2005) Development of value added product candy from carrots. Process Food Ind 8: 26-30.

Malo S E and Campbell C W (1994) The Guava. University of Florida-IFAS extension. Bulletin. Available online: http://edis.ifas.ufl.edu/MG045. Last accessed: August, 2004.

Marcelin O, Williams P and Brillouet J (1993) Isolation and characterization of the two main cell-wall types from guava (*Psidium guajava* L.) pulp. Carbohydr. Res. 240, 233-243.

Mercadante A, Steck A and Pfander H (1999) Carotenoid from Guava (*Psidium guajava*)

Isolationand Structure Elucidation. J. Agric. Food Chem. 47: 145-151.

Mazur S P, Nes A, Wold A B, Remberg S F, Martinsen B K and Aaby K (2014) Effects of ripeness and cultivar on chemical composition of strawberry (Fragaria× ananassa Duch.) fruits and their suitability for jam production as a stable product at different storage temperatures. Food Chem 146: 412-422.

Mehmood A, Jaskani MJ, Khan IA, Ahmad S, Ahmad R, Luo S and Ahmad NM (2014) Genetic diversity of Pakistani guava (*Psidium guajava* L.) germplasm and its implications for conservation and breeding. Scientia Horticulturae 172: 221-232.

Menezes C C, Borges S V, Cirillo M A, Ferrua F Q, Oliveira L F, and Mesquita K S (2009) Physical and physicochemical characterization of different formulations of guava preserve (*Psidium guajava* L) from Pedro Sato cultivar. J Food Sci Technol 29(3): 618-25.

Mercado-Silva E, Benito-Bautista P and Garcia-Velasco M (1998) Fruit development, harvest index and ripening changes of guavas produced in central Mexico. Postharvest Biol. Technol, 13: 143-150.

Miean KH and Mohamed S (2001) Flavonoid (myricetin, quercetin, keampferol, luteolin, and apigenin) content of edible tropical plants. J. Agric. Food Chem. 49: 31062112.

Misra K and Sheshadri T R (1968) Chemical components of the fruits of *Psidium guajava*. Phytochem 7: 641.

Misra K and Sheshadri T R (1968) Chemical components of the fruits of guava. Phytochemistry, 7(4): 641.

Misra K and Seshadri T (1967) Chemical components of the fruits of *Psidium guajava*. Phytochemistry. 7, 641-645.

Mitra R J and Bose T K (1990) Guava. In: Fruits: Tropical and subtropical. Bose T K and Mitra S K. Eds. Nayaprokash. Calcatta-6 India. pp. 280-303.

Mitra S (1997) Postharvest physiology and storage of tropical and subtropical fruits, CAB International: New York, New York.

Morton J F (1987) Fruits of warm climates. Agris.fao.org

Mowlah G and Itoo S (1982) Quantitative changes in guava polyphenols and the polyphenol oxidase (PPO) at different stages of maturation, ripening, and storage. Nippon Kogyo Gakkaishi. 29: 413-417.

Moyle A W, Strachan C C and Atkison F E (1962) Making jam Commercially, Canada Dept. of Agric –Publication 1144.

Mullins E D, McCollum T G and McDonald R E (2000) Consequences of ethylene metabolism of inactivating ethylene receptor sites in diseased non-climacteric fruit. Postharvest Biol. Technol. 19: 155-164.

Nag A R (1998) Physico-chemical changes of four guava varieties during different stages of ripening. M. S. Thesis, Dept. of Horticulture, BAU, Mymensingh. P. 75.

Nidhi, Gehlot R, Singh R, Siddiqui S and Rana M K (2007) Changes in chemical composition of bael guava blends ready-to-serve beverage and squash during storage. Haryana J. Hort. Sci., 36(1/2): 46-48.

Norman W (1970) The Technology of Food Preservation. National Biscuit Company Research Center, Fair Town, New Jersey.

Nyambo A, Nyomora A, Ruffo C and Tengnas B (2005) Fruits and nuts: species with potential for Tanzania. Technical Hand Book (34): 160.

Ordóñez-Santos L E and Vázquez-Riascos A (2010) Effect of processing and storage time on the vitamin C and lycopene contents of nectar of pink guava (*Psidium guajava* L.). Archivos Latinoamericanos De Nutricion 60(3): 280.

Orwa C, Mutua A, Kindt R, Jamnadass R and Simons A (2009) Agroforestree database: a tree species reference and selection guide version 4.0. World Agroforestry Centre ICRAF, Nairobi, Kenya.

Padula M and Rodriguez-Amaya D B (1986) Characterisation of the carotenoids and assessment of the vitamin A value of Brasilian guavas (*Psidium guajava* L.). Food Chem 20(1): 11-19. Pakistan J Scient Industrial Res 18: 179-83.

Palaniswmy K P and Shanmugavelu K G (1974) Physico-chemical characters ofsome guava varieties. South Indian Hort., 22(1-2): 8-11.

Pandey A K and Singh I S (1999) Studies on preparation and preservation of guava ready-to-serve beverage. Indian J Hort 56(2): 130-32.

Pandey A K and Singh I S (1998) Studies on preparation and preservation of guava squash. Prog. Hort., 30(3-4): 190-193.

Pasupuleti V and Kulkarni S G (2014) Lycopene fortification on the quality characteristics of beverage formulations developed from pink flesh guava (*Psidium guajava* L.). J. Food Sci. Technol. 51(12): 4126-31.

Parashkova L P (1982) Use of low methylated pectine for the manufacture of jelly like fruit preserves. Konservanaya I ovoshchosuchil Inaya Promyshle most. USSR, 2: 16-17.

Patel R K, Maiti C S, Deka B C, Deshmukh N A and Roy D (2011) Variability studies in Guava (*Psidium guajava* L.) genotypes for growth, yield and quality attributes at mid-hills of Meghalaya. Indian Journal of Hill Farm 24: 24-28.

Patel H H and Amin B K (2015). Formulation and standardization of different milk ice-cream fortified with pink guava pulp. International Journal of Dairy Science, 10(5): 219-227.

Paull R (1994) Response of tropical horticultural commodities to insect disinfestation treatments. Hort. Sci. 29: 988-996.

Phandis N A (1970) Physico-chemical composition of guava fruits. Indian J. Hort., 27: 417-433.

Pommer C V, Murakami K R N (2009) Breeding Guava (*Psidium guajava* L.). In: Breeding plantation tree crops: Tropical Species. Springer, pp. 83-120 processing 2: 597.

Raab C A and Oehler N (1999) Making Dried Fruit Leather. Corvallis, or .: Extension Service, Oregon State University.

Ranganna S (1992) Hand Book of Analysis of Fruit and Vegetable Products. Tata McGraw Hill Cl. Ltd., 1-30. New Delhi. India.

Rao A and Agarwal S (1999) Role of lycopene as antioxidant carotenoid in the prevention of chronic diseases: A review. Nutr. Res. 19, 305-323.

Rasheda K (2011) Studies on storage stability of guava juice and jelly. Masters of Science (MS) in food engineering, department of food technology and rural industries, Bangladesh agricultural university, Mymensingh. P-26.

Rathore D S (1975) Effects of Season on growth and chemical composition of guava fruits. J. Hort. Sci., 51 (1): 41-47.

Reyes M U and Re E Paul(1995) Effects of storage temperature and ethylene treatments of guava (*Psuidium guajava* L) fruit ripening post – harvest Biology and Technology, 6(3-4): 357-365.

Reyes M U and Paull R E (1995) Effect of storage temperature and ethylene treatment on guava (*Psidium guajava* L.) fruit ripening. Postharvest Biol. Technol., 6: 357-365.

Rodríguez N N, Valdés J, Rodríguez J A, Velásquez J B, Rivero D, Martínez F, González G, Sourd D G, González L and Cañizares J (2010) Genetic resources and breeding of guava (*Psidium guajava* L.) in Cuba. Biotecnología Aplicada 27(3): 238-240

Rodriguez R C, Cruz P H and Rios H G (2001) Pectins in fruits having gastrointestinal activity their participation in hemagglunating property of Escherichia coli. Arch Med Res 32(4): 251-57.

Sadhu M K and Chattopadhyay P K (2001) Guava. In: 'Introductory Fruit Crops', Naya Prokash, 206, Bidhan Savani, Kolkata-700 006, pp. 282.

Saltveit M (1999) Effect of ethylene on quality of fresh fruits and vegetables. Postharvest Biol. Technol. 15, 279-292.

Ahmed S A M (2007) Quality of Jam Prepared at Home Level, University of Khartoum Faculty of Public &Environmental Health Department of Food Hygiene & Safety P: 25-27.

Samson J A (1980) Tropical fruits. Longman, London and New York.

Sato A C K, Sanjinéz-Argandoña E J and Cunha R L (2006) The effect of addition of calcium and processing temperature on the quality of guava in syrup. International journal of food science & technology, 41(4): 417-424.

Selvamuthukumaran M, Khanum F and Singh Bawa A (2007) Development of sea buckthorn mixed fruit jelly. International J. Fd. Sci. & Tech. 42: 403-410.

Shah W H, Sufi N A and Zafar S I (1975) Studies on the storage stability of guava fruit juice.

Shah W H, Sufi N A and Zafar S I (1975) Studies on the storage stability of guava fruit juice. Pakistan J Scient Industrial Res 18:179-83.

Shankar G(1967) Physico-chemical studies of five guava varieties of Uttor Prodesh. Allahabad Faming, 41: 9-12.

Sharma A, Sehrawat SK, Singhrot R S and Ajinath T (2010) Morphological and chemical characterization of Psidium species. Notulae Botanicae Horti Agrobotanici ClujNapoca 38 (1): 28.

Sidhu J S (2006). Tropical fruits: Guava, lychee, and papaya. Handbook of fruits and fruit processing, 597.

Singh A K, Mishra S K and Singh Ajeet(2008) Studies on physico-chemical characters of different guava *(Psidium guajava* L.) cultivars. Plant Archives, 8(1): 453-455.

Singh J and Chandra S (2012) Preparation and evaluation of guava-carrot jelly. Int J Food Fermentation Technol 2(2): 197-200.

Singh M (1988) Performance of some cultivars of guava (*Psidium guajava*) with special reference to their commercial significance in the Central Gangetic Plains. Punjab J Hort 28: 50.

Singh P K, Karanjalker G R and Rajwade V B (2013) Chemical and sensory evaluation of nougat prepared from guava (*Psidium guajava* L.) cv. Allahabad Safeda. Int. J. Agric. Envt. Biotech. 6(3): 455-60.

Singh R B, Rastogi S S, Singh N K, Ghosh S and Niaz M A (1992) Effects of guava intake on serum total and high-density lipoprotein cholesterol levels and on systemic blood pressure. Am J Cardiol 70(15): 1287-91.

Singh R B, Rastogi S S, Singh N K, Ghosh S, Gupta S and Niaz M A (1993) Can guava fruit intake decrease blood pressure and blood lipids. J Hum Hypertens 7(1): 33-38.

Singh S P and Pal R K (2008) Controlled atmosphere storage of guava (*Psidium guajava* L.) fruit. Post-harvest Bio Tech 47: 296-306.

Singh S P and Yahia E M (2011) Guava *(Psidium guajava* L.) Postharvest biology and technology of tropical and subtropical fruits. Volume 3: cocona to mango 3: 213-45.

Steven K L, Brekke J E and Stern D J (1970) Volatile constituents in guava. J. Agric. Food Chem., 18(4): 598.

Tanwar B, Andallu B and Chandel S (2014) Influence of processing on physicochemical and nutritional composition of *Psidium guajava* L. (guava) products. Int. J. Agri. Food Sci. Technol. 5: 47-54.

Thimann K(1980) Senescence in plants, CRC Press: Boca Raton, FL,

Ullah M A, Saha S K, Ghose G H and Haque M A (1992) Physico-chemical characteristics of the fruits of nine guava cultivars. Bangladesh Hogt., 20(1): 7-11.

United States Department of Agriculture-Animal and Plant Health Inspection Service [USDA-APHIS]. 2004. Available online: http://www.aphis.usda.gov. Last accessed: March, 2005.

Van de Berg H, Faulks R, Granado H F, Hirschberg J, Olmedilla B, Sandmann G, Southon S and Stahl W (2000) The potential for the improvement of carotenoid levels in foods and the likely systemic effects. J. Sci. Food. Agric, 80: 880-912.

Verma A R and Shrivastava J C (1965) Pectin in guava during growth and maturity. Indian J. Hort. 22(1 and 2): 318.

Wei L, Li Z and Chen B (2000) Clinical study on treatment of infantile rotaviral enteritis with *Psidium guajava* L. Chin. J. Integr. Med. 20(12): 893-95

Wilberg V and Rodriguez-Amaya D (1995) HPLC quantitation of major carotenoids of fresh and processed guava, mango, and papaya. Lebensm-Wiss. U. Technol., 28, 478-480.

Wills R B H, Muholland E E and Brown B I (1983) Storage of two new cultivars of guava fruit for processing. Trop Agric 60: 175–178.

Wilson W C (1980) Guava. In: Nagy S and Shaw P E (1980) Tropical and subtropical fruits: composition, properties and uses. AVI Publishing Co., Inc., Westport, Connecticut.

Wilson C W (1980) Guava In: Tropical and Sub-Tropical Fruits: Composition, Properties. AVI publishing, Westport, Conn. P. 179.

Yadava U (1996) Guava production in Georgia under cold-protection structure. In: J. Janick (ed.) Progress in new crops; ASHS Press: Arlington, VA.

Yamdaghni R, Siddiqui S and Godara R K (1987) Physico-chemical changes in fruits of guava (*Psuidium guajava* L) during different stages of ripening. Research and Development Report, 4 (2): 154-158.

Yang G, Ibrahim S A and Lu Z (2009) Antimicrobial effect of guava products against foodborne pathogen E. coli O157: H7. Acta Hortic.

Yusof S (2003) Guavas. In: Caballero B, Finglas P, Trugo L. Encyclopedia of Food Sciences and Nutrition. New York Academic press. Pp 2985-92.

Yusof S (1990). Physico-chemical characteristics of some guava varieties in Malaysia. Acta Hortic. 269: 301-306.