VALUE ADDITION TO WATERMELON RIND THROUGH JAM PREPARATION

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Dedicated to

My

Beloved Parents

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CERTIFICATE

*This is to certify that the thesis entitled "**VALUE ADDITION TOWATERMELON RIND THROUGH JAM PREPARATION**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS) in HORTICULTURE, embodies the results of a piece of bona fide research work carried out by **MOHAIMINUL ISLAM**, **Registration. No.17-08245** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

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ABSTRACT

An experiment was conducted at Postharvest Laboratory, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka during February 2018 to December 2018 to add value to Watermelon rind and to study quality of watermelon rind jam as influenced by different concentration of rinds and sugar with flavors. This single factors experiment was consisted of sixteen treatments with three replications and laid out in CRD. The treatments were T_1F_0=50% rind+50% sugar+no flavor; T_1F_1=50% rind+50% sugar+strawberry flavor; T_1F_2=50% rind+50% sugar+pineapple flavor; T_1F_3=50% rind+50% sugar+vanila flavor; T_2F_0=80% rind+20% sugar+no flavor; T_2F_1=80% rind+20% sugar+strawberry flavor; T_2F_2=80% rind+20% sugar+pineapple flavor; T_2F_3=80% rind+20% sugar+vanila flavor; T_3F_0=60% rind+40% sugar+no flavor; T_3F_1=60% rind+40% sugar+strawberry flavor; T_3F_2=60% rind+40% sugar+pineapple flavor; T_3F_3=60% rind+40% sugar+vanila flavor; T_4F_0=40% rind+60% sugar+no flavor; T_4F_1=40% rind+60% sugar+strawberry flavor; T_4F_2=40% rind+60% sugar+pineapple flavor; T_4F_3=40% rind+60% sugar+vanila flavor. At first qualitative test was done for prepared jam. Then organolaptic test was done and last of all various chemical changes were determined with the storage period. T_1F_1 was statistically best. The chemical analysis of T_1F_1 jam was pH (3.80), TSS (6.00 %,), TA (2.48%), vitamin C (0.26mg/100g). This suggested that 50% rind+50% sugar and strawberry flavor was the promising formulation for the preparation of good quality of watermelon rind jam.

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ABBREVIATIONS AND ACRONYMS

The following abbreviations were used throughout this thesis:

ANOVA	Analysis of Variance
DMRT	Duncan's Multiple Range Test
Cont'd.	Continued
CRD	Completely Randomized Design
CA	Controlled Atmosphere
dw	Distilled Water
e.g.	*Exempli gratia* (by way of example)
et al.	And others
i.e.	*Edest* (means That is)
Wt.	Weight
TA	Titratable acidity
WMR	Water melon rind

CHAPTER I

INTRODUCTION

Watermelon (*Citrullus lanatus*) is a tropical fruit widely consumed around the world. It belongs to the family of Cucurbitaceae, which is inherent to tropical Africa and a popular thirst-quencher during the hot summer weather. The Cucurbitaceae is a large plant family found mainly in the warmer parts of all continents. It consists of 119 genera with altogether 825 species (Schipper, 2002). Fruits of Cucurbitaceae have a considerable economic value. Total global production of watermelon was 108.9 million tons whereas India Production was 0.4 million tons in 2013 (FAO, 2016). China is the largest producer of watermelon with 69.3 million tons of the total world production. Other major producing countries are Turkey, Iran, Brazil, the United States, Egypt, Russia and Mexico (FAO, stat 2005).

In Bangladesh, fruit cultivate area is about 137,557.08 ha with the production of 45869188 tons in 2013–2014 (BBS, 2014). Watermelon cultivation area is about 12,228.75 ha with the production of 293103 metric tons (BBS, 2014). Among the watermelon growing districts in 2013–2014 Patuakhali produces 4772 metric tons in 541.70 ha land (BBS, 2014).Watermelon contains Vitamin C and A. Watermelon is also expectedly high in citrulline, amino acid and arginine (used in the urea cycle to remove ammoniacal from the body). Watermelon is the third most popular fruit in the world containing good quantity of nutrients (Zhao *et al.,* 2013).

Pigment extracted from watermelon acts as functional ingredient and can be incorporated into breakfast cereals, frozen dairy desserts, yoghurts, spreads, candy, carbonated beverages, confectionary, sauces and soups etc. (Olempska, 2006). Cucurbit seeds are source of food particularly protein and oil. The flesh which constitutes approximately 68% of the total weight, the rind approximately 30% and the seeds approximately 2% (Kumar, 1985). Watermelon rinds contained about 14.9-35.7% protein (full fat free basis) and 35-59% on fat free basis (De Mello *et al.*, 2000). The lipids were found to be rich in linoleic and oleic acids while the protein was rich in arginine, glutamic acid, aspartic acid and leucine amino acids in watermelon (El Adawy *et al.,* 2001).

Almost one third of all fruits and vegetables produced in the world are not consumed as a result of postharvest losses, of which watermelon is no exception (Kader, 2005). Huge losses of watermelon during storage 17% were caused by rot and more than 50% was due to physiological problems such as bruising and sun scorching (Lamptey, 2010). Providing different postharvest facilities but shelf life of watermelon cannot be increased more than one month. Being a seasonal fruit, watermelon is available in season but in off season it is totally absent because of its short shelf life. Watermelon stored at 10 to 15°C with a relative humidity of 90% will be acceptable for up to 3 weeks. Watermelons held in below 24°C will have approximate shelf life up to 10 days. If temperatures are above 24°C, shelf life will decline to 5 days. At temperatures between 0 and 7°C, watermelons are subject to chilling injury that may result in pitting, off-flavors, and color loss. To increase the shelf life as well as fulfill the demands of consumers, processed product can be alternate of fresh watermelon in off season. So the preservation of the process products and its year round availability is important to meet the demands of consumers.

There are different processed products of fruits such as juice, sauce, jam, jelly, leather etc. Among them jam is the oldest and most widely used preservation method in fruit process industries. It involves the reduction of as much water as possible from the fresh fruit to arrest enzymatic and microbial activities; hence, stopping deterioration (Teshome, 2010).

Watermelon rind is one of the major solid wastes generated by several restaurants, cottage fruit juice producers and food industries in Bangladesh. Unfortunately, more than 90% of the rind is discarded indiscriminately into the environment thereby constituting environmental challenges. This waste rind is not presently being utilized for any value added processes due to limited research activities focusing on the possible conversion of the waste to other valuable products thereby making it available for dumping as solid waste. Chemically Watermelon rind contains large amount of water with promising levels of solid matters but devoid of high content of soluble sugar. These characteristics made it a viable candidate for the production of high quality jam. This novel use of Watermelon rind will among other things reduce the amount of the waste discarded, create more income for farmers, food processors and more importantly reduce environmental impacts of the waste.

Therefore, the main focus of this research is to successfully document the physicochemical properties and sensory characteristics of jam made from Watermelon rind.

Considering the nutritional quality of jam the present study was undertaken with the following objectives:

a) To produce quality jam from water melon rind.
b) To study the physio-chemical properties of jam produced from water melon rind.

CHAPTER II

REVIEW OF LITERATURE

The Cucurbitaceae exhibit much parallel variation among genera and species in the size, shape and coloration of the fruits (Vavilov, 2005). The genus *Citrullus* contains four diploid species, with basic chromosome number of (2n=22, n=11). (*Cirullus lanatus*). Matsum and Nakai, whichis divided into two botanical varieties, (Citrulluslanatus var. lanatus) that thrives in west Africa and is called egusi melon, and the preserving melon (*Citrullus lanatus var. citroides*) that is grown in Southern Africa (Whitaker and Bemis 1976) and is called tsamma melon. *Citrullus colocynthis (L.)* Schrader, a perennial species, with globes fruits of 5-10 cm in diameter. The fruit of this species is bitter and even poisonous (Schipper, 2002), it grown in sandy areas throughout Northern Africa, South West Asia and the Mediterranean (Jarret. *et al.*,1997). *Citrullus ecirrhosus Cogniaux*, a perennial species, grown in Southern Africa and West Namibia, it grows without tendrils and with woody deeply penetrating taproot. The fourth species, *Citrullus rehmii* De Winter, an annual wild species, its distribution is confined to the western escarpment in Namibia (Schipper 2002). It resembles *citrullus lanatus* but can be distinguished by its pink to orange mottled surface of the rind. All the species in the genus *Citrullus* are cross compatible to each other. *Citrullus lanatus* and *Citrullus ecirrhosus* appear to be more closely related to each other than either is to *C. colocynthis* (Navot and Zamir 1987). There are two other closely related species: *Praecitrullu sfistulosus* (Stocks) from India and Pakistan, the genus has a basic chromosome number of n=12 (Schipper 2002). Tinda varieties with their green-fleshed fruits that found in Kenya, Zimbabwe, and Ghana are belonging to this species. The other species is *Acanthosicyo snaudinianus* (Sond) a wild species native to southern Africa. As a result, throughout human history, the identities of various cucurbits, cultivated and wild, have been confused. *Citrullus* is readily distinguished from other cucurbit genera by the pinnatifid shape of its leaf laminae (Paris *et al.,* 2013). Watermelon is one of the commonly consumed fruits in many of countries. Watermelons are sometimes confused with melons, Cucumismelo, as both are often large and sweet. The most salient features distinguishing them are the shape of the leaf laminae, distribution of staminate and pistillate (or hermaphroditic) flowers on the plant, range of fruit shape, fruit surface features,

wetness of the fruit, thickness of the fruit rind, fruit flesh color, and shape, color and distribution of seeds within the fruit (Paris et al., 2012b). In the field, watermelons ripen evenly over the course of the harvest season but melons ripen in two distinct waves (Rosa, 1924; McGlasson and Pratt, 1963; Pratt *et al.*, 1977).

Watermelons have no well-marked indicators of fruit ripening but melons typically become aromatic and yellow, and abscise from the plant upon ripening (Isenberg *et al.*, 1987; Nonnecke, 1989). Apart from quenching of thirst, the fruit is also known to provide several health benefits (Rahmat *et al*., 2002). It is a rich source of lycopene; a well-known antioxidant and has potential role in prevention of prostate cancer (Li *et al.*, 2009). Watermelon contains more than 91% water and up to 7% of carbohydrates. Additionally, watermelon has a number of essential micronutrients and vitamins (Desamero *et al*., 1993). In addition, total phenolic content of 26 mg/100 g was reported from watermelon (Vinson et al., 2001), which includes 9.5% of free and 90.3% of conjugated phenolics (Fabian *et al*., 2002).

2.1 Origin of watermelon

Watermelon (*Citrulllus lanatus* Thunb) belongs to the family *Cucurbitaceae* and is believed to have originated from South-Africa. The natives in Kalahari Desert region knew of sweet as well as bitter forms growing throughout the area, which is considered an evidence to prove that the species is indigenous to tropical Africa, more specifically the southern parts of Africa (Whenner 2005). Southern Africa is a primary center of diversity, with wild relatives found in West Africa. China and India considered as secondary centers of diversity since diversity of related species occur in the area, in addition to areas of Middle East and Mediterranean (Rahmat *et al*., 2002).

Though *Citrullus colocynthis* has been often been considered to be an undomesticated ancestor of watermelon, and is now found native to North and West Africa, Dane and Liu (2007) suggest on the basis of chloroplast DNA investigations that the cultivated and undomesticated watermelon appear to have diverged independently from a common ancestor, most likely *Citrullus ecirrhosus* from Namibia. As postulated by Rahmat *et al*., 2002, there is evidence sufficient to prove that watermelon may be native to tropical Africa.

2.2 Varieties of watermelon

There are four basic groups of watermelon varieties: Picnic, Ice-Box, Seedless, and Yellow-Flesh. All over the world, more than 1,200 varieties of watermelons are produced, with between 200 and 300 varieties grown in the United States alone (National Watermelon Promotion Board 2003). In the Ice-Box group are varieties such as Sugar Baby, Petite Sweet, and Yellow Doll (National Watermelon Promotion Board 1999). These melons are round, weigh 2.5-7 kg, can have either red or yellow pulp, and can have dark or light green rind (National Watermelon Promotion Board 2003b).The Picnic type is oblong in shape, have dark green skin/rind (with or without stripes), weight 9-11 kg, and have red flesh (National Watermelon Promotion Board 2003b). This group includes varieties named Sangria, Fiesta, and Regency. Varieties such as Crimson Trio, Farmers Wonderful, and Honey Heart are seedless type of watermelons (National Watermelon Promotion Board 1999b). Seedless watermelons weigh 4.5-11 kg, are oval to round in shape, have a light green rind with dark green stripes, and can have either red or yellow flesh. The melons in the "yellow-flesh" variety have yellow to bright orange flesh/pulp, are oblong to long in shape, weigh 4.5-14 kg, and have light green rind with blotchy stripes (National Watermelon Promotion Board 2003b). Crimson sweet, Jubilee 2, star brite, sweet favorite , shiny boy, yellow baby, triple crown and moon and star are the main varieties.

2.3 Health benefits of watermelon

A case in point is made for lycopene. Studies have shown that lycopene has the potential of reducing the risk of cancer of the lungs, prostate, colon and stomach. (Giovannucci, 1999).Apart from lycopene, other beneficial phytochemicals and antioxidants such as, carotenoids, Vitamin C and beta-carotene has been indicated to be present in watermelon (Erhardt *et al*., 2003). Additionally, the risk of developing heart attack and other cardi ovascular diseases has been shown to be reduced by lycopene (Kohlmeier *et al.,* 1997) possibly due to its high cholesterol reducing effects. Vitamin C is also an essential nutrient for humans because it plays a crucial role in the synthesis of collagen in addition to protecting against oxidative damage.Vitamin C for an example helps prevent infections and viruses, and also helps slow the aging process and development of cataracts (National Watermelon Promotion Board, 2003).

Vitamin C consumption has also been shown to protect against cancers of the mouth and lungs, improve cholesterol, and prevent scurvy (Fontham *et al.*, 1988).Small amounts of potassium, which can help alleviate muscle cramps, along with miniscule amounts of calcium and iron are also found in watermelons (National Watermelon Promotion Board, 2003).

2.4 Microbial Contamination

There has been a rapid increase in foodborne illness outbreaks linked to fresh produce. One of the largest foodborne outbreaks associated with consumption of fresh produce occurred primarily within the southern states of the U.S. in 2008. The initial cause of the Salmonella outbreak was identified as tomatoes (Warriner *et al*., 2009). Approximately 48 million cases of foodborne illness occur annually and 25% of these are associated with fresh-cut fruits. Each year these illnesses result in an estimated 128,000 hospitalizations and 3,000 deaths (USFDA). Microbial load of fresh-cut products depend on several factors including raw material, agricultural practices and conditions of harvesting, and processing. As argued in Corbo *et al*. (2004) during the minimal processing, skin micro flora could be transferred to fruit flesh. Fresh-cut fruits provide suitable environment for microbial spoilage since microorganisms can grow rapidly upon exposure to nutrients and nutrient rich juices. In addition, cross contamination may occur during cutting and create an environment conductive to growth of microorganism (Gonzales-Aguilar *et al*., 2004). Intrinsic factors of raw material (water activity, pH, redox potential, nutrients, structures, and antimicrobial agents), as well as extrinsic factors or environmental conditions (temperature, relative humidity, and atmosphere) are very important microbial quality of fresh-cut fruits (Raybaudi-Massilia *et al*., 2009). As discussed by Castell-Perez *et al*., (2004), one of the most serious problems challenging the fresh-cut industry is microbial invasion during marketing. Since fresh cut products contain unprotected cut surfaces, a variety of microorganisms easily find a way to grow rapidly which in turn causes infection and limits the shelf life. Microbial quality of fresh products refers to the overall effects of microbial growth, enzymatic and metabolic activity, and also visual quality of foods. The quality of food highly depends on harvesting, handling, transporting, storage, and marketing conditions. Physical factors including temperature, pH, and moisture also affect metabolic activity of microorganism (Sela and Fallik, 2009).

Both the type and the number of pathogenic and spoilage bacteria present on the food surface determine quality, safety, and shelf life of ready-to-eat (RTE) foods. Therefore processing steps such as slicing and packaging operations are major points at which both pathogenic and spoilage organisms can be introduced into RTE foods, such as fresh-cut fruits (Cagri *et al.*, 2004). The major agents of microbiological spoilage in fruits can be bacteria, as well as yeasts and molds. Although both molds and yeasts are able to grow in fruit tissue, the latter are more often associated with spoilage of cut fruits due to their ability to grow faster than molds (Raybaudi-Massilia *et al*., 2009). United States and most European countries have regulations which limit the counts of aerobic microorganisms to 106 CFU/g. In particular, some pathogenic microorganisms are not allowed (i.e. Salmonella) or are greatly restricted (E.coli, L. monocytogenes) in ready-to eat foods prepared from raw material. In general, pathogens including Salmonella spp. and Shigella spp. may often be able to grow on some fruits surfaces such as melon, watermelon, papaya, avocado due of the high pH of the fruit products (Oms-Oliu *et al*., 2010; Martin Belloso *et al*., 2006).

As discussed in Soliva-Fortuny *et al*., (2003) acidification of the product surface using citric acid has been widely accepted as effective method in reducing pH. On the other hand, naturally occurring compounds with antimicrobial capacity such as phenols, aldehydes, organic acids, and essential oils have been tested to prove their effectiveness in fresh-cut fruits. However, since they have strong odors and tastes, their usage is limited (Soliva-Fortuny and Martin-Belloso, 2003).

2.5 Introduction of rind jam and their preparation

Jams are solid gels made from fruit pulp or juice, sugar and added pectin. They can be made from single fruits or a combination of fruits or from vegetables. The fruit content should be at least 40%. In mixed fruit jams the first named fruit should be at least 50% of the total fruit added (based on UK legislation). The total sugar content of jam should not be less than 50%. Many types of fruits are now used in processing jam. Such as mango, pineapple, strawberry, wood apple, melon, papaya, ash pumpkin. In mixed fruit jam use more than one fruit. In the European Union, the jam directive (Council Directive, 1979) set minimum standards for the amount of "fruit" in jam, but the definition of fruit was expanded to take account of several unusual kinds of jam made in the European Union. For this purpose, "fruit" is considered to include fruits

that are not usually treated in a culinary sense as fruits, such as tomatoes; fruits that are not normally made into jams; and vegetables that are sometimes made into jams, such as rhubarb (the edible part of the stalks), carrots, sweet potatoes, cucumbers, and pumpkins. The preservation principles of jam is quite complex, but in essence involve the correct combination of acidity, sugar level and pectin content. All three must be correct to obtain a satisfactory product. Fresh or pre cooked fruit is boiled with a solution of cane or beet sugar until sufficient water has been evaporated to give a mixture which will set to a gel on cooling and which contains 32-34% water. Gel formation is dependent on the presence in the fruit of the carbohydrate pectin, which at a pH of 3.2 - 3.4 and in the presence of a high concentration of sugar, has the property of forming a viscous semi solid. During jam boiling, all micro organisms are destroyed within the product, and if it is filled hot into clean receptacles which are subsequently sealed, and then inverted so that the hot jam contacts the lid surface, spoilage by micro-organisms will not take place during storage. When consider spread, mostly consumed spread are fat spreads. Some other spreads are fruit spreads and vegetable spreads. Nowadays people with busy life styles always prefer meals which can be prepared within a short period. Especially for breakfast, easy but nutritious meals should be taken. Instead of having those trivial food items with less nutritive values, well nutritious and hygienically prepared foods are more suitable. Spreads can be prepared with various types of tastes. Sri Lankan consumers prefer spicy tastes spreads. Jam and Jelly making procedures that offer the highest quality, the least health and safety risks, and the lowest chance of losing product, all extension recommendation for jams and jellies include a boiling water canning process for room temperature storage of sealed jars standard canning jars used with self-sealing flat metal lids and screw bands, pre-sterilization of clean canning jars, hot filling of product into the jars, and processing for 5 minutes in a boiling water canner are recommended for highest quality and to prevent mold growth. Cruess and Mcnair (1961) described the role of added sugar in 'raising the viscosity of the solution and to increase the concentration of juice. They also observed mould growth at sugar concentration lower than 65% and crystallization of sugar in jellies with 72-75% sugar when the acidity was too low. Lal *et al*., (1967) concluded that for a maximum of 68.5% of sugar in jams, generally 55 lbs of sugar is added to every 45 lbs of fruit pulp. They also pointed out that higher the sugar concentration higher is the jelly strength. Larger - the amount of acid present lower the pH. Generally citric acid,

tartaric acid or malic acid is used to supplement the acidity of the fruit which are deficient in it, for making jam in order to give a good combination of pectin, sugar and acid for good" set in jam. Vail *et al*.,(1978) reported that the problems of crystallization of sugar in jams are due to over cooking. Adding of sugar too late in the cooking process also causes crystallization.Saraanan et al. (2004) evaluated the physicochemical analysis and sensory qualities which indicate that papaya jam which consist of pulp l kg sugar 1kg and citric acid 3g had excellent organoleptic qualities he also noticed a slight decreases in acidity of papaya jam, during storage similarly acidity reduction observed in the guava juice concentrate prepared from vacuum concentration method.

2.6 Preservation methods of jam

Gil *et al*., (2006) reported quality changes and nutrient retention in fresh-cut versus whole fruits during storage. Fresh-cut pineapples, mangoes, watermelons, strawberries, and kiwifruits and whole fruits were stored for up to 9 days in air at 5 degrees C Losses in vitamin C after 6 days is 5% in mango, strawberry, and watermelon pieces, . No losses in carotenoids were found in kiwifruit slices and watermelon cubes, Total carotenoids contents increased in mango and watermelon cubes after 9 days. Hugher and Bennino (1990) analyzed the spoiled food and reported chemical and physical changes that render the food inedible and hazardous the two chief causes of food spoilage found where microorganism including bacteria yeast, moulds and action of enzymes that occurs normally in the food preservation by adding preservatives (adding substances) inhibits the growth of undesirable microorganism the common preservatives are sugar, salt, vinegar acid and spices. Acid and salts where commonly used in pickle and chutney sugar and acid are used in large amount in the products like jam jellies preserve and candies.Sharma *et al.*, (1981) observed that the reducing -sugar content of jelly increased during six months storage.

Chauhan (1981) observed. a gradual decrease in the acidity was found with increases in the period of storage in guava jelly . The decrease in acidity might, be due to formation of sulphourous acid during storage. Dabhade and 'Khedkar (1982) reported that an equilibum' relative humidity ERH of 51 percent of mango fruity. Bhatet. *et al*., (1982) reported the preservative of fruit by addition of sugar.

The fruit suitably prepared by placing in -sugar syrup of a density, somewhat higher than that of the fruit. The water moved out of the fruit had sugar move into it unit the syrup and the juice of the fruit has reached equilibrium as per the principal of osmosis. In-this way the sugar was gradually added, when the syrup was too dense and the flow of water from the fruit was fast, it required the cells and fruit become tough shriveled. In preservatives, heat, and high sugar concentration acted as preservatives. Bhatnagar (1991) reported utilization of watermelon rind for jam making process which is use as animal feed only. The jam was prepared by steaming of watermelon rind for 10 min in hot water then removing the white portion and cooking it with sugar it soft and adding pectin and preservative for storage. Gopalan *et al.,* (1993) reported that calcium was not affected up to three months but between the third and six months a significant reduction was observed. This might be due to binding of calcium with certain organic substances. Srivastiva and Kumar (1994) suggested a method of preparation of aonla preserve and candy. The fruits were pricked, and then steeped in 12% salt solution for 24 hours to move astringency.

Then the fruits were washed in water, dipped in 2% alum solution for 24 hour. They again washed the fruit with water thoroughly. The -fruits were blanched till softening and continued this process for third day. Added 200gm sugar on fourth day and' then boiled for a few minutes kept the products for 6 days. Next day they were rolled in powdered sugar and dried in the shade. Khan *et al.,* (2005) reported Pasteurization of watermelon juice resulted -in a slight decrease in lycopene contents on or little change in color acidity and ph Based on the physico-chemical analysis and sensory scores, it is concluded that juice pressed from cold macerate (I) was better in quality than from the other methods used.

2.7 Physical quality of jam

2.7.1 Color

Fruit surface coating retained greener skin colour in pears compared to the control treatment (Meheriuk and Lau, 1988). Dang *et al.,* (2008) also reported that the external colour of mango fruit is generally retained when coated with aloe gel. Lazan *et al*. (1990) reported that the papaya fruit coated with sucrose polyester was effective in retarding the development of skin colour. A similar observation was also made on

cucumber and bell peppers, where chitosan coatings maintained deeper green colour than control fruits (El Ghaouth *et al*., 1991). Paull and Chen (2004) indicated that the storage life of mangoes can be extended by holding the fruit in an environment with 3 to 5% O2 and 5 to 10% CO2, at 7 to 90C and 90% atmospheric relative humidity. They note that some types of coating can cause off-flavors or abnormal skin color in mangoes. Hassan (2006) stated that days required reaching different color stages of mango during storage and ripening were determined objectively using the numerical rating scale. Radulovicet. *et al*., (2007) studied change in quality parameter and physiochemical change in watermelon during storage at ambient temperature pH value changes slightly microbiological degradation of carbohydrates is negligible, reducible sugars decreased for 42.5%, to 3.76%, greatest change occurred in sweetness in watermelon at storage period. Davies and Hobson (1981) also reported that color changes were subjected to genetic control in view of the variation in color development across cultivars. Processing cultivars changed color more rapidly while they maintained higher firmness ratings than non-processing cultivars, suggesting slower degradation of protopectin by the two enzymes pectinesterase and polygalacturonase than chlorophyll breakdown and pigment synthesis which is also in agreement with the findings of Mohammed et al. (1999) and Moraru *et al*. (2004).

Singh *et al*., (2006) observed that quality attributes especially colour Hunter colour lab in tomato puree was prepared using three different blanching treatments viz. Hot water, Steam blanching and Microwave blanching. The pre-requisite samples of tomato puree were taken for the measurement of Hunter Lab The different value are as followed, Microwave blanched puree received highest hedonic scale for color after 90 days storage so microwave puree was best in all over acceptability.

2.8 Biochemical quality

Postharvest product quality develops during growing of the product and that could be maintained, but not improved by postharvest technologies. This could be achieved through selection of genotypes with better keeping quality when harvested at optimum maturity (Ramakrishnan *et al*., 2010; Vijay *et al*., 2010). Moreover, Tan (2006) indicated that available genetic material allows discrimination of external and internal quality attributes that must satisfy consumer requirements and indulgences.Food quality is the sum of all desirable attributes which make a food acceptable for consumption. Quality attributes of a product may be divided into three

major categories sensory, hidden and quantitative (Salunkhe *et al*., 1991). The sensory attributes are colour, flavor, texture, taste, etc. The hidden attributes are nutritive values, presence of dangerous contaminants and poisonous materials. The quantitative parameters are those, which contribute to the overall food quality such as the yield of a dried product. In order to determine the quality of the dried product, several parameters need to be examined through quality evaluation.

2.8.1 Total soluble solids (TSS) content

Soluble solid concentration (SSC) is the most important quality parameters of leather. Shindem *et al*., (2009) studied to increase the shelf life and to minimize the postharvest losses in mango fruit cv. 'KESAR', under the influences of various plant extract treatments. The fruits were treated with different plant extracts and wrapped with various wrapping materials. The fruits treated with neem oil (10 percent) proved to be most effective with respect to slower increase in TSS, while slower decrease in ascorbic acid and acidity during storage of 10 days. Jiang and Li (2001) stated that the slower increase in total soluble solids in the fruit pulp subjected to the coating treatment could probably due to reduction of oxygen supply on the fruit surface, which inhibited respiration rate and the growth of spoilage organisms. Results of at study are in agreement with findings of previous works on various fruits coated with different coatings, such as sweet cherry (Mart´ınez-Romero *et al*., 2006), table grapes (Valverde *et al*., 2005) and mango (Dang *et al*., 2008).Reni *et al.*, (2000) evaluated the storage stability of 12 papaya cultivars and after 4 months they observed that the TSS in pulp decreased during storage with the ripening, the total soluble solids in the peel of papaya increased. Jones (2002) conducted an experiment to assess the respiration and the chemical changes of papaya fruits in relation to temperature (40, 45, 50, 55 and 60°F) and reported that the TSS decreased with decreasing temperature. Singh *et al*., (2005) revealed that during storage of the jam, the/ total soluble solids (TSS) and total sugars increased up to three months.

Throughout the storage period of six months, the reducing sugars and browning increased, whereas, acidity and non-reducing sugars showed a decreasing trend. They also reported that the organoleptic rating decreased from 8.36 to 6.57 irrespective of the recipes during storage.Kalara and Revanthi (1983) reported a slight decrease in TSS of guava pulp during 60 days storage in glass container at room temperature. The

TSS of mango pulp varied up to 10 % during storage. Jain et.al (1983) reported that the total soluble solid and the total sugars were found to increase, while acidity showed a continuous fall during storage in aonla preserve. An increase in total soluble solids might be possible due to the conversion of polysaccharides in to sugar.

2.8.2Titratable acidity and pH

The treated fruits lost their acidity at higher rate probably due to the rapid utilization of acids as respiratory substrates during ripening. Results of this study are in agreement with Valverde et al. (2005) who reported that the titratable acidity of aloe gel coated table grapes decreased with time but to a lesser extent than that of uncoated fruits during the storage. In another study, the titratable acidity of aloe gel-based coated mango fruits have also been reported to decrease with time during storage (Dang *et al.,* 2008). Ghanta *et al*., (1994) argued that the titratable acidity in fruit pulp decreased gradually throughout the fruit development until it reached the full ripe stage. Those results corroborated with those reported by El Ghaouth *et al.,* (1991a) and Garcia *et al.,*. (1998) on strawberry that the decrease in acidity during the storage demonstrated fruit senescence. In a study O' Hare (1995) reported that titratable acidity was declined slowly when mango fruits were stored at 130C. They also claimed that the titratable acidity decreased during storage in a refrigerated room. According to Upadhay and Tripathi (1985) titratable acidity was decreased during storage and ripening. Leon and Lima (1968) also observed similar results. According to them, acidity was reduced during later growth stage on attainment of maturity and ripening. Shahjahan *et al.,* (1994) noted that the acidity of mango was decreased gradually at the time of storage and ripening.

2.8.3 Ascorbic acid content

Mango is a good source of vitamin C at the early stages of development, which decreases rapidly 5-7 weeks after fruit set (Gofur *et al*., 1994). They also experienced that at 12 weeks after fruit set ascorbic acid content was 105.2, 65:7 and 17.3 mg/100 g in Langra, Ashwini and Fazli varieties, respectively. They also observed that the ascorbic acid decreased with the increased in storage duration.Laborem *et al*., (1992) claimed that there was a tendency for ascorbic acid content to be higher in cold storage.

They also noted that the lower the temperature the higher the vitamin C content.The same fact was also verified by Dhaka et al. (2001) and Jain et al. (2001): they reported that higher ascorbic acid content in the mango fruits stored in cool chamber.The maximum portion of vitamin C was lost when the fruits were stored at room temperature (20-30°C). In addition, reduction in vitamin C with progress of fruit maturity and ripening was found in the cv. `Gopalbhog', `Khirshapat', `Langra' and `Fazli' as described by Shahjahan *et al*., (I994).

Jiang and Li (2001) experimented that biological control exhibited the best effect on the content of ascorbic acid by slowing down with increasing in storage time, which can be attributed to low respiration rate. The content of ascorbic acid in fruits subjected to the treatment increased steadily until 21 days of storage and then decreased slightly till the end of the storage period. That slower increase in ascorbic acid content might be due to reduced internal oxygen that resulted in retarding the oxidation of ascorbic acid (Sumnu and Bayindrili, 1995a). A similar trend of increased ascorbic acid content was reported for coated apples, pear and apricot during storage (Sumnu and Bayindrili, 1995).Guptra and Bopaish (1986) reported an easy way to prepare anolamurabba with higher retention of vitamin C. The physicochemical aspect in the murabba preparation at different source such as laboratory, homemade and of market showed higher retention of vitamin C content in laboratory (46.7mg/100g pulp) and low retention in market and home made products i.e. 29.7mg/100g pulp and 23.4mg/100g vit.C, respectively. Iftikhar *et al.,* (2008), a comparative study was carried out on mixed fruit jam of (ber+pear) pulp, incorporated within ratio 50:50, 60:40, 40:60.

Kumar et.al. (1992) reported that the loss of ascorbic acid content during preparation of candy and preserve has been observed in ber. Kaneker *et al.,* (1992) reported that some fungal species like Aspergillusniger, Penicilliumspp, Curvularia spp., Alterneria spp., Micrococcus luteus and Bacillus cagullans etc. were pesent in mango jam and also reported increase in microorganism in the jam due to increase in the storage period. Ram (1993) found that 2% alum solution blanching removed the estringency of the aonla fruit for the preparation of murabba 1kg fruit+ 10.5kg water and 2g citric acid were used but citric acid was not used for the preparation of candy. Dhawan and Gupta (1996) studied the comparison of guava hybrids with commercial cultivars for

making jelly. The acidity of jelly was decreased as the period of storage. Though a linear relationship was found but the acidity decreased at higher rate during storage. The decreased in acidity might be due to formation of sulphurous acids and free fatty acids. Baramanray *et al*., (1996) also reported that ascorbic acid content of guava jelly decreased remarkably (30.44%) during 90 days of storage period. However, loss of ascorbic acid content was comparatively lower during first month of storage. All the sample stored in sterilized glass jars and evaluated physiochemical for ascorbic acid, acidity, PH, total soluble solid reducing and no reducing sugars for interval of 15 days 3 months storage period. A decrease was observed in ascorbic acid and non reducing sugar.

While increase was noted in acidity % reducing sugar and TSS during evaluation. Rajput (2007) observed gradual deceases in the ascorbic acid acidity, tannin and calcium and iron content of the prepared and stored anola honey spread and an increase was observed on the TSS content.

2.9 Sensory attributes

Various food companies regularly use sensory tests, such as descriptive analysis and consumer's preference tests to study ingredient effects, processing variables and storage changes on the perceived sensory properties of their products. Sensory analysis provides marketers with an understanding of product quality, directions for product quality, and profiles of competing products and evaluations of product reformulations from the consumer perspective (Stone and Sidel, 2010).

There are three types of testing commonly used in sensory analysis, each with a different goal.

Those are:

1. Discriminative sensory analyses

2. Descriptive sensory analyses

3. Consumer affective tests.

Discriminative sensory analyses are used to detect differences between two or more

types of products (Lawless and Heymann, 2010). Among the discriminative sensory tests, paired-comparisons, duo-trio tests and triangle tests are most commonly used. he descriptive sensory analyses tests are used to quantify the perceived intensities of the sensory characteristcis of a product (Lawless and Heymann, 2010). This type of sensory analysis is widely used to characterize aroma, flavor and oral textural attributes of food products. All descriptive analytical methods involve the objective detection, description and quantification of sensory attributes of a product by trained panelists (Meilgaard *et al*., 1999). Consumer affective tests are used to quantify the degree of liking or disliking of a product. This type of testing is also called hedonic or effective testing (Lawless and Heymann, 2010).Consumer affective tests are the most straight forward approach and panellists a choice between alternative products to watch if there is a clear preference from the majority of respondents. Data obtained from consumer affective tests are vital in product development, quality control, food product acceptance, and food service evaluation. armanray *et al*., (1996) evaluated organoteptic quality of freshly prepared jelly to be highly acceptable and reduced significantly with the increased storage period. He also reported that colour, flavour, texture, and acceptability of jelly, from cultivar sardar has higher initial score but decreased significantly at 90 days of storage.

There are two types of affective tests: quantitative and qualitative. The qualitative tests (i.e. focus group interviews, focus panels, one-on-one interviews) measure the subjective responses of a small group of representative consumers to the sensory properties of products by having them talking about their feelings in an interview or group setting (Meilgaard *et al*., 1999). The quantitative tests determine the responses of a large group of consumers to a set of questions regarding preference, liking, sensory attributes, etc. (Meilgaard *et al*., 1999).The most important quality attributes of a food product to consumers are its sensory characteristics (e.g. texture, flavor, aroma, shape and color). In this research, fruit leathers composed mainly of blueberries are being developed; this is a natural product and has yet to be commercialized in quantity. Therefore, conducting a sensory trial of the product is necessary as it will characterise the sensory properties of blueberry fruit leather and determine the consumer's sensory profile which will drive product acceptance and purchasing intention. A hedonic scale is often used in product development and redevelopment to establish the degree of acceptability for a product. Given that

blueberry fruit leather is a new product, a hedonic approach is an appropriate choice to find the degree of consumer's acceptability.

Several other studies on fruit leather are used in the hedonic scale to assess the degree of acceptability for a product. Che Man and Sin (1997) used the hedonic scale for their research on jackfruit leather and Irwandi (1998) conducted the sensory analyses for taste, texture, appearance, aroma and overall acceptability for durian leather using a 7-point hedonic scale (1=dislike extremely, 7= like extremely). Gujral and Khanna (2002) used the 9-point hedonic scale to evaluate mango fruit leather samples for flavor, color and texture, whereas Azeredo *et al.,* (2006) used the 7-point hedonic scale for color, flavor and toughness attributes of mango fruit leather with no preservatives or added sugar. The sensory panel for both mango leathers studies comprised at 20 trained and 30 non-trained panelists, respectively. For the evaluation of papaya leather (Kumar *et al.,* 2010), the 9-point hedonic scales and 10 semi-trained panelist were used to measure appearance, flavor, fruitiness, toughness and chewiness of the product. It was necessary to measure all of the above quality attributes for the production of blueberry fruit jam. Therefore, the objectives of that project were to produce blueberry fruit leathers using locally grown blueberry cultivars and natural ingredients. Sensory evaluation was conducted to find the acceptability of the blueberry fruit leather. For both fresh and processed blueberries, physico-chemical analyses were conducted to find the effect of drying on the nutritional properties.

CHAPTER III

MATERIALS AND METHODS

The present research work was conducted at Postharvest Laboratory, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka during February 2018 to December 2018. The quality of fresh fruits and processed jam were evaluated by the determination of nutritional analysis, texture and physico-chemical analyses. Finally, sensory evaluation watermelon jam was conducted. The location of the experimental sit, materials used and methods followed in different operations during the experiment as well as in data collection are described here under the following sub-heads:

3.1 Procurement of raw materials

Some useful materials viz watermelon rinds, Sugar, Citric acid, Mint, Basil, Ginger, Clove, Cardamom, Butter, Pectin powder, Butter paper, different flavors were purchased from local market of Hatkhola road and Agargoan bazar, Dhaka.

3.2 Tools and Equipments used

- Knife
- Plate
- Weight machine
- Pan
- Muslin cloth
- Wooden spoon
- Tea spoon
- Mixer grinder
- Thermometer
- Glass bottle
- Glass gar
- Butter paper
- Plastic jar
- pH meter
- Refractometer
- Burette

3.3 Methods

The following methods were used for the present investigation, each for specific purposes. Those were:

a) Extraction of watermelon rinds
b) Processing of watermelon rinds
c) Preparation of watermelon jam
d) Pouring and storing of jam
e) Assessment of quality of jam

3.4 Treatments

The experiment consisted of one factor. Factor was consisted of different combinations (watermelon rind, sugar and different flovor) that was consider as a treatment .There was 16 treatments such as

T_1F_0=50% rind+50% sugar+no flavor
T_1F_1=50% rind+50% sugar+strawberry flavor
T_1F_2=50% rind+50% sugar+pineapple flavor
T_1F_3=50% rind+50% sugar+vanila flavor
T_2F_0=80% rind+20% sugar+no flavor
T_2F_1=80% rind+20% sugar+strawberry flavor
T_2F_2=80% rind+20% sugar+pineapple flavor
T_2F_3=80% rind+20% sugar+vanila flavor
T_3F_0=60% rind+40% sugar+no flavor
T_3F_1=60% rind+40% sugar+strawberry flavor
T_3F_2=60% rind+40% sugar+pineapple flavor
T_3F_3=60% rind+40% sugar+vanila flavor
T_4F_0=40% rind+60% sugar+no flavor
T_4F_1=40% rind+60% sugar+strawberry flavor
T_4F_2=40% rind+60% sugar+pineapple flavor
T_4F_3=40% rind+60% sugar+vanila flavor

These treatments were replicated three times in this study.

3.5 Experimental design

The one factor experiment was laid out in the Completely Randomized Design (CRD) with three replications. The postharvest treatments were assigned randomly in each replication. The collected data on various parameters were statistically analyzed using data were analyzed using SPSS (1995) version 11.5 (SPSS inc., Chicago, IL, USA). One way ANOVA and completely randomized test were conducted to determine significance existing in the mean values at $P \leq 0.05$.

3.6 Experimental materials

Fruits

Best quality watermelon fruits were used in this experiment. Healthy fruits with uniform size, shape, and maturity were purchased from the local market. Fruits were medium to large in size, about 4-5 kg in weight. The skin color was green to dark green and thick to highly thick, non-adhering and somewhat heavy; the seed was small but rinds were fleshy and thick. All fruits were thoroughly washed with tap water, followed by ringing with sterile distilled water.

3.7 Procedure for making watermelon rinds jam

a. Collection of watermelon rinds

The following procedure was developed based on the preliminary trials to optimize the ingredients and methods. At first watermelon fruits were washed in clean water. The fruits were cut into small pieces (Plate 3.1) and rind was collected to remove pulp by knife. The rind was blended using a blender.

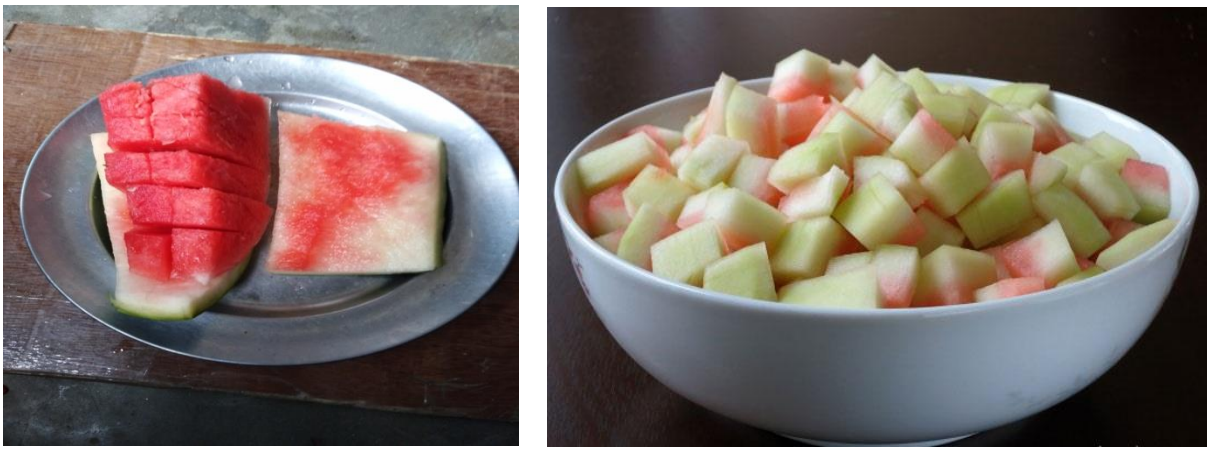

Plate 3.1 Pieces of watermelon rind

b. Preparation of jam

The blended watermelon rind (Plate 3.2) was low in brix. Mixtured of rind and sugar which kept at 45 minute in room temperature then 5g pectin was added. The rind was increased by heating at 2000 watt for 1 hr on an induction cooker until the brix became 60%. Flavors were added at the last stage of cooking.

Plate 3.2 Blended Watermelon rind

c. Pouring and storing of jam

When jam was prepared then it was stored in glass jar (Plate 3.3). Jars were autoclaved before used. It was autoclaved for killing the harmful microorganism.

Plate 3.3 Watermelon rind jam stored in jar

3.8 Physical characteristics of jam

The physical characteristics of the treated jam viz. color and texture were studied in the present experiment.

3.8.1 Determination of color

The peel colour of the jam was determined using a Android Application Software namely “On Color Measure” (developed by Potato tree Soft, Version 3.0) equipped with an aim pointer. It provides the easiest way to store the information of each color detection. Color measurements were done at each face of jam sample and a mean value was obtained. The leather color determination was expressed in chromaticity values of Red (R*), Green (G*) and Blue (B*) (Plate 3.4).

Plate 3.4 An application overview of the”On Color Measure” (source: potato tree software version 3 Google play apps)

For measuring the color the camera was aimed at the target color point and clicked on crosshair pointer and moved it to any place on the screen. The dashboard displays the information of the color detected. Grab button was clicked to capture the screen image and saved all the detailed color information including RGB, HSV, color names, hex code and screen images.

3.9 Chemical characteristics

The chemical characteristics of jam viz. titratable acidity (TA), soluble solid concentration (SSC), pH and ascorbic acid content (Vita-C) of watermelon rind jam, were studied in the present experiment.

3.9.1 Determination of pH

The pH was determined using a glass electrode pH meter (GLP 21, Crison, Barcelona, and EEC). Before being used, the pH meter was calibrated with buffers at pH 4.0 followed by pH 7.0. After that, the glass electrode was placed into the filtrate to measure the pH and stabilized reading was recorded.

For accuracy of the reading, the glass electrode was washed after each reading with distilled water and wiped to dry with soft tissue paper.

3.9.2 Determination of tritratable acidity (% Citric Acid)

The titratable acidity was estimated through the chemical analysis using watermelon rind jam. The titratable acidity of watermelon jam was determined according to Ranganna (1979). The following reagents were used for the determination of the titratable acidity.

i) Standard NaOH solution (0.1N)
ii) 1% phenolphthalein solution
iii) Extraction of the jam

Ten gram of fresh watermelon jam sample was taken in a 500 ml beaker and homogenized with distilled water in a blender (MX-798S, National, Malaysia). The blender materials were then filtered and transferred to a 500 ml volumetric flask and the volume was made up to the mark with distilled water.

Procedure

Five milliliters of the pulp solution was taken in a conical flask. Two to three drops of phenolphthalein indicator solution was added and then the conical flask was shaken vigorously. It was then titrated immediately with 0.01N NaOH solution from a burette till the permanent pink color appeared. The volume of NaOH solution required for the titration was noted from burette reading and at the percent titratable acidity was calculated using the following formula:

Citric acid (%) =

$$\frac{\text{Titre (mL)} \times \text{NaOH normality (0.1 M)} \times \text{Vol. made up (50 mL)} \times \text{Citric acid eq. weight (64 g)} \times 100}{\text{Volume of sample for titrate (5 mL)} \times \text{Weight of sample taken (10 g) x 1000}}$$

3.9.3 Determination of the ascorbic acid (Vitamin C)

The ascorbic acid content was determined according to Ranganna (1979). The following reagents were used for the estimation of ascorbic acid content.

i) Three percent (3%) Metaphosphoric acid (HPO_3)

It was prepared by dissolving 30g of HPO_3 in 1000 ml of distilled water.

ii) Standard ascorbic acid solution

Ten milligram of L-ascorbic acid solution was prepared by dissolving the ascorbic acid in 100ml of 3% metaphosphoric acid solution.

iii) Dye solution

It was prepared by dissolving 50 mg of the sodium salt of 2, 6-dichlorophenol indophenol in approximately 50 ml of hot distilled water containing 42 mg of sodium bicarbonate. It was then cooled and diluted to 100 ml with distilled water. The following steps were followed for the estimation of the ascorbic acid.

Standardization of the dye solution

Ten milliliters (10 ml) of the standard ascorbic acid solution was taken in a conical flask and 5 ml of metaphosphoric acid HPO_3 was added to it. A micro burette was filed with the dye solution. The content of the conical flask was titrated with the dye solution. The contents of the conical flask were titrated with the dye till the pink-colored end point appeared. The milliliters of dye solution required to complete the titration was recorded. The dye factor was calculated using the following formula:

$$\text{Dye factor} = \frac{X}{\text{Titre (mL)}} \qquad \text{Here, x =0.5}$$

Preparation of the sample

Five grams of the jam sample and 35 ml of 3% metaphosphoric acid solution was taken in a blender and homogenized for 2 minutes. After blending it was filtered and centrifuged at about 2000 ppm for 5 minutes. The supernatant homogenized liquid was transferred to a 50 ml volumetric flask and the volume was made up with 3% metaphosphoric acid.

Procedure

Ten milliliters of the aliquot was taken in a conical flask and titrated with dye solution. Then the ascorbic acid content of the samples was calculated using the following formula:

$$\text{Ascorbic acid (mg 100 g}^{-1}) = \frac{\text{Titre (mL) x dye factor (0.081) x vol.made up (50 mL) x 100}}{\text{Aliquot used for estimation (5 mL)} \times \text{sample weight (10 g)}}$$

3.9.4 Determination of soluble solid concentration

The total soluble solids concentration of the jam was determined using a digital refractometer (Model N-1 α, Atago, Japan). The remaining of the filtrated juice from TA determination was used to measure the SSC of the pulp. Before measurement, the refractometer was calibrated with distilled water to give a 0% reading. About 1-2 drops of the filtrate was placed on the prism glass of the refractometer to obtain the % SSC reading. The readings were multiplied by dilution factor to obtain the original % SSC of the pulp tissues. Since differences in sample temperature could affect the measurement of SSC (Boourne, 1982), each of the reading was standardized to a temperature of 20ºC by adding 0.28% to obtain % SSC at 27ºC.

3.10 Sensory evaluation of jam

A consumer acceptability sensory trial was conducted at the post-harvest Laboratory of Department of Horticulture, Sher-e-Bangla Agricultural University (Plate 3.5). The panelists comprised of 5 volunteers who were students of the university. An interview schedule was used for the sensory evaluation of the jam. Each panel list was asked to taste 16 treatments of jam. Each panel list was asked the five quality (attributes) questions and one question about their overall preference for the sample. Attributes selected for jam was overall appearance, texture (perception, stickiness and chewiness) sweetness, chewiness, flavor and overall acceptability of the sample. A 5-point hedonic scale was used. Therefore, the respondents answers were coded 1-5 with 7 being ‘like extremely’ and 1 being ‘dislike extremely’. Three further questions were asked to assess whether the respondents liked the fruit leathers and sauce they had tasted. If they would buy the product and which they liked the best. Responses were subjected to one-way ANOVA to determine any statistical differences.

Plate 3.5 Sensory evaluation by selected member

CHAPTER IV

RESULTS AND DISCUSSION

The results of the analyses of variance in respect of all the parameters studied in the present investigation are presented and discussed in this chapter. The results on the different parameters are presented in tables and Appendices for ease of discussion under the following sub-headings and possible interpretations are also given whenever necessary. A summary of the analyses of variance of the data in respect of all the parameters studied are shown in the Appendices.

4.1 Composition of the fresh watermelon

The fresh watermelon had 95% moisture on the fresh weight .The pH, total soluble solids (TSS), Tritratable acidity, total sugar and reducing sugar are presented in table 4.1.

Table 4.1 Composition of the fresh watermelon used in the study

Constituents of watermelon	Quantity
1.Moisture	95%
2. pH	5.01
3. Total soluble solids	15%
4. Tritratable acidity (citric Acid)	3.12%
5. Total sugar	12.02%
6.Reducing sugar	5.52g

The results of those experiments are presented and discussed separately under different titles.

4.2 Physical characteristics

4.2.1 Color

Color is one of the most important criteria of quality of watermelon. The changes of outer color of jam were monitored by measuring the value of Red (R), Green (G) and Blue (B). Values are presented in the Figure 4.1. At the treatment-1, RGB% was 50, 6 and 0 respectively. The green (G) color content was highest at the T_1F_1 (50% rind+50% sugar+strawberry flavor) RGB % (55, 7, 0) and lowest at the T_4F_3 (40% rind+60% sugar+vanila flavor) RGB % (38, 2, 0).

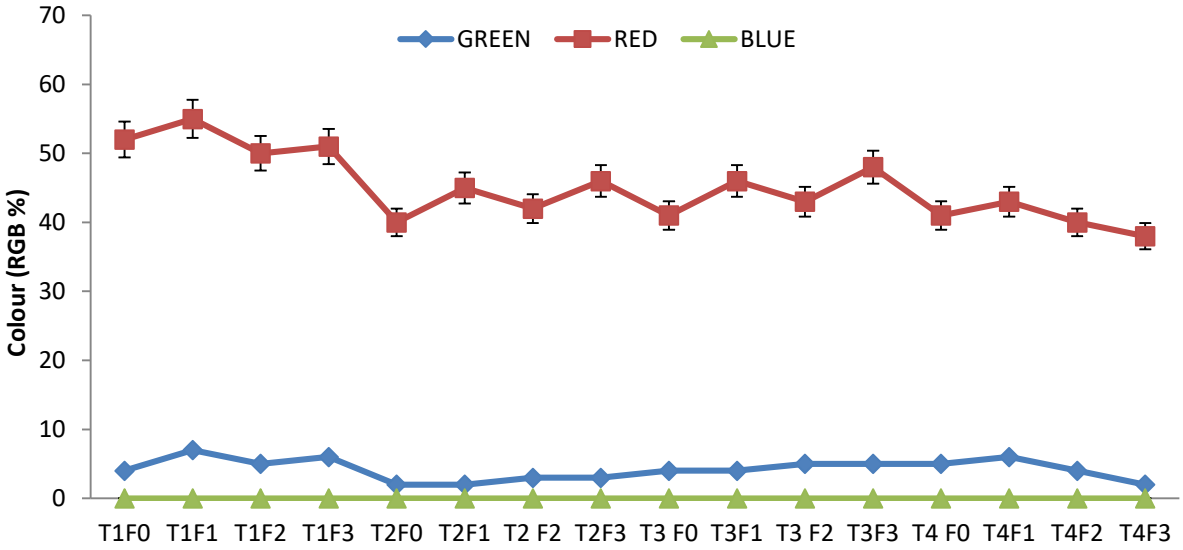

Figure 4.1 RGB% of watermelon jam at different treatments.

There was no significant difference regarding the changes in R and B values among the treatments. Blue color values was absent due to the induce heat during preparing rinds..

4.3 Bio-chemical characteristics at different treatments of jam

4.3.1 pH value

4.3.1.1 Effect of different concentration of rinds and sugar with flavors for pH

The pH of jam at different treatments varied significantly which was given below (Table 4.2). During storage there was gradually increase and decrease of pH value of jam.

The change was occurred after 30 to 90 days of storage time. At first the highest pH value (4.46) was found in T_1F_1 and lowest pH value (4.09) was found in T_3F_3.

Table 4.2 Effect of different concentration of rinds and sugar with flavors for pH

Treatments	pH at different days after storage			
	0 days	30 days	6o days	90 days
T_1F_0	4.40±.117^{ab}	4.07±.133^{cd}	4.20±.117^{d}	4.10±.116^{d}
T_1F_1	4.46±.115^{a}	4.43±.140^{a}	4.42±.115^{ab}	4.40±.115^{a}
T_1F_2	4.00±.115^{bc}	3.80±.115^{bc}	4.00±.116^{d}	3.90±.114^{bd}
T_1F_3	4.20±.115^{bc}	3.93±.143^{cd}	3.90±.117^{cd}	3.90±.114^{bd}
T_2F_0	4.20±.115^{bc}	4.00±.115^{bc}	4.50±.115^{a}	4.20±.115^{bc}
T_2F_1	4.20±.114^{b}	3.90±.117^{cd}	4.00±.115^{b}	4.00±.115^{c}
T_2F_2	4.20±.114^{b}	3.90±.117^{cd}	4.00±.114^{b}	3.80±.115^{d}
T_2F_3	4.20±.114^{b}	4.00±.114^{bd}	4.00±.114^{b}	4.00±.114^{bd}
T_3 F_0	4.40±.114^{b}	4.20±.115^{bc}	4.30±.115^{bc}	4.00±.117^{c}
T_3F_1	4.23±.115^{bc}	3.93±.154^{abc}	4.10±.117^{d}	3.90±.114^{bd}
T_3F_2	4.10±.088^{d}	3.90±.057^{d}	4.00±.117^{d}	4.00±.115^{bc}
T_3F_3	4.09±.117^{d}	3.80±.115^{bd}	3.90±.117^{bd}	3.83±.088^{d}
T_4F_0	4.20±.114^{b}	3.90±.116^{c}	4.00±.117^{d}	3.80±.117^{d}
T_4F_1	4.20±.147^{bd}	4.00±.115^{bc}	4.20±.115^{bc}	4.30±.114^{bd}
T_4F_2	4.23±.088^{d}	4.03±.057^{b}	4.20±.115^{bc}	4.10±.115^{bc}
T_4F_3	4.13±.081^{bd}	3.90±.100^{cd}	4.03±.100^{cd}	4.00±.088^{d}
Level of Significance	*	*	*	*

Means in each column followed by the same letter (s) are significantly different at P≤0.05 According to Duncan‟s Multiple Range Test (T_1F_0=50% rind+50% sugar+no flavor T_1F_1=50% rind+50% sugar+strawberry flavor, T_1F_2=50% rind+50% sugar+pineapple flavor, T_1F_3=50% rind+50% , sugar+vanila flavor, T_2F_0=80% rind+20% sugar+no flavor, T_2F_1=80% rind+20% sugar+strawberry flavor, T_2F_2=80% rind+20% sugar+pineapple flavor, T_2F_3=80% rind+20% sugar+vanila flavor, T_3F_0=60% rind+40% sugar+no flavor, T_3F_1=60% rind+40% sugar+strawberry flavor, T_3F_2=60% rind+40% sugar+pineapple flavor, T_3F_3=60% rind+40% sugar+vanila flavor, T_4F_0=40% rind+60% sugar+no flavor, T_4F_1=40% rind+60% sugar+strawberry flavor, T_4F_2=40% rind+60% sugar+pineapple flavor,T_4F_3=40% rind+60% sugar+vanila flavor).

After 90 days the highest pH value (4.40) was found in T_1F_1 and lowest pH value (3.80) was found in T_4F_0 that was gradually decreased. The pH value was decreased due to the increased of acidity during storage of time. The same result was found Shahjahan *et al.,* (1994) noted that the acidity of mango was decreased gradually at the time of storage.

4.3.2 Total soluble solids concentration

4.3.2.1 Effect of different concentration of rinds and sugar with flavors for Total soluble solids

The total soluble solids concentration of jam at different treatments varied significantly which was given below Table (4.3). It was significant ($P \leq 0.05$). During storage there was gradually increase TSS value of jam. The change was occurred after 30 to 90 days of storage time. At first the highest TSS value (6.50%) was found in T_3F_1 and the lowest value (1.90) of TSS was found in T_2 F_2.After 30 days the TSS value was increased and the highest value (7.50%) of TSS was found in T_4 F_0 and the lowest value (2.95%) of TSS was found in T_2F_0. The TSS value was gradually increased at 90 days and the highest value (7.00) of TSS was found in T_3F_1 and the lowest value (3.00) of TSS was found in T_2F_2. Singh *et al.,* (2005**)** was found the similar result that during storage of the jam, total soluble solids (TSS) was increased. . An increase in total soluble solids might be possible due to the conversion of polysaccharides in to sugar. Jiang and Li (2001) stated that the slower increase in total soluble solids in the fruit pulp subjected to the coating treatment could probably due to reduction of oxygen supply on the fruit surface, which inhibited respiration rate and the growth of spoilage organisms. Shindem *et al.,* (2009) reported that increase the shelf life and to minimize the postharvest losses in mango fruit cv. 'KESAR', under the influences of various plant extract treatments. The fruits were treated with different plant extracts and wrapped with various wrapping materials. The fruits treated with neem oil (10 percent) proved to be most effective with respect to slower increase in TSS, while slower decrease in ascorbic acid and acidity during storage of 10 days. The storage stability of 12 papaya cultivars and after 4 months they observed that the TSS in pulp decreased during storage with the ripening, the total soluble solids in the peel of papaya increase

Table 4.3 Effect of different concentration of rinds and sugar with flavors for Total soluble solids

Treatments	Total soluble solids % at different days after storage			
	0 day	30 days	60days	90 days
T_1F_0	3.80±.115^{a}	5.50±.115^{a}	5.50±.117^{c}	5.50±.115^{a}
T_1F_1	3.80±.115^{a}	5.50±.115^{a}	6.00±.115^{a}	6.00±.114^{b}
T_1F_2	3.60±.154^{b}	6.00±.115^{b}	5.00±.114^{b}	5.50±.117^{d}
T_1F_3	3.70±.117^{c}	6.00±.115^{b}	5.50±.117^{b}	5.00±.115^{cd}
T_2F_0	2.20±.114^{b}	2.95±.088^{b}	3.00±.117^{c}	3.50±.115^{bc}
T_2F_1	2.03±.117^{c}	3.50±.088^{b}	3.20±.115^{bc}	3.20±.117^{b}
T_2 F_2	1.93±.088^{b}	3.00±.088^{b}	3.03±.115^{b}	3.00±.117^{b}
T_2F_3	2.50±.088^{bd}	3.50±.115^{b}	2.50±.088^{d}	3.17±.081^{b}
T_3 F_0	3.90±.088^{b}	5.50±.114^{b}	5.00±.088^{b}	5.00±.088^{b}
T_3F_1	6.50±.088^{b}	6.50±.114^{b}	7.00±.088^{b}	7.00±.088^{b}
T_3 F_2	4.53±.088^{b}	5.00±.114^{b}	5.00±.088^{c}	5.00±.088^{b}
T_3F_3	4.00±.114^{b}	5.00±.114^{b}	4.00±.088^{d}	5.00±.088^{b}
T_4 F_0	5.80±.114^{b}	7.20±.088^{b}	6.00±.115^{bc}	6.00±.081^{bc}
T_4F_1	4.00±.114^{b}	5.00±.088^{b}	4.50±.114^{b}	4.50±.115^{b}
T_4F_2	5.10±.114^{b}	6.47±.114^{b}	6.50±.117^{d}	6.50±.115^{b}
T_4F_3	5.00±.114^{b}	7.00±.114^{b}	6.50±.117^{d}	6.00±.115^{d}
Level of Significance	*	*	*	*

Means in each column followed by the same letter (s) are significantly different at P≤0.05 according to Duncan‟s Multiple Range Test (T_1F_0=50% rind+50% sugar+no flavor T_1F_1=50% rind+50% sugar+strawberry flavor, T_1F_2=50% rind+50% sugar+pineapple flavor, T_1F_3=50% rind+50% , sugar+vanila flavor, T_2F_0=80% rind+20% sugar+no flavor, T_2F_1=80% rind+20% sugar+strawberry flavor, T_2F_2=80% rind+20% sugar+pineapple flavor, T_2F_3=80% rind+20% sugar+vanila flavor, T_3F_0=60% rind+40% sugar+no flavor, T_3F_1=60% rind+40% sugar+strawberry flavor, T_3F_2=60% rind+40% sugar+pineapple flavor, T_3F_3=60% rind+40% sugar+vanila flavor, T_4F_0=40% rind+60% sugar+no flavor, T_4F_1=40% rind+60% sugar+strawberry flavor, T_4F_2=40% rind+60% sugar+pineapple flavor,T_4F_3=40% rind+60% sugar+vanila flavor).

4.3.3 Titratable acidity

4.3.3.1 Effect of different concentration of rinds and sugar with flavors for Titratable acidity content

The titratable acidity of jam at different treatments varied significantly ($P \leq 0.05$) which was given below (Table 4.4). During storage there was gradually decrease TA value of jam. The change was occurred after 30 to 90 days of storage time. At first the highest TA value (2.60%) was found in T_1F_1 and the lowest value (1.64%) of TA was found in T_3 F_0. After 30 days the TA value was decreased and the highest value (2.56%) of TSS was found in T_1 F_1 and the lowest value (1.44%) of TA was found in T_3F_1 due to decrease of acidity. After 60 days the TA value was decreased and the highest value (2.50%) of TSS was found in T_1 F_1 and the lowest value (1.52%) of TA was found in T_3F_0.The TA value was gradually decreased at 90 days and the highest value (2.48%) of TA was found in T_1F_1 and also the lowest value (1.45%) was found T_3F_0.

It was happened for the lower acidity. Leon and Lima (1968) also observed similar results. The titratable acidity of aloe gel coated table grapes decreased with time but to a lesser extent than that of uncoated fruits during the storage. Dhawan and Gupta (1996) studied the comparison of guava hybrids with commercial cultivars for making jelly.

The acidity of jelly was decreased as the period of storage increased. Though a linear relationship was found but the acidity decreased at higher rate during storage. So it indicated that there was great change during storage and some treated jam was gradually small decrease and some showed higher decrease. Same value was found during storage of time. Among all the combined treatment and flavors T_1 F_1 showed the best value during storage of time. Titratable acidity is also importance for the maintenance of quality so T_1 F_1 indicated the best quality during storage of time for the low decreased of TA.

Table 4.4 Effect of different concentration of rinds and sugar with flavors for Titratable acidity

Treatments ×flavors	Titratable acidity % at different days after storage			
	0 day	30 days	60days	90 days
T_1F_0	2.56±.012^{bc}	2.56±.011^{bc}	2.30±.015^{c}	2.30±.011^{c}
T_1F_1	2.60±.012^{b}	2.56±.014^{bc}	2.50±.013^{d}	2.48±.011^{b}
T_1F_2	2.30±.011^{d}	2.29±.011^{b}	2.23±.013^{d}	2.20±.011^{d}
T_1F_3	2.43±.011^{b}	2.30±.011^{d}	2.30±.013^{c}	2.30±.011^{d}
T_2F_0	2.30±.012^{b}	2.18±.012^{b}	2.30±.014^{c}	2.30±.011^{c}
T_2F_1	2.56±.014^{b}	2.43±.014^{b}	2.30±.014^{d}	2.30±.014^{d}
T_2 F_2	2.43±.011^{b}	2.42±.014^{b}	2.37±.014^{d}	2.35±.011^{b}
T_2F_3	2.43±.014^{d}	2.41±.014^{c}	2.40±.014^{d}	2.39±.011^{b}
T_3 F_0	1.64±.014^{c}	1.56±.014^{c}	1.52±.014^{d}	1.45±.011^{b}
T_3F_1	1.79±.012^{d}	1.44±.014^{c}	2.18±.014^{d}	2.30±.011^{b}
T_3 F_2	1.79±.011^{d}	1.66±.011^{c}	1.66±.014^{b}	1.52±.011^{b}
T_3F_3	1.66±.011^{d}	1.66±.011^{d}	1.59±.011^{c}	1.55±.011^{b}
T_4 F_0	2.18±.012^{b}	1.92±.012^{d}	1.92±.011^{d}	1.75±.012^{d}
T_4F_1	2.30±.011^{d}	2.18±.011^{d}	2.18±.015^{d}	2.15±.015^{d}
T_4F_2	2.30±.011^{c}	2.18±.011^{b}	2.18±.015^{d}	2.13±.011^{d}
T_4F_3	2.30±.012^{c}	2.30±.012 ^{d}	2.18±.015 ^{d}	2.18±.011^{d}
Level of Significance	*	*	*	*

Means in each column followed by the same letter (s) are significantly different at P≤0.05 according to Duncan"s Multiple Range Test (T_1F_0=50% rind+50% sugar+no flavor T_1F_1=50% rind+50% sugar+strawberry flavor, T_1F_2=50% rind+50% sugar+pineapple flavor, T_1F_3=50% rind+50% , sugar+vanila flavor, T_2F_0=80% rind+20% sugar+no flavor, T_2F_1=80% rind+20% sugar+strawberry flavor, T_2F_2=80% rind+20% sugar+pineapple flavor, T_2F_3=80% rind+20% sugar+vanila flavor, T_3F_0=60% rind+40% sugar+no flavor, T_3F_1=60% rind+40% sugar+strawberry flavor, T_3F_2=60% rind+40% sugar+pineapple flavor, T_3F_3=60% rind+40% sugar+vanila flavor, T_4F_0=40% rind+60% sugar+no flavor, T_4F_1=40% rind+60% sugar+strawberry flavor, T_4F_2=40% rind+60% sugar+pineapple flavor,T_4F_3=40% rind+60% sugar+vanila flavor).

4.3.4 Vitamin C

4.3.4.1 Effect of different concentration of rinds and sugar with flavors for Vitamin C content

The vitamin C of jam at different treatments varied significantly ($P \leq 0.05$) which was given below (Table 4.4). During storage there was gradually decrease vitamin C value of jam. The change was occurred after 30 to 90 days of storage time. At first the highest value (0.35mg/100g) of vitamin C was found in T_1F_1 and the lowest value (0.18mg/100g) of vitamin C was found in T_4 F_3. After 30 days the vitamin C value was decreased and the highest value (0.30mg/100g) of vitamin C was found in T_1 F_1 and the lowest value (0.17mg/100g) of vitamin C was found in T_4F_3. After 60 days the vitamin C value was decreased and the highest value (0.27mg/100g) of vitamin C was found in T_1 F_1 and the lowest value (0.16mg/100g) of vitamin C was found in T_4F_3.Vitamin C value was gradually decreased at 90 days and the highest value (0.26mg/100g) of vitamin C was found in T_1F_1 and also the lowest value (0.16mg/100g) of vitamin C was found T_4F_3.

Dhawan and Gupta (1996) found the same results when the comparison of guava hybrids with commercial cultivars for making jelly. The acidity of jelly was decreased as the period of storage. Though a linear relationship was found but the acidity decreased at higher rate during storage. The decreased in acidity might be due to formation of sulphurous acids and free fatty acids. Baramanray *et al.,* (1996) also found the same result that ascorbic acid content of guava jelly decreased remarkably (30.44%) during 90 days of storage period.

However, loss of ascorbic acid content was comparatively lower during first month of storage. So it indicated that there was great change of vitamin C during storage and some treated jam was gradually small decrease and some showed higher decrease. Same value was found during storage of time. Among all the combined treatment with flavors T_1 F_1 showed the best value during storage of time. Vitamin C is also importance for the maintains of quality of jam so T_1 F_1 prepared jam had given the best quality of during storage of time for the low decreased of vitamin C.

Table 4.5 Effect of different concentration of rinds and sugar with flavors for Vitamin C

Treatments	Vitamin C mg/100gat different days after storage			
	0 day	30 days	60days	90 days
T_1F_0	$0.26\pm.005^{c}$	$0.20\pm.005^{bc}$	$0.20\pm.006^{bc}$	$0.20\pm.006^{bc}$
T_1F_1	$0.35\pm.005^{a}$	$0.30\pm.005^{a}$	$0.27\pm.006^{a}$	$0.26\pm.006^{a}$
T_1F_2	$0.27\pm.005^{b}$	$0.25\pm.007^{c}$	$0.24\pm.006^{d}$	$0.22\pm.006^{c}$
T_1F_3	$0.25\pm.006^{e}$	0.25±.006b	$0.24\pm.007^{bd}$	$0.23\pm.007^{d}$
T_2F_0	$0.26\pm.006^{d}$	$0.20\pm.007^{bc}$	$0.20\pm.007^{d}$	$0.20\pm.006^{bc}$
T_2F_1	$0.31\pm.008^{c}$	$0.26\pm.002^{b}$	$0.20\pm.007^{d}$	$0.20\pm.013^{ac}$
T_2F_2	$0.32\pm.008^{b}$	$0.26\pm.006^{bd}$	$0.24\pm.005^{c}$	$0.23\pm.006^{d}$
T_2F_3	$0.32\pm.006^{b}$	$0.26\pm.007^{b}$	$0.25\pm.006^{b}$	$0.22\pm.005^{b}$
T_3F_0	$0.26\pm.005^{abc}$	$0.20\pm.005^{d}$	$0.20\pm.007^{bc}$	$0.20\pm.006^{c}$
T_3F_1	$0.32\pm.006^{cd}$	$0.26\pm.005^{bc}$	$0.24\pm.003^{cd}$	$0.23\pm.006^{b}$
T_3F_2	$0.26\pm.006^{d}$	$0.20\pm.006^{d}$	$0.14\pm.024^{d}$	$0.20\pm.007^{b}$
T_3F_3	$0.26\pm.006^{bc}$	$0.24\pm.006^{d}$	$0.20\pm.006^{cd}$	$0.26\pm.013^{d}$
T_4F_0	$0.20\pm.005^{c}$	$0.20\pm.006^{b}$	$0.20\pm.006^{b}$	$0.20\pm.007^{d}$
T_4F_1	$0.24\pm.013^{b}$	$0.22\pm.024^{d}$	$0.20\pm.010^{cd}$	$0.20\pm.007^{d}$
T_4F_2	$0.24\pm.006^{b}$	$0.22\pm.037^{d}$	$0.20\pm.006^{bc}$	$0.20\pm.007^{cd}$
T_4F_3	$0.18\pm.007^{b}$	$0.17\pm.037^{d}$	$0.17\pm.006^{d}$	$0.16\pm.006^{d}$
Level of Significance	*	*	*	*

Means in each column followed by the same letter (s) are significantly different at $P\leq0.05$ according to Duncan"s Multiple Range Test (T_1F_0=50% rind+50% sugar+no flavor T_1F_1=50% rind+50% sugar+strawberry flavor, T_1F_2=50% rind+50% sugar+pineapple flavor, T_1F_3=50% rind+50% , sugar+vanila flavor, T_2F_0=80% rind+20% sugar+no flavor, T_2F_1=80% rind+20% sugar+strawberry flavor, T_2F_2=80% rind+20% sugar+pineapple flavor, T_2F_3=80% rind+20% sugar+vanila flavor, T_3F_0=60% rind+40% sugar+no flavor, T_3F_1=60% rind+40% sugar+strawberry flavor, T_3F_2=60% rind+40% sugar+pineapple flavor, T_3F_3=60% rind+40% sugar+vanila flavor, T_4F_0=40% rind+60% sugar+no flavor, T_4F_1=40% rind+60% sugar+strawberry flavor, T_4F_2=40% rind+60% sugar+pineapple flavor,T_4F_3=40% rind+60% sugar+vanila flavor).

4.3.5 Sensory Evaluation

The highest hedonic scale of appearance, texture, sweetness, and flavor point was recorded.

Table: 4.6 Mean score for color, appearance, texture, sweetness, and flavor and for jam sample

Treatments	Taste	Flavor	Sweetness	Texture	Appearance
T_1F_0	2.33	2.00	5.00	4.67	4.33
T_1F_1	5.00	4.00	5.00	4.67	4.67
T_1F_2	5.00	5.00	5.00	4.67	4.67
T_1F_3	4.00	4.00	5.00	4.67	4.00
T_2F_0	2.00	2.00	2.00	1.67	2.00
T_2F_1	3.67	4.00	2.00	2.00	2.33
T_2F_2	3.33	3.00	2.00	2.00	2.33
T_2F_3	3.00	4.00	2.00	1.67	2.33
T_3F_0	2.33	2.00	3.00	3.00	3.00
T_3F_1	4.67	4.33	3.00	3.00	3.33
T_3F_2	4.33	5.00	3.00	3.00	3.33
T_3F_3	3.67	4.00	3.00	3.00	3.33
T_4F_0	2.33	2.33	3.67	2.67	4.67
T_4F_1	5.00	4.33	4.00	3.33	4.67
T_4F_2	4.00	5.00	4.00	3.00	4.33
T_4F_3	2.33	2.00	5.00	4.67	4.33

Where, 1=extremely dislike; 2=dislike; 3=medium; 4= like; 5= extremely like

The recorded value was showed in 4.5. The highest hedonic scale of taste, appearance, texture, sweetness, and flavor point was recorded withT_1F_1.The lowest hedonic scale of appearance, texture, sweetness, and flavor point was recorded at T_2F_0. So it indicated that T_1F_1 prepared jam is good among all treated jam.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present research work was conducted to prepare watermelon rind jam to determine the quality of jam at the Postharvest Laboratory Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka during February 2018 to December 2018**.**Sixteen treatments with different flavors of jam were studied. The experiment was laid out in CRD. Sixteen treatments viz.T_1F_0=50% rind+50% sugar+no flavor T_1F_1=50% rind+50% sugar+strawberry flavor, T_1F_2=50% rind+50% sugar+pineapple flavor, T_1F_3=50% rind+50% , sugar+vanila flavor, T_2F_0=80% rind+20% sugar+no flavor, T_2F_1=80% rind+20% sugar+strawberry flavor, T_2F_2=80% rind+20% sugar+pineapple flavor, T_2F_3=80% rind+20% sugar+vanila flavor, T_3F_0=60% rind+40% sugar+no flavor, T_3F_1=60% rind+40% sugar+strawberry flavor, T_3F_2=60% rind+40% sugar+pineapple flavor, T_3F_3=60% rind+40% sugar+vanila flavor, T_4F_0=40% rind+60% sugar+no flavor, T_4F_1=40% rind+60% sugar+strawberry flavor, T_4F_2=40% rind+60% sugar+pineapple flavor,T_4F_3=40% rind+60% sugar+vanila flavorwith three replications. The data were recorded on color, pH, total soluble solids concentration, titratable acidity, Vitamin C.

The red (R) colour was highest with T_1F_1 RGB % (55, 7, 0) and lowest at the T_4F_3RGB %(38, 2, 0). The pH value was significantly high and after 90 days of storage the highest pH value (4.40) was found in T_1F_1 and lowest pH value (3.80) was found in T_4F_0.

After 90 days of storage the highest value (7.00%) of TSS was found in T_3F_1 and the lowest value (3.00%) of TSS was found in T_2F_2.The TA value was gradually decreased at 90 days and the highest value (2.48%) of TA was found in T_1F_1 and also the lowest value (1.45%) was found T_3F_0. Vitamin C value was gradually decreased at 90 days and the highest value (0.26mg/100g) of vitamin C was found in T_1F_1 and also the lowest value (0.16mg/100g) of vitamin C was found T_4F_3.

The highest hedonic scale of taste, appearance, texture, sweetness, and flavor point was recorded with T_1F_1 .The lowest hedonic scale of appearance, texture, sweetness, and flavor point was recorded at T_2F_0. So it indicated that T_1F_1 prepared jam was “Like very much” among all prepared jam.

In conclusion, the present study suggests that, T_1F_1prepared jam is the best quality among all jam. The physical, chemical and sensory qualities are better with T_1F_1 than other treatments with flavors. So the quality of watermelon rind jam may be good up to 90 days by preparing50% rind+50% sugar+strawberry flavor. Therefore, to ensure the best quality of jam further research studies are necessary on fungal and bacterial growth.

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APPENDICES

Appendix I Days average temperature and relative humidity during the storage period from April 2018 to July 2018

Months		Room Temperature		Relative humidity (%)	
		Maximum	Minimum	Maximum	Minimum
01-04- 2018	1	30.5	22.6	100	44
	2	28.5	20.4	100	43
	3	25.9	21.0	100	41
13-04-2018	1	28.5	18.0	100	31
	2	27.0	19.0	100	30
	3	29.5	21.0	100	29
26-04-2018	1	30.5	19.0	100	28
	2	28.6	21.0	100	26
	3	26.5	18.5	100	27
09-05- 2018	1	32.6	22.5	100	58
	2	31.0	19.0	100	47
	3	30.3	18.0	100	44
22-05-2018	1	29.1	15.2	100	36
	2	28.0	12.2	100	38
	3	27.5	11.5	100	35
05-06-2018	1	29.1	13.3	100	32
	2	30.5	11.6	100	34
	3	18.1	10.0	100	29
28-06- 2018	1	29.5	10.5	100	26
	2	28.6	10.1	100	28
	3	30.0	14.4	100	24
11-07- 2018	1	33.0	15.8	100	36
	2	35.5	20.2	100	32
	3	34.7	21.6	100	53
24-07-2018	1	34.5	20.0	100	32
	2	36.8	22.3	100	41
	3	38.9	25.1	98	43

Source: Wet and dry bulb hygrometer, Zeal, G.H. ZEALTA

(Note: 1= Mean values of 1-4 days of a months, 2= Mean values of 4-8 days of a months, 3= Mean values of 8-12 days**)**

Appendix II. Analysis of variance (mean square) of the Physical characteristic (color) at different treatments of jam

Source of Variation	Degrees of freedom	Mean square value of Physical characteristics at different treatments
		colors
Treatment	15	3.348
Error	30	0.725

Pictorial Board

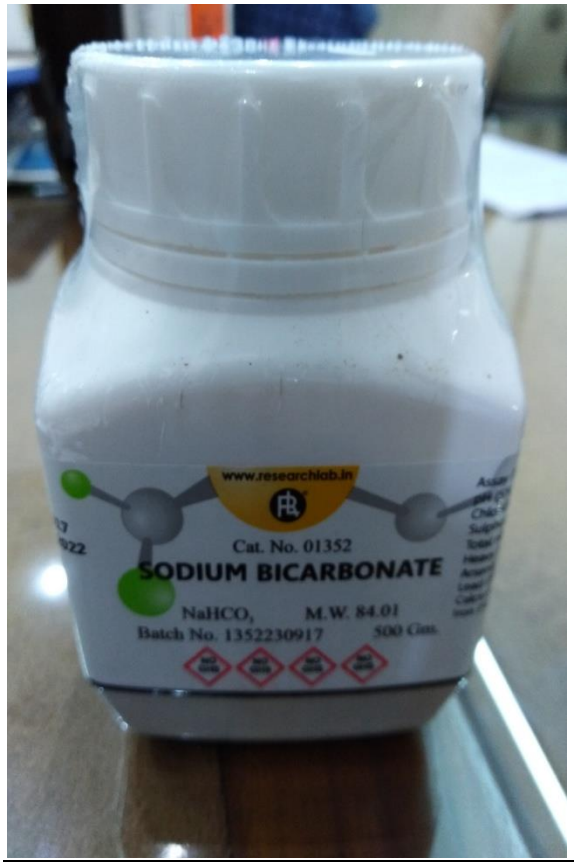
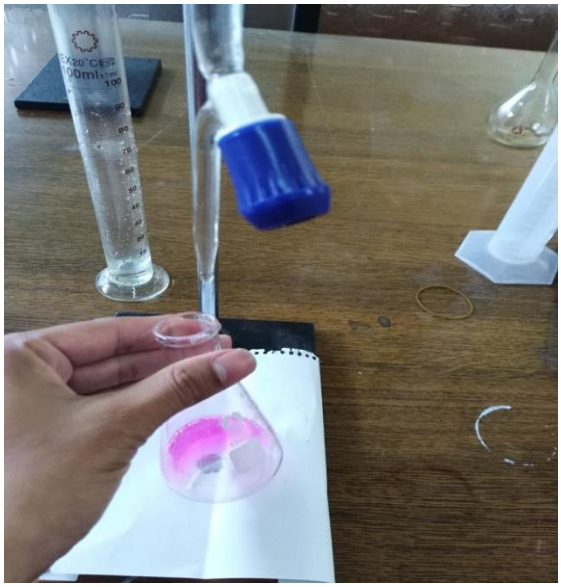


Plate: Different chemicals



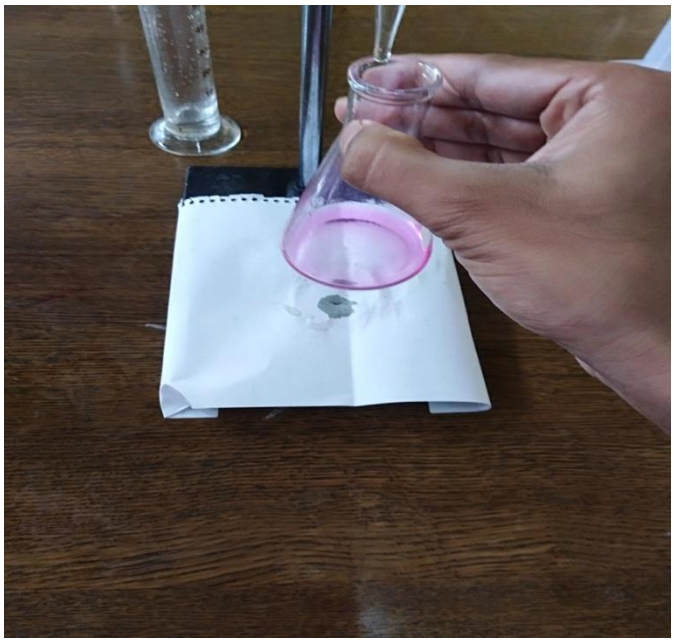


Plate: Determination of vitamin C

Plate: Determination of TSS

Plate: Determination of pH



Plate: Determination of TA

Plate: Prepared sample