CHAPTER -1: INTRODUCTION

1.1 Background

Bangladesh is plentiful with a diverse range of tropical and subtropical fruits that are not only rich in essential nutrients, vitamins, and minerals but also include some delectable seasonal citrus options. Among these, the pineapple (Ananas comosus, Bromeliaceae family) stands out as a remarkable fruit. It enjoys global popularity, despite not being a citrus fruit, primarily because of its exceptional juiciness, vibrant tropical flavor, and a well-balanced blend of sugar and acidity. In Bangladesh, ripe pineapple fruit is savored in its fresh form and serves as a key ingredient in various culinary creations such as jams, jellies, and pickles. Additionally, pineapples contain polyphenolic compounds known for their antioxidant properties.(Hossain et al., 2011).

The pineapple originated from South America was introduced to the world by Spanish and Portuguese explorers. The first commercial cultivation of pineapples took place on the Hawaiian island in the United States. Nowadays, it is cultivated globally and yields approximately 24.8 million tons each year. Pineapples are cultivated in warm and humid climates, with the ideal temperature range for their growth being between 15°C and 32°C. Temperatures exceeding 35°C are detrimental to fruit development, particularly in conditions of low relative humidity (RH). (Bartolome et al., 1995).

Fruits plays an important role human diet. Fruits contain high quality of carbohydrates, minerals, vitamins, dietary fibers, and antioxidants. They are abundant in glucose, fructose, and sucrose. Fats and proteins are very negligible. There are other nutrients which are present in a small amount with many important roles during processing and storage. (Oliveira et al., 2014).

In Bangladesh highest pineapple production seen in Dhaka division like Tangail, Mymensingh, Gazipur, also cultivated abundantly in Chattogram, Bandarban, Khagrachari and Rangamati districts. Bangladesh is generating 434,583 tons of produce from 22,000 hectares of land, yielding at a rate of 21 metric tons per hectare. This makes it the third most significant horticultural product and a swiftly growing sub-sector within the country. The Ministry of Agriculture suggests that adults should ideally consume 250 grams of fruit daily, but currently, the average per capita intake in Bangladesh stands at just 80 grams. (BBS statistics, 2017).

Pineapple is an excellent source of vitamins and minerals that contains a vast amount of vitamins and minerals like potassium, vitamin C and vitamin A, carbohydrates, crude fiber which helps to maintain standard weight and balanced nutrition. Bromelain on the other hand helps in digestion. It can help to reduce osteoarthritis, inflammation and coagulation of blood. Study shows that there is an effect of bromelain and proteolytic enzymes that increase the survival rates of animals with various tumors (Lee et al., 2000).Osmophillic microflora is responsible for the spoilage of pineapple. (Tahiri et al., 2006).

1.2 Significance of the study

This post-harvest loss is highly prominent in pineapple because of its high perishability After picked, Whole pineapple can sit out at room temperature for two or three days where 4-5 days in refrigerator, then this slows the softening. Once it fully ripe, the fruit becomes soggy and its edibility and marketing quality deteriorates rapidly. (Zhang et al., 2013).

Food preservation is critical for sustaining the global food supply through various production and processing technologies. These technologies improve the quality, quantity and public health standards of food products while preserving the environment and fulfilling consumer expectations. (Montinola, 1991).

The pineapple processing industry is now implementing modern methods to maintain the nutritional quality due to greater consumer awareness and a rising demand for pineapple products. This change is being made in order to satisfy consumer desires for wholesome food with superior sensory qualities. These contemporary methods are significantly extending the shelf life of the product, unlike unprocessed pineapples, which are susceptible to quick spoilage due to their susceptibility to microbial contamination, higher respiration rates, and increased ethylene production, resulting in enzymatic browning, texture deterioration, rapid microbial proliferation, weight loss, and the production of unwanted volatile compounds. (Corbo et al., 2009).

Making jelly is an effective way to preserve fruit, and the main reason for this is the high concentration of sugar that aids in preservation. Only strained fruit juice is used in this recipe. Instead of fruit pulp suspended in the gel, extracted juice is used to create the crystal-clear jams known as jellies. (Madhav and Pushpalatha 2006).

By using processing and preservation methods at the farmer level as well as on an industrial scale, losses can be minimized when the fruit is in its prime. Such initiatives will aid in the growth of processing industries in the nation's developing regions. Additionally, this will result in a rise in output and provide the growers of pineapple with a profit. If acceptable techniques for preserving these fruits are created, they might be made available all year round for both farmers and consumers to use. It is wise to do thorough research and development while creating products for household and public consumption because both the producer and the consumer will gain. The study will be helpful to reduce the losses of such delicious and nutritious fruits and best usages of our resources. The aim of this investigation was to determine how to make pineapple jellies in order to find a new market for fruit products. (Barrett DM and Lloyed B, 2012).

1.3 Specific objectives of the study

The above phenomena the present study are designed to fulfill the following objectives:

1. To prepare pineapple jelly.
2. To determine the qualitative values: pH, vitamin C,TSS, acidity, total sugar, reducing sugar, non-reducing sugar, moisture content, ash and Sensory (color, flavor, taste, acceptability)
3. To determine the relationship between qualitative values with storage

CHAPTER -2: REVIEW OF LITERATURE

Pineapple is a wonderful tropical plant of the species Ananas comosus in the bromeliaceae family has long, vibrant flavor, exceptional juiciness, sword like leaves. It is native comes from Central and South America, but has been introduced elsewhere, and now it is cultivated around the world. (Krauss, 2009).

2.1 Food Preservation

Food preservation includes all of the steps to maintain food's desirable properties over a lengthy period of time. The foundation for these preservation methods is a thorough analysis and comprehension of the entire food supply chain, which includes cultivation, harvesting, processing, packaging, and distribution. Consequently, a comprehensive strategy is crucial. Food preservation is the main goal of food processing and the foundation of food science and technology. (Hossain MF and Islam MA, 2017).

2.2 Jelly

Jelly can be defined as a semi-solid elastic food product made by using gelatin or pectin especially a fruit juice with sugar. It has a transparent and crystal clear structure that is produced using filtered fruit juice instead of fruit pulp and eaten as a dessert. (Thakur et al., 1997).

The incorporated pectin content in food is responsible for the formation of jelly. Fruit are cooked with sugar, extracted acids, and pectin’s. When the proper balance of sugar, pH and pectin are achieved then there will be formation of jelly. (Crandall et al., 2016)

2.3 Nutritional composition of pineapple

Pineapples provide a variety of health benefits, including being a valuable source of ascorbic and carotene, as well as being reasonably high in vitamin B1 and vitamin B2. They also include important minerals like iron, phosphorus, calcium, magnesium, and potassium. About 50 calories, or about the same as the number of calories in an apple, are included in a 100-gram portion of pineapple. (Daquinta et al., 1999).

Table: 2.1 Nutritive value of pineapple per 100 gram

Nutrients	Nutrient Value
Energy	50 Kcal
Carbohydrates	13.12 g
Protein	0.54 g
Total Fat	0.12 g
Dietary Fiber	1.40 g
Folates	18 µg
Niacin	0.500 mg
Pyridoxine	0.112 mg
Riboflavin	0.018 mg
Thiamin	0.079 mg
Vitamin C	47.8 mg
Vitamin E	0.02 mg
Vitamin K	0.07 µg
Sodium	1 mg
Potassium	109 mg
Calcium	13 mg
Iron	0.29 mg
Magnesium	12 mg
Phosphorus	8 mg

Source: USDA National Nutrient data base, 2018)

2.4 Agro climatic criteria of pineapple cultivation

Pineapple is a tropical plant that belongs to the category of multiple fruits and is characterized by its herbaceous, perennial nature. Its height ranges from 1 to 1.5 meters and is distinguished by its distinctive features, including 30 or more pointed leaves that are trough-shaped and measure between 30 and 100 centimeters in length. These leaves form a protective ring around a robust stem. As long as the temperature stays within a particular range, this fruit grows well in a variety of places, including inland and coastal settings. The ideal temperature range for successful cultivation falls between 22°C and 32°C. It can be grown at altitudes of up to 1000 meters above sea level, and planting is feasible throughout the year, except during the heavy rainfall months of June and July. For optimal growth, it is advisable to use sandy loam soil with a pH level ranging from 5.0 to 6.0. (Krauss, 2009).

2.5 Ripening stage of pineapple

It is crucial to pick the fruit while it is already ripe for immediate consumption since at room temperature, the fruit's starch won't convert to sugar once it is separated from the plant. Even though the fruit can still ripen after being picked, certain temperature conditions must exist for this to happen. When it comes to ripening, pineapples in particular present a problem because they take a while to mature and can become overripe in a day or two. Pineapples shouldn't be kept in the refrigerator because they are delicate to cold temperatures. Notably, in the last two weeks before the fruit reaches full ripeness, the sugar content of the fruit can alter significantly, rising from 4% to 15%. (Krauss, 2009).

2.6 Storage of pineapple

Pineapple can be stored for between 4-6 weeks at 14-20^{o}Celsius and 80-90 % RH. But chilling injuries occurs at 4.5 degree Celsius or below. There is a possibility that storage life might be prolonged by dipping the fruits in a wax emulsion containing a suitable fungicide. Irradiation also extends the shelf life of half- ripe pineapples by about one week. (Paullet al., 2012).

2.7 World scenario of pineapple production

The ninth-largest fruit crop is pineapple. About 24.8 million tons of pineapples are produced worldwide, with just 12 countries making up 80% of the total. The world's greatest producer of pineapples is Costa Rica, closely followed by Brazil and the Philippines. Additionally, these fruits are grown throughout Asia, Central and South America, and Africa. (Leal et al., 2002).

2.8 Pineapple production in Bangladesh

In Bangladesh, pineapple farming has become more prevalent and has spread to almost all of the country's districts. In terms of cultivated area, Sylhet, Tangail, Dhaka, and Rangamati are in first place. Currently, pineapples are grown on about 33,687 hectares of land, with a total production of about 211,833 tons. (BBS. 2017). Notably, Dhaka and Tangail districts alone account for 49% of the entire pineapple-growing acreage in Bangladesh and 59% of the country's pineapple production. (Hossain MF and Islam MA, 2017).

2.9 Health benefits of pineapple

Bromelain, a proteolytic enzyme found in pineapple, aids in food digestion by disitegrating protein. There is a lot of proof that bromelain has anti-inflammatory properties. The fruit and root are consumed or used topically as a proteolytic and anti-inflammatory agent. (Bender et al., 2005).

Pineapple does not contain saturated fats or cholesterol. Also a good remedy for gastro-intestinal disorders. (Parle et al., 2010). Additionally, pineapple can improve digestion. It is quite helpful in preventing infections of the voice cords. Pineapple juice helps to maintain a healthy heart and kills intestinal worms. The proteolytic enzyme bromelain are responsible for this beneficial activity. (Maurer, 2001).

High fiber content boosts intestinal health and may provide relief from gastritis and other stomach conditions like ulcers, heartburn, and acid reflux. This fruit's wealth of micronutrients helps protect against ailments including cancer, stroke, and heart disease while strengthening the bones of elderly people. With the right dosage, pineapple juice can help the body eliminate unwanted compounds from the body, reduce inflammation and digestive issues, fight intestinal parasites, and improve kidney function. (Ranjan et al., 2018).

Pineapple contains vitamin C, a powerful antioxidant that prevents bacterial and viral infections and aids in the body's absorption of iron. Half of an adult's daily necessary vitamin intake is found in one cup of pineapple juice. It turns out that pineapple contains copper, which helps with iron absorption and controls blood pressure and heart rate. (Devnath et al., 2012).

2.10 Importance uses of pineapple in prospect of industrial demand

Paper made from pineapple fiber is renowned for its thinness, smoothness, and malleability. Additionally, its plant's stems and leaves can be utilized produce white, creamy, silk-like fabric. (Montinola LR, 2011).

2.11 Biological use of pineapple

Ethylene (C_2H_4) is a naturally occurring plant hormone synthesized by various plants, including the pineapple plant. It plays a crucial role in regulating the growth, maturation, ripening, and aging processes in all plants. When exposed to external sources of ethylene, such as ethylene gas, fruits undergo a consistent ripening process. However, at lower temperatures, the effectiveness of ethylene action diminishes. This happens because when fruits, like pineapples, reach their minimum temperature thresholds, they become essentially dormant and do not readily respond to external factors, including the application of ethylene gas. (Burg et al., 2013).

2.12 Effect of heat treatment on pineapple

The rate of reaction is directly linked to temperature within the range of 0 to 45 degrees Celsius. Within this range, the enzyme bromelain exhibits a behavior where its reaction rate doubles for every 10^o Celsius increase in temperature. Nevertheless, the interplay between this beneficial temperature-induced acceleration and the harmful denaturation effect leads to a unique situation. Consequently, it is commonly stated that all enzymes possess an ideal temperature at which their activity is maximized. (Marrero et al., 2006).

The higher the temperature the enzyme experiences and the more prolonged the heating process persists, the larger the fraction of enzyme molecules that become impaired. Elevated temperatures and extended treatment durations can lead to a reduction in the vitamin C content of pineapples. (Padayatty et al., 2003)

2.13 Pineapple Jelly

Fruit juice must first be extracted, filtered, and combined with a certain ratio of acid, pectin, and sucrose before being reduced to the required consistency for jelly manufacture. Starting with fully ripe and imperfectly imperfect raw ingredients, making sure they are free from mold and any physical damage, is essential to producing high-quality jelly. As the mixture cools and goes through a gelatinization process, it turns into jelly. Jelly is primarily a colloidal phenomena that is influenced by variables such the pectin concentration, pectin type, pectin molecule size, hydrogen ion concentration, and sugar content. (Vibhakara et al., 2016)

2.14 Importance of jelly making in prospect of Bangladesh

As pineapple is perishable food with high cost of transportation from production areas to consumer areas. These facts indicate that there is a necessity for development of appropriate technology to cope with these problems. Every year large amount of pineapple damaged for lack of storage and transportation facilities. It is high time to investigate to develop suitable inexpensive method for processing and preservation of pineapple. It seems that pineapple juice and jelly could be stored at normal temperature by using simple ingredients. There is a wide prospect of producing pineapple products such as juice, pulp, jelly, squash, marmalade, ready to serve beverage etc. (Hossain MF, Islam MA, 2017).

2.15 Criteria of final jelly

A perfect jelly is clear, sparkling, transparent, and an attractive color. Final jelly should not be sticky, syrupy, or gummy. It should retain the flavor and aroma of the original fruit the exact concentration of sugar, pectin, and acid must be present to cause the formation of the gel as well as jelly. (Deka et al., 2005).

Final jelly should contain at least 0.5 % - 0.75 % acidity, it should not contain more than 1% acidity, because at larger quantities of acids synthesis is likely to occur. Good acid-sugar ratio improves the sensory quality of jam and jelly. (Srivastava et al., 2006).

2.16 Raw materials for jelly making

Following ingredients are considered as the basic ingredient for jelly making.

a. Fruit juice
b. Sugar
c. Pectin
d. Acid

2.16.1 Criteria of fruit juice

Fruits need to have a high pectin concentration, a low pH, and high total soluble solids content. Green fruit has a low pectin level, making it unsuitable for jellies.(Srivastava et al., 2006)

2.16.2 Role of Sugar in jelly making

Sugar act as a preservative during jelly making. It must be white in color and high in quality. At the concentration of 55 percent by weight, acts as a preservative. Cane sugar or beet sugar is the usual source of sugar can be used to make jelly.The majority of the water is absorbed by sugar. It works as an osmosis catalyst in jelly and a microorganism toxin. (Srivastava et al., 2006).

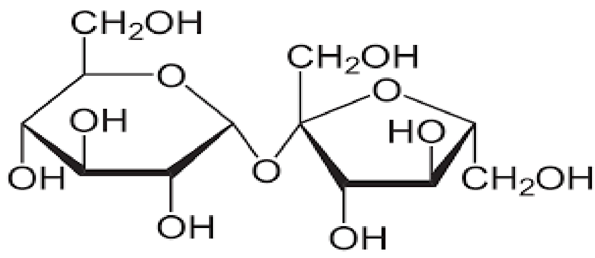

Figure 2.1: Structure of sucrose

(Ikdera et al., 2008) reported that jelly with too little sugar will easily develop mold. The completed product contains 70% sugar and has a smooth consistency. Fruit can be preserved by adding sugar. In this case, the fruit's density maintained higher than the sugar syrup's. In accordance with the osmosis principle, water moved out of the fruit and sugar moved in until the syrup and fruit juice reached equilibrium. The fruit's cells were ruptured and the fruit turned rough and shrunk as a result of the steady addition of sugar when the syrup grew too thick and the water flow from the fruit was rapid. Also stated that the molecules of pectin and the gel, sucrose assists in the formation of hydrogen bonds. Upto a certain extent, adding more sugar quickens the jelly's setting and enhances the gel strength mostly due to increased dehydration.

2.16.3 Pectin in fruits

(Thakur et al., 2007). defined that the pectin molecule is made up of a polymer of galacturonic acid units connected by carbons 1 and 4 to form a structure resembling a chain. Methoxyl groups or the equivalent acid make up the side chains. The pectin molecule has a non-reducing group at one end and a reducing group at the other end. . Pectin quality was better in rainy-season fruits. More jelly is produced from the half ripe fruit than the unripe fruit.

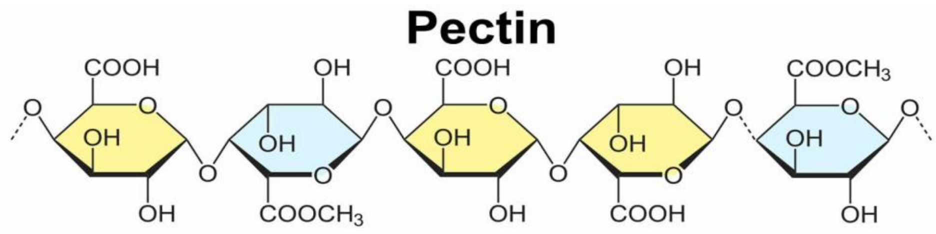

Figure: 2.2 Structure of pectin

There are three types of pectin’s

a. Slow set pectin.
b. Medium set pectin.
c. Rapid set pectin.

70 parts of hot water, 20 parts of sugar and 10 parts of pectin is the most satisfactory procedure for dissolving pectin. The sugar and pectin should be mixed in dry form, and then hot water to be added gradually with continuous mixing until the pectin is dissolved completely. (Saeed et al., 2010)

2.16.3.1 Role of pectin in pineapple jelly making

Pectin forms a colloidal solution in water and derives from protopectin in the process of ripening of the fruit. Pectin also helps reducing the boiling time, which in turn assist in preserving the volatile substances and prevent the excessive inversion of sugar. Also reported that 1.00% of pectin in jelly is necessary to form the gel and to obtain a suitable texture. He also suggested that use of commercial pectin's and food acids in jellies no longer requires fruit at the peak of maturity to obtain a gel formation, but they are necessary for the best flavor and color. (Baker, 2010)

2.16.3.2 Factor affecting pectin required for jelly making

a. The contents of the soluble solids in the end product.
b. Type of pectin used.
c. The nature of the recipe.

2.20.3.3 Pectin and Gel Formation

(Marudova et al., 2009) reported that Fruits and their extracts have the ability to make jelly because of a compound called pectin. Jelly is formed when a suitable concentration of pectin- sugar – acid in water is reached. Plant tissues contain water soluble pectin, insoluble pectic acid, protopectin, and a compound containing some pectic substance and cellulose.

During further ripening, pectin may be decomposed to form methyl alcohol and insoluble pectic acid. Protopectin is the binding agent between growing cells, the conversion to pectin results in a softening of the green fruit as it matures, corresponding to the change from protopectin to pectin. In the presence of sugar and acid, protopectin is unable to form gel. (Duckworth, 2007).

2.16.3.4 Criteria of gel Formation in jelly

In an acid fruit substrate, pectin is negatively charged colloid. The addition of sugar modifies the pectin-water equilibrium created and causes the pectin to become unstable. It conglomerates and establishes a network of fibers. This structure is able to support liquids. The continuity of the network formed by the pectin and the denseness of the formed fibers are established by the concentration of pectin.The higher the concentration, the more dense the fibers in the structure. The rigidity of the network is influenced by the sugar concentration and acidity. The higher the concentration of sugar, the less water supported by the acidity of the substrate. 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. There is a narrow range of pH that influences the formation of gel. The ideal pH range for gel formation is approximately 3.2. When the pH falls below 3.2 to around 3.4, the gel's strength gradually reduced. Beyond a pH of 3.4, gel formation is not achievable within the typical range of soluble solids. Too high concentration of solids results in a gel with sticky characteristics. Gelatinization takes place during the cooling process. (Ikdera et al., 2008).

Jelly production is a colloidal process that is influenced by a number of variables, including pectin quantity, constituent type, molecular size, acidity level (hydrogen-ion concentration), and sugar content. Syneresis also occurs which means released liquids from the gel. This is commonly also called weeping of jelly. (Vibhakara et al., 2006).

2.16.4 Function of acid in jelly making

Jam manufacture uses citric acid which is the most popular and is added when the mixture reaches 64% total soluble solids. According to (Saeed et al., 2010)

a. Reduce the PH to the value recommended to jelly formation.
b. Increase the total acidity in order to enhance the flavor and taste.
c. Preservative effect.

(Oliveria et al., 2014) investigated how much pectin preparation was utilized in conjunction with pH extraction. According to their investigation, the degree of etherification polymerization and gelatin capacity consistently decreased as the acidity of the extraction rose. However, in terms of gelatin capacity yield, no particular pattern was seen. It was also discovered that the concentration of hydrogen ions, not general acidity, is the main factor determining the production of high methoxyl pectin gel. Jelly strength was observed to increase with increasing hydrogen ion concentration, especially up to a level of 3.0.

(Ikdera et al., 2008) has shown that jelly will be firmer if the juice has a higher concentration of hydrogen ions, as long as the gel doesn't solidify too quickly. The presence of hydrogen ions reduces the stability of the pectin solution by lowering its ability to hold water. If the pH is very high, the pectin undergoes demethylation, and if the pH is excessively low, the pectin breaks down.

(Deka et al., 2015) reported that Fruit's organic acids have an effect on the jam and jelly's color, flavor, and keeping power. Jam and jelly have better sensory quality when the acid/sugar ratio is good. He observed that a pH of 3.5 is required for jelly to form. As the pH is decreased, jelly firmness also grows up to a certain point. Lower pH juices resulted in a reduction in the amount of pectin used.

2.16.5 Role of Preservatives in jelly making

(Ikdera et al., 2008) reported that insufficient sugar content in jelly makes it susceptible to mold growth. Benzoic or propionic acid is frequently used in food preservation as a chemical that inhibit fungus development. On the other hand, it has been proven that sorbic acid is an excellent and safe fungistatic agent for food products. Information on the safety and behavior of sorbic acid in food products has been provided by a number of researches.

(Salunkhe, 2016) stated that certain fungicides, in particular benzoic and proprionic acid, give foods an unfavorable flavor, especially acidic foods. However, this fungicide has no negative effects on the flavor of the foods that contain sorbic acid.

2.17 Theories of gelation

(Ikdera et al., 2008) has briefly outlined several theories of gelation as follows-

Pectin sol stability relies on hydration and the negative charge carried by pectin particles. Altering the solution's alkalinity or acidity reduces stability, with the highest stability observed at a neutral pH. Sugar plays the role of a precipitating agent, and the more acidic the solution, the less sugar is needed. According to Olsen's gelation theory, pectin is a negatively charged hydrophilic colloid, and sugar acts as a dehydrating agent.

The concentration of hydrogen ions decreases the negative charge on pectin, allowing it to precipitate and form an interconnected network of insoluble fibers, given sufficient sugar concentration. The hydration of pectin micelles by sugar doesn't happen instantaneously but requires time to reach equilibrium, and the maximum strength of the jelly is achieved at this equilibrium point. Any ingredient added to a pectin jelly system that alters the final jelly strength of that system works by altering the pace at which gelatin is added, by modifying the final structure of the jelly, or by a combination of both.

2. 18 Selection of Fruits for jelly making

According to (Vidhya et al., 2011) fruits ideally suited to jam making having three factors in common-

a. High pectin content,
b. Relatively low PH
c. High total soluble solids.

It's important to keep in mind that protopectin, which is present in green fruit, continuously transforms into pectin as fruit ripens and, eventually, into pectic acid in overripe fruit. Due to the fruit's low pectin content when it is very green, jellies cannot be made with it. When jelly is heated, some of the protopectin in very green fruit turns to pectin, but not enough to produce enough pectin for optimum gel formation. Natural enzymes accelerate the conversion of protopectin into pectin as the fruit ripens, increasing the pectin content while lowering the protopectin level. This causes the pectin to progressively change into pectic acid as the fruit matures, which reduces the fruit's capacity to gel. Since pectin concentration and propectin and peptic acid levels are lowest when fruit is fairly ripe, that is the ideal time to use it for jam-making. But even when a fruit's pectin level is at its highest, some kinds lack enough pectin to produce jam successfully. Fruits including strawberries, raspberries, peaches, and apricots are examples of low-pectin foods. Bananas and fully ripe, delicious apples are two examples of fruits that are less ideal for jam-making because of their low acidity by nature. Berries, citrus fruits, and grapes, on the other hand, contain the ideal level of acidity for jelly-making.

It's also important to select fruits with enough acid and pectin while choosing fruits. You may simply increase the acidity of a fruit if it is deficient by adding lemon juice or similar acid. To enhance the pectin content in the fruit, commercially prepared pectins made from apple skins, apple cores, or the white core of citrus fruit peels (albedo) are easily accessible in liquid or powdered forms. While liquid pectin is convenient and has a longer shelf life than powdered pectin, it should be utilized quickly once it has been opened to avoid pectin breakdown. (Vidhya et al., 2011)

(Duckworth, 2007) reported that at the peak of ripeness, when the amount of undegraded yet soluble pectic components is present, fresh fruit should be used for jam manufacturing. Fresh fruit is only readily available for a very short period of time, and the majority of the fruits used to make jam are stored either as pulp treated with sodium or potassium metabisulphite since it is crucial that the product should set to a fairly solid gel.

2.19 Factors Affecting Production control of Jelly

(Ikdera et al., 2008) established following factors applicable to form good quality jelly-

a. Total soluble solids content (T.S.S)
b. The Sucrose -invert sugar ratio.
c. Acidity and pH value.
d. Sugar /acid ratio.

2.19.1 Total Soluble solids content of jelly

Minimum 66 % total soluble solids and a minimum 45% fruit are required to prepare jelly. TSS below 66% will have a very poor setting and be susceptible to microbial deterioration by yeast and molds because of high water activity. (Deka et al. 2005).

2.19.2 Sucrose - invert sugar balance of the jelly

The sucrose-invert sugar ratio is very important in jam manufacture otherwise crystallization will occur during storage. Jam with total soluble solids of 67-70 % should have 20-28 % reducing are factors affecting the inversion of sugar are greatly affected by the pH of the jam, boiling temperature, and time. (Rickman et al., 2017).

2.19.3 pH of jelly

pH is an important parameter for 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. (Palve et al., 2013).

2. 19.4 Sugar /acid ratio

When creating jelly, it's critical to maintain an ideal balance between the sucrose and invert sugar concentrations. A sucrose solution that has been boiled with acid goes through a process called hydrolysis, which produces reducing sugars like dextrose and levulose. Through this procedure, sucrose is changed into inverted sugar. The rate of this conversion is influenced by variables such solution pH, heating time, and temperature. It's crucial that the ratio of invert sugar to sucrose be kept within limits.

It can be tough to consistently attain the required ratio of invert sugar to sucrose since fruit acidity and boiling conditions can vary. (Deka et al., 2015).

2.20 Changes during storage of pineapple jelly

(Uckiah et al., 2009) experiment on pineapple processed products like juice, jelly and sorbet. The jam was kept for two months at 22-25 ℃. The peeled fruit typically contains an average of 24.8 mg of Ascorbic acid. The process of turning pineapples into jelly was found to result in the most significant loss of ascorbic acid, with a decrease of 46.8 percent.

(Millanes et al., 2005) The weight of the fruit, the amount of non-reducing sugar, the amount of acidity, the weight of the pulp and the weight of the core of different species of pineapples are the main determinants of the qualities of the jelly, such as color, flavor, and general likeability. After 90 days of storage, pectin has the most noticeable effect on the product's color. After 30 days, taste is most affected, and after 60 and 90 days, overall likeability is impaired. As the time spent in storage increases, the jelly's sensory quality degrades.

(Torralba et al., 2014) experiment on microbiological analysis on pineapple jelly and showed that the processed products were still acceptable and edible even after 3 months of storage at room temperature.

CHAPTER-3: MATERIALS AND METHODS

3.1 Site and period of the study

The experiment was carried out in the lab of the Department of Applied Food Science and Nutrition, Applied Chemistry and Chemical Technology, and Food Processing and Engineering at the Chittagong Veterinary and Animal Sciences University, Chittagong. The investigation was carried out from January 1 to June 30, 2018, across a six-month period.

3.2 Collection of sample

Pineapples that were recently been purchased from Chittagong's local market. Because the pectin content of pineapples relies on age, they were carefully selected to attain the best ripeness. The laboratory stocks were used to obtain the necessary supplies for the experiment, including sugar, citric acid and pertinent components.

3.2 Method of Preparation

3.2.1 Extraction of pineapple juice

Deionized water was used to wash the fruit sample in order to remove any foreign objects that might interfere with the measurement of the nutrients. The seeds were gently peeled, divided into four halves, and the center fibrous piece was removed using a sharp stainless steel knife. The soft flesh of the pineapple was then used after being chopped into little pieces. Then, pineapple and water were cooked. Then 1.5 liters of water and 1 kg of pineapple slices were cooked. Citric acid (2 g per kg of fruit) was added during the boiling process. The boiled pieces were crushed and strained through a thick fabric/muslin cloth to remove the suspended matter, which was made up of fruit tissue, seed, skin, gums, and protein in colloidal form. This was done in order to separate the juice from the pulp. The jelly were prepared as per method described by (Leal et al., 1986)

3.2.2 Ingredient for pineapple Jelly

According to (Srivastava et al., 2006) following amount of ingredients need to prepare pineapple jelly-

Ingredient	Amount
Pineapple juice	1 Kg
Sugar	600 g
Pectin powder	5 g
Citric acid	5 g / Kg of juice

3.2.3 Preparation of pineapple jelly

After collecting fruit juice Add 5 g of pectin, 200 g of sugar, and 5 g of citric acid. The boiling solution was then gradually added to the mixture while being constantly stirred. In most cases, 0.5 to 0.1 percent of high-quality pectin was enough to make decent jelly. The remaining sugar was then added. When the mixture started to get thick, stir it thoroughly. The solution was then brought back to a boil until it reached the end point, which is indicated by a Total Soluble Solids (TSS) value between 65 and 70 °Brix as measured by the sheet test method. The jelly was put into glass jars that had already been sterilized before cooling, and it was kept at room temperature.

This jelly ingredient is crucial since it gives the jelly its sweetness and substance. If the concentration of sugar is high, the jelly holds less water resulting in a stiff jelly, probably because of crystallization. (Srivastava et al., 2006).

3.2.4 Flow chart for preparation of standard pineapple jelly

Pineapple fruit juice (firm not over ripe)

↓

Washing of fruits

↓

Cutting into thin slices and extraction of juice

↓

Boiling with water

(1.5 times the weight of fruit juice for 20-30 minutes)

↓

Addition of citric acid during boiling (2 g per kg of fruit)

↓

Straining of extract

↓

Pectin test (For addition of sugar)

↓

Addition of sugar and pectin

↓

Judging of end point 65% TSS

↓

Removal of scum or foam

↓

Add color (if required) and add remaining citric acid

↓

Filling into clean sterilized glass bottles

↓

Waxing (paraffin wax)

↓

Capping and storage at ambient temperature

3.3 Physicochemical Analysis of Pineapple jelly

Jelly were analyzed for moisture, ash, vitamin-C (ascorbic acid), total soluble solid, pH, titratable acidity, reducing sugar, non- reducing sugar and total sugar content as per the methods of (Saeed et al., 2010).

3.3.1 Determination of pH

A digital pH meter (Model: LMPH-10) was used to measure pH value.

3.3.2 Total Soluble Solids

The fruit's total soluble content was determined using a handheld refractometer. The total soluble solids (TSS) were measured directly using a digital refractometer (specifically, the Atago RX 1000), and the findings were expressed as a percentage of soluble solids (Brix) following the procedure outlined in AOAC guidelines.

3.4.3 Determination of Titratable Acidity

The titratable (or total) acidity of the samples was assessed following the established AOAC method from 2003. The acidity percentage was quantified in terms of anhydrous citric acid by titration against N/10 NaOH while utilizing phenolphthalein as an indicator. To do this, 10ml of juice was consistently measured and placed into a 100ml volumetric flask. Distilled water was then added to reach a total volume of 100ml. Subsequently, 10ml of the diluted juice was titrated against N/10 NaOH, with phenolphthalein serving as the indicator. The appearance of a pink color signified the endpoint of the titration process. This titration was performed three times, and the average value was recorded to determine the titratable acidity, which can be determined as follows:

Calculation:

Titratable acidity (%) $= \frac{n \times v}{V} \times 100$

N (%) = Acidity Percentage;

n = Normality of NaOH;

v (ml) = Quantity of 0.1 N NaOH needed for acid titration;

V (ml) = Quantity of flour dispersion.

3.3.4 Determination of Ascorbic acid

The method for ascorbic acid determination followed the (AOAC, 1990) guidelines. Vitamin C was quantified in plant extracts based on its capacity to reduce the dye 2,6-dichlorophenol indophenols. In this process, Vitamin C underwent oxidation by the colored dye, resulting in the formation of dehydroascorbic acid. Concurrently, the dye was reduced to a colorless compound, allowing for the straightforward identification of the reaction endpoint.

It was crucial to perform a swift extraction and filtration to prevent excessive introduction of oxidizing agents into the plant product, which could partially degrade Vitamin C during sampling and grinding. To counter oxidation, metaphosphoric acid was employed during the extraction process. The titration had to be completed within one minute. The dye displayed a blue hue in aqueous solutions, turned pink in acidic solutions, and became colorless upon complete reduction.

Reagent

- 260 mg of dye (2, 6-dichlorophenol indophenols)
- 210 mg of $NaHCO_3$dissolved in 100 ml of distilled water.
- Metaphosphoric acid solution. (3%)
- 15/7.5mg of Metaphosphoric acid.
- 40/20ml of glacial acetic acid dilutes to make 500/250 ml with distilled water.
- Standard ascorbic acidsolution
- 50/25 mg of crystalline ascorbic acid dissolved in 500ml/250ml of metaphosphoric acid solution.

Procedure

1. Dye solution was taken in the burette up to 0marks.
2. Then 5 ml Vitamin C solution was taken in a conicalflask.
3. The conical flask was placed under the burette and the dye was added drop wise.
4. Titration was completed when pink color was appeared and stayed for 20 seconds and thendisappeared.
5. The reading was taken at least 3 times.

6. The same procedure was performed for ascorbic acid solution of unknown concentration.
7. The result was expressed as milligram percentage (mg %)

3.3.5 Total Sugars

The sugar content in a food sample is assessed by measuring the volume of an unknown sugar solution needed to completely reduce a specified volume of Fehling's solution. The sugar content was determined following the A.O.A.C (1970) Official Lane-Eyon Titrimetric method.

For the determination of monosaccharides and oligosaccharides, a method based on their reducing properties was employed. Many of these substances act as reducing agents and can react with other components to form precipitates or colored complexes, which were then quantified. The acidity was measured in accordance with the AOAC method from 1995 and expressed as the concentration of citric acid in grams per liter (g/L).

Reagents

a. Fehling's SolutionA,
b. Fehling's SolutionB,
c. Dextrose anhydrous GR,
d. Methylene Blue Indicator Solution

Standardization of Fehling's Solution:

3 grams of a primary standard dextrose, which had been pre-dried under vacuum conditions at 100°C for two hours, were placed into a 500 ml volumetric flask. The dextrose was then dissolved and further diluted with water to reach the desired volume mark. Next, in a 250 ml conical flask containing a few glass beads, 5 ml of both Fehling's Solution A and B were combined. This solution was subsequently titrated using the standard dextrose solution.

Method

Approximately 4-5 ml of the juice sample was placed into a 200 ml volumetric flask. Water was then added to bring the volume up to 200 ml. The sample was filtered using Whatman filter paper no. 1, and the residue on the filter was rinsed three times to collect all the sample components. The resulting filtrate was transferred into another 200 ml volumetric flask and adjusted to the 200 ml mark, creating what we'll call a "stock sample solution."

In a 250 ml conical flask, 5 ml each of Fehling's Solution A and Fehling's Solution B were combined. The contents of the conical flask were boiled for two minutes, and 1 ml of methylene blue solution was added without interruption. While the solution continued to boil, the stock sample solution was gradually added from a burette until the blue color of the indicator disappeared, turning into a brick-red hue. The titration process was completed within the final one-minute period, ensuring that the contents of the flask boiled uninterrupted for a total of three minutes. (United State Pharmacopeia Volume 2, 2012)

Calculations:

$$\% \text{ Reducing Sugar} = \frac{F \times 200 \times 100}{V1 \times W}$$

Where,

F = Factor for 5 ml. of Fehling’s Solution

V1 = Volume of sample solution consumed

W = Weight in gm. of the sample

3.3.6 Reducing Sugar

Standard method of titration

Take 10 ml of the mixed Fehling's solution and distribute it evenly into two 250-milliliter conical flasks. Load the 50-milliliter burette with the titration solution. Slowly introduce most of the sugar solution into the flask for the purpose of reducing the Fehling's solution, leaving about 0.5 to 1.0 milliliter for the final titration phase. Thoroughly mix the contents of the flask, heat them until they come to a boil, and maintain gentle boiling for 2 minutes. Afterward, add 3 drops of methylene blue solution with caution, ensuring it doesn't touch the sides of the flask.

Conduct the titration within 1 minute by adding 2 to 3 drops of sugar solution every 5 to 10 seconds until the indicator completely loses its color. At the endpoint, the boiling liquid will revert to the brick-red color characteristic of cuprous oxide precipitate, resembling its appearance prior to adding the indicator. Make note of the volume of solution used during the titration.

3.3.7 Total sugars

Use a pipette to draw 50 ml of the clear solution and place it in a 250-ml conical flask. Add 5 g of citric acid along with 50 ml of water. Gently boil the mixture for 10 minutes to ensure complete inversion of sucrose and then let it cool. Transfer this mixture to a 250-ml volumetric flask and neutralize it with 1 N NaOH while employing phenolphthalein as an indicator. Adjust the volume to the desired level.

For inversion at room temperature, transfer a 50 ml portion of the clarified and lead-free solution to a 250-ml flask. Add 10 ml of HCI (1+1) and allow it to stand at room temperature (20°C or higher) for 24 hours. Afterward, neutralize it using concentrated NaOH solution and adjust the volume as needed. Take an aliquot and determine the total sugars as invert sugars.

Calculation

a = % Reducing sugars = $\frac{\text{mg of invert sugar} \times \text{dilution} \times 100}{\text{Titre} \times \text{weight of sample} \times 100}$

b = % Total Sugar as = Calculate as in (a) making use of the titre value

Obtained in the determination of total sugars after inversion

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

d = % Reducing sugars + % Sucrose

% Reducing sugars = $\frac{\text{factor} \times \text{dilution} \times 100}{\text{Titre} \times \text{weight of the sample}}$

3.3.8 Estimation of moisture

The moisture content was assessed following the AOAC method from 2005.

Moisture is naturally found in food products. To determine its amount, the food sample is subjected to a straightforward process: it is heated in an oven at a temperature of 104-105°C for 3-4 hours. After heating, the sample is allowed to cool in a desiccator to absorb any remaining moisture.

This heating and cooling process is repeated multiple times until the sample reaches a consistent weight, indicating that all the moisture has been removed.

Calculation:

Calculate the moisture percentage as follows

$$\%\text{ Moisture } = \frac{\text{w} - \text{w1}}{\text{w}} \times 100$$

Where,

w= Weight of fresh sample

w_1= Weight of dried sample

3.3.9 Ash

AOAC method 14.006 (2005) was used to determine the total ash content.

Procedure

A 5-gram sample was carefully measured and placed into a clean and dry porcelain ashing dish. It was heated until no more white smoke was produced. Subsequently, the sample was ignited using a gas burner until white smoking ceased. Following this, the sample was introduced into a muffle furnace set at 550°C and subjected to heat until it turned into a light gray ash, signifying a constant weight. After cooling the sample in desiccators, its weight was recorded. The ash content was then determined using the following calculation.

$$\%\text{ Ash } = \frac{\text{W} - \text{W1}}{\text{W2}} \times 100$$

Where,

W= Weight of crucible with ash

W1= Weight of crucible

W2 = Weight of sample

3.5 Sensory evaluation

Nine points Hedonic rating test method as recommended by (Joshi, 2006) was used for the purpose of sensory evaluation. This assessment gauges the level of consumer satisfaction. To evaluate the consumer acceptability of the newly developed products, a testing panel was assembled. The panelists were individuals without formal training and were selected from the student body, faculty, and staff of the Department of Applied Chemistry and Chemical technology in Chattogram Veterinary and Animal Sciences University, Chattogram. There were a total of 15 panelists who were instructed to assign appropriate scores to each tested product using a hedonic scale ranging from 1 to 9. They evaluated the products based on characteristics such as color, flavor, texture, and overall acceptability of the jelly samples.

The scale was structured as follows: 9 = Liked extremely 8 = Liked very much 7 = Liked moderately 6 = Liked slightly 5 = Neither liked nor disliked 4 = Disliked slightly 3 = Disliked moderately 2 = Disliked very much 1 = Disliked extremely

3.6 Storage studies of pineapple jelly

The prepared pineapple jellies were bottled and stored at room temperature (29-33°C), R.H. 80-85%. The glass jar was opened at every 30 days' interval to determine its TSS, pH, TSS, Vitamin- C, acidity and moisture, ash content up to 3 months.

4.1 Proximate Analysis of pineapple jelly

Physicochemical analysis of pineapple samples was performed in the laboratory.

Parameter	**1 Day**		**30 Days**		**60 Days**		**90 Days**	
	3.75		3.71		3.65		3.59	
pH	3.70	3.64	3.65	3.59	3.59	3.53	3.54	3.47
	3.48		3.42		3.35		3.29	
TSS (º B)	68.47		68.52		68.57		68.67	
	68.56	68.50	68.61	68.55	68.61	68.59	68.70	68.68
	68.47		68.52		68.58		68.66	
	.602		.609		.617		.624	
Titratable acidity %	.601	.603	.612	.610	.619	.618	.626	.625
	.605		.610		.618		.627	
Ascorbic acid mg/ (100 g)	22.68		21.30		20.02		19.82	
	22.85	22.80	21.43	21.42	20.14	20.12	19.59	19.75
	22.81		21.48		20.18		19.54	
Reducing sugar %	34.64		35.34		35.79		36.24	
	34.79	34.72	35.49	35.44	35.96	35.90	36.43	36.36
	34.72		35.48		35.94		36.41	
Non reducing sugar %	17.43		17.01		16.86		16.70	
	17.32	17.40	17.05	17.02	16.81	16.82	16.66	16.67
	17.45		17.03		16.79		16.67	
	52.14		52.62		52.88		53.13	
Total sugar%	52.08	52.09	52.55	52.54	52.80	52.79	53.05	53.03
	52.04		52.46		52.70		52.97	
	28.62		28.65		28.99		29.76	
Moisture content %	27.21	27.31	28.25	27.79	27.53	28.60	28.31	28.98
	26.12		26.14		27.45		28.21	
	.28		.26		.24		.22	
Ash content	.26	.26	.25	.25	.23	.23	.24	.22
	.24		.23		.22		.21	

Table 4.1: Physiochemical components of pineapple during storage

CHAPTER- 4: RESULTS

Table: 4.2 Statistical analysis of physiochemical constituent of pineapple jelly during storage.

Parameter	A	B	C	D	P-value	Post Hok (1- Anova)
pH	3.64	3.59	3.53	3.47	.582	No significance
TSS (º B)	68.35	68.40	68.43	68.52	.892	No significance
Titratable Acidity (%)	.602	.610	.618	.625	P=.000	All areSignificance
Ascorbic Acid (mg/100g)	22.80	21.42	20.12	19.75	P=.000	All are Significance
Reducing Sugar (%)	34.72	35.40	35.90	36.36	P=.000	No significance
Non Reducing Sugar (%)	17.40	17.02	16.82	16.67	P= .000	No significance
Total Sugar (%)	52.09	52.54	52.89	53.06	P= .000	All are significance. Expect (C vs. D) are not significance (P=.1)
Moisture Content (%)	27.32	27.79	28.60	28.98	.472	All are Positively Significant
Ash content	.26	.25	.23	.22	.340	No significance

Where, A= 1 Day, B=30 Days, C=60 Days, D= 90 Days
*= Level of significance

4.1 Physiochemical analysis of pineapple jelly

The prepared pineapple jelly was analyzed at monthly interval on different chemical parameters were subjected to statistical analysis are tabulated in (Table 4.1 and Table 4.2). The jelly was stored in ambient condition and analyzed for pH, moisture, TSS, acidity, reducing sugars, total sugars, ascorbic acid ash and moisture content at 0, 30, 60 and 90 days interval during study.

4.1.1 pH

The pH content of Pineapple jelly decreased gradually with the increase of storage days at room temperature (25-33^{0}C). However, the difference of pH was not statistically significant (P>0.01). Highest pH values of pineapple jelly were recorded as 3.64 at firstday of preparation and lowest pH value was observed 3.47 at 90 days (Table: 4.2)

4.1.2 Total soluble solid

The TSS of jelly increased slightly during storage period. TSS in jelly not increasing not significantly. TSS (°B) was found maximum as 68.52 at 90 days of storage.

4.1.3 Titratable acidity

Acidity of jelly increased gradually with the increase of storage time. There was inversely proportional situation found in this analysis between acidity and pH value. From the statistical analysis found that acidity increasing significantly during storage.

4.1.4 Ascorbic acid

The ascorbic acid (22.80 mg/100g) content of pineapple jelly found highest at first day of preparation. All values of ascorbic acid were decreased significantly. Ascorbic acid content minimum found (19.75mg/100g) at 90 days (Table.4.2).

4.1.5 Reducing sugar

The variation was observed in reducing sugar at storage conditions. The data indicates that the reducing sugar was increased from 34.72 per cent to 36.36 per cent at ambient temperature within storage period of 90 days. From the statistical study no significant difference was found in case of reducing sugar (Table.4.2).

4.1.6 Non reducing sugar

The variation was observed in non-reducing sugar at storage conditions. No significant difference was observed in statistical study. Non reducing sugar decreased from to 16.67 percent during initial to 90 days' storage. Contrary to reducing and non-reducing sugar (Table.4.2) the non-reducing sugar of jelly decreased continuously throughout the entire period of storage (Table.4.2).

4.1.7 Total sugar

Total sugar of the jelly was increased from 52.09 to 53.06 per cent throughout the entire period of storage in present investigation. All value found significant in statistical analysis. As (P=.1) found during 60 to 90 days, which indicates there found was no difference between 60 to 90 days of preservation (Table: 4.2).

4.1.8 Moisture content

The data indicates that the moisture was increased from 27.32 per cent to 28.98 per cent within storage period of 90 days at ambient temperature. Statistical analysis also pointed out that all values of moisture content were increased significantly (Table.4.2).

4.1.9 Ash content

In present findings indicates that during storage intervals, there was no significant variation in ash content of jelly at storage condition. Maximum ash content was found.26 % at day one and minimum found on .22 % at day 90 (Table.4.2)

4.3 Sensory quality evaluation of pineapple jelly

The pineapple jellies were stored in airtight bottles at room temperature (25-30°C). At one-month intervals during the storage period, the jellies were subjected to evaluation by a panel of 15 testers in terms of their acceptability and any organoleptic signs of spoilage. The responses and comments provided by the panelists regarding the jelly were recorded systematically using a hedonic rating test. These data were then statistically analyzed to assess the variance in sensory perceptions over the storage duration.

To examine the overall mean differences in sensory parameters based on the scores given by the panelists, a one-way ANOVA (Analysis of Variance) test was conducted. The results presented in Table 4.4 indicated a significant difference in the mean scores of the samples across the storage period.

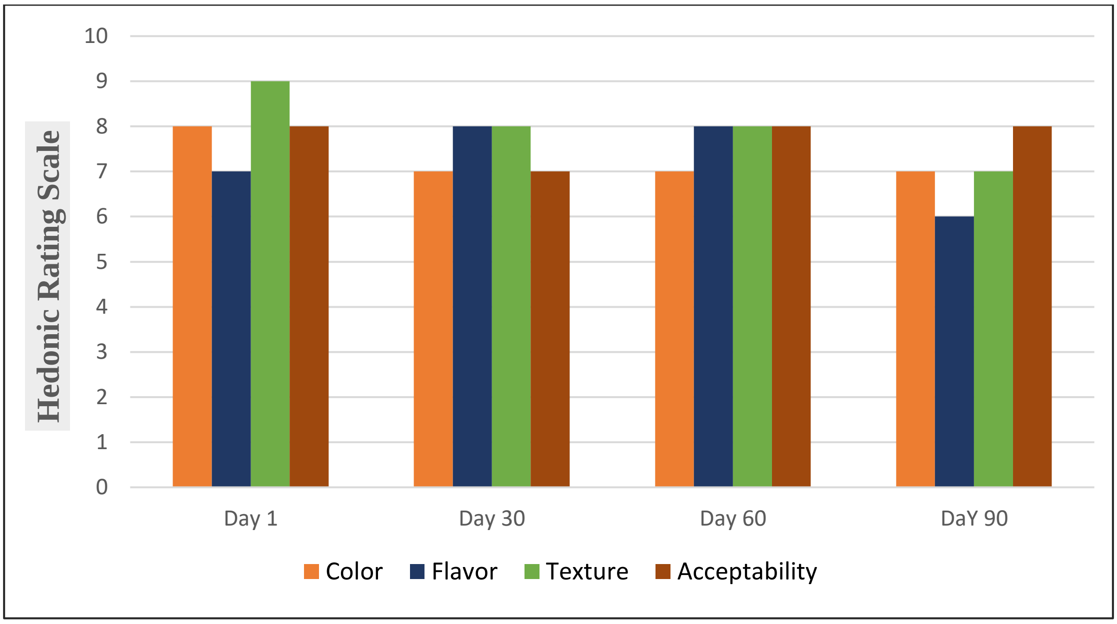

Figure 4.1 Descriptive attributes of pineapple jelly

It was observed that the mean scores of hedonic scales were significantly different for color and acceptability between samples. The mean score of color and flavor were not significantly different and the multiple Tukey's Multiple Comparison Test (TMCT) at ($p<0.05$) was performed to show that significant difference of texture and acceptability of different categories. It was observed that regarding to color of jelly within minimum 2 months was not different.

Table 4.3 Mean rating score for sensory test of pineapple jelly during storage

Parameter	Sample	Storage period				F-test
		Day 01	Day 30	Day 60	Day 90	
Color	P1	5.34^a	5.39^a	5.20^a	5.07^a	0.182^{NS}
	P2	5.47^a	5.8^b	5.33^a	5.53^a	4.24*
	P3	7.33^a	6.80^b	6.73^b	6.66^b	14.24**

Flavor	P1	6.40[a]	6.19[a]	6.33[a]	5.93[a]	0.023[NS]
	P2	6.20[a]	6.33[a]	6.13[a]	6.08[a]	0.16[NS]
	P3	6.83[a]	6.67[a]	6.80[a]	6.57[a]	0.92[NS]
Texture	P1	5.93[a]	5.90[a]	5.80[a]	5.86[a]	0.062[NS]
	P2	6.74[a]	6.78[a]	6.27[b]	6.11[b]	6.04*
	P3	6.82[a]	6.47[ab]	6.18[b]	5.93[b]	16.19**
Overall Acceptability	P1	5.96[a]	6.04[a]	6.07[a]	6.18[a]	0.053[NS]
	P2	5.80[a]	5.73[a]	5.13[b]	5.39[ab]	1.511*
	P3	6.99[a]	6.67[b]	7.07[a]	6.17[b]	11.87**

Legends: All values in the table showed mean of data, superscripts a, b, c denotes significant difference ($P<0.05$) between samples, NS= Not Significant, *= significant ($P<0.05$), **= significant ($P<0.01$).

CHAPTER- 5: DISCUSSION

5.1 Physiological Analysis

The pineapple jelly that was prepared was stored under suitable ambient conditions, and various chemical components such as pH, acidity, moisture content, reducing and total sugar, and nutritional elements like Vitamin C were analyzed both when it was initially made and at 30-day intervals over a period of three months.

5.1.1 pH value

The pH level of the pineapple jelly gradually decreased as the storage duration at room temperature (25-33°C) increased. However, this change in pH was not statistically significant ($P>0.01$). The pH of the pineapple jelly remained relatively higher compared to its initial value at the time of preparation. This observation could be attributed to the fermentation of the added sugar into alcohol and carbon dioxide during the storage period. The highest pH value for the pineapple jelly was recorded as 3.75 on the first day of preparation, while the lowest pH value, 3.29, was observed after 90 days of storage. This finding aligns with previous studies conducted by (Nirmara and Reddy, 2011). They authorized that natural pineapple fruit products contain pH of 3.6. Similarly, other researches showed pH values for pineapple products falls between 3.0 and 4.0 (Tasnim et al., 2010).

The pH of pineapple can vary due to factors such as where it is grown, the time of harvest, the fruit's level of ripeness, and other elements that affect pH characteristics. (Bartolome et al., 1995).

5.1.2 Total soluble solid

There were no notable disparities in the soluble solids content throughout the storage period. Interestingly, it was noted that the total soluble solids (TSS) of the jelly reached their peak after 90 days of storage. This phenomenon is likely a result of the partial breakdown of complex polysaccharides and the dissolution of pulp components that occurred during storage. These results were in conformity with the earlier findings by (Sawant et al.2009) in kokam + pineapple blended jelly and (Priya et al. 2010) in mixed fruit jam.

(Deen et al., 2013) experiment on wood apple jelly and in karonda jelly and found that both cases. (Kuchi et al. 2014)found also similar incident on guava jelly.The results of present study are in close conformity to the findings of (Deen and Singh, 2013) in karonda jelly and (Kuchi et al., 2014) in guava jelly bar.

5.1.3 Titratable acidity

All acidity values in this study were found to be statistically significant. The acidity of the jelly showed a slight increase as the storage period extended. The overall acidity percentage of the jelly reached its maximum after 90 days and was significantly lower at the very beginning of the preparation process. This increase in acidity could be attributed to the formation of organic acids resulting from the degradation of ascorbic acid and the de-esterification of protein molecules. This rise in acidity might also be linked to the generation of organic acids through the degradation of ascorbic acid.

The average titratable acidity of pineapple juice was measured at 0.433 percent. (Khurdiya et al., 1987) reported that the typical acidity range of pineapple juice is from 0.3 to 0.8 percent. These findings were in accordance with results obtained by (Patel et al., 2015) in per jam and (Shakir et al., 2008) in apple and pear mixed fruit jam. (Shukla et al., 2018) reported a significant increase in acidity with increase in storage period of guava jelly.

5.1.4 Ascorbic acid content

A significant reduction in ascorbic acid content was noted during the three-month storage period of the jelly. The ascorbic acid content decreased from 22.8 to 19.75 mg/100g in the course of the experiment, representing approximately a 13% loss of ascorbic acid during storage. This decline can be attributed to the sensitivity of Vitamin C, or ascorbic acid, to factors such as oxidation, light exposure, and temperature fluctuations.

This decrease in ascorbic acid content could likely be attributed to the oxidation process, where ascorbic acid is converted into dehydroascorbic acid, catalyzed by the enzyme ascorbinase. (Mapson et al., 1970) observed that oxidation due to temperature and greater catalytic activity of fructose in the catabolization of vitamin-C could be the reason for its decrease.

This kind of observations were also recorded by (Shakir et al., 2008) in apple and pear mixed fruit jam and (Sawant et al., 2009) in (kokam + pineapple) blended jam.(Achinewhu et al., 2003) investigated that Storing the fruits after harvest resulted in a reduction of 28 percent in ascorbic acid content over a six-day period. Additionally, the process of making jelly led to an overall decrease of 62.5 percent in ascorbic acid content.

(Uckiah et al., 2009) kept pineapple jam for two months at 22-25°C and found that 46.8% ascorbic acid were lost. The finding of present investigation matches with those as reported by (Kumaret al., 2017)for wood apple jelly and (Deen et al., 2013) in karonda jelly.

5.1.5 Moisture content

The moisture content in the jelly experiences a slight increase during storage. This rise in moisture could potentially be influenced by factors such as relative humidity, frequent opening of the container and the presence of trapped air, all of which can contribute to elevated moisture levels in the jelly. Additionally, moisture can lead to the hydrolysis of sugar within the jelly.

5.1.6 Ash content

The average ash content of pineapple jellies were recorded 0.26-.21 %.Ash content was remained same throughout the storage period. (Palve et al., 2013) reported that the ash content of jelly made from pineapple and aloevera was 5.42 percent. (Hakim et al., 2012) found that total mineral content (ash) varies from 0.61 to 0.95% in pineapple and 0.93 to 0.97% in banana.

5.1.7 Reducing sugar

Variations in reducing sugar content were noted under storage conditions, with a significant increase observed precisely at the 90-day mark of storage. The percentage of reducing sugar showed a greater rise compared to non-reducing sugar. This observed trend of increasing reducing sugars during storage might be linked to an intensified acid hydrolysis of polysaccharides and the conversion of non-reducing sugars into reducing sugars. This can be attributed, in part, to the acid hydrolysis of starch and disaccharides present in the pulp, resulting in the formation of invert sugars. Additionally, it involves the conversion of certain non-reducing sugars into glucose and fructose through inversion processes. These identical observations on increase in reducing sugars were also recorded by (Sawant *et al*., 2009). in kokam + pineapple blended jam and (Relekar et al., 2011) in sapota jam.

5.1.8 Non reducing sugar

In different circumstances an overall non-reducing sugars (%) of jelly was decreasing rapidly at 3 months during storage. These results were more or less similar to the study by (Shakir et al., 2008) in pear mixed fruit jam.

5.1.9 Total sugar

Over the course of the 90-day storage period, there was a gradual rise in the total sugar content. This increase could be attributed to moisture loss that occurred during storage. The overall sugar content of the jelly increased due to several factors, including the hydrolysis of polysaccharides such as pectin and starch. Additionally, the conversion of insoluble polysaccharides into simple sugars resulted from the solubilization of juice constituents during storage, especially at higher ambient temperatures. A similar increase in total sugars has been reported by (Relekar et.al., 2011). in sapota jam. Following result also found by (Sawant et al., 2009) in kokam with pineapple blended jelly and (Ewaidah et al., 1992) in guava jelly.

5.1.10 Sensory evaluation

It was observed during sensory valuation that up to 90 days, at 30 days' interval that texture and flavor remain best at 60th day then decrease somewhat. Alternatively, color remains constant and overall sensory attributes keep same during this time.

5.1.11 Storage and shelf life of pineapple jelly

After evaluating chemical and sensory analyses finally it can be concluded that this pineapple jellies qualitative values remain best up to 90 days of preservation at room temperature.

CHAPTER- 6: CONCLUSIONS

A high quality value-added product can be created using pineapple. The results of this research can serve as valuable guidance for the production and preservation of pineapple jelly, ensuring both product quality and nutritional value. The creation of this value-added product opens up opportunities to make it accessible during different seasons and offers the potential for increased returns for pineapple farmers.

From the chemical experiment, where TSS, ascorbic acid, ash content gradually decreased during 3 months of storage. While pH and total sugar were increased. On the other hand, during sensory evaluation while color, flavor, texture and overall acceptability of jelly remain satisfactory during this time. Finally, it can be concluded that its qualitative values remain best up to 3 months of preservation at room temperature.

CHAPTER-7: RECOMMENDATIONS AND FUTURE PERSPECTIVES

i. These studies have yielded positive outcomes in the emerging field of cost-effective technologies for enhancing the value of fruits. They have also demonstrated the commercial potential and improved marketability of such innovations. Based on the current research, the following recommendations are proposed for further exploration in this area.

ii. To validate the experimental results, it is advisable to replicate the present studies.

iii. Further adjustments can be made to the recipe, including the exploration of mixed jellies with various pineapple ratios.

iv. Pineapple jelly formulations can be adapted to incorporate low-calorie sugar substitutes instead of sucrose.

v. The outcomes hold therapeutic significance, particularly for individuals with digestive issues, as pineapple serves as a digestive aid and a natural anti-inflammatory fruit.

vi. Enhanced value-added pineapple products expand the range of canned goods, offering a convenient option for preserving pineapples for a minimum of 90 days and catering to off-season periods and regions where pineapple cultivation is limited.

vii. Economically disadvantaged individuals stand to benefit from these products, which capitalize on the flavor and medicinal properties of pineapple, potentially generating increased profits through value addition.

viii. Similar research efforts should be extended to other fruits available in the market, particularly those harvested off-season, such as berries, grapes, papayas, mangoes, and so forth.

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Appendix

Appendix A: Photo Gallery

Fig: A1: Peeling of pineapple

Fig A2: Thin slices of pineapple

Fig A3: Squeezing of juice

Fig A4: Prepared pineapple jell

Fig B1: Determination of vitamin C

Fig B2: Determination of pH

Fig B3: Determination of titrable acidity

Fig B4: Weighing of samples

Fig B5: Determination of ash content

Appendix B: Tasting of pineapple jelly (Hedonic Rating Test)

Name of Taster........................... Date: ....

Please taste these samples and check how much you like or dislike each one on four sensory attributes such as color, flavor, texture and overall acceptability. Use the appropriate scale to show your attitude by checking at the point that best describe your sense and feeling about the sample please give a reason for this attribute. Remember you are the only one who can tell what you like. An honest expression of your personal feeling will help us.

For Color / Flavor / Taste / Overall Acceptability

Hedonic	Color			Flavor			Texture			Acceptability		
	A	B	C	A	B	C	A	B	C	A	B	C
Like extremely												
Like very much												
Like moderately												
Like slightly												
Neither like nor dislike												
Dislike slightly												
Dislike moderately												
Dislike very much												
Dislike extremely												

The scale is arranged such that; Like extremely =9, Like very much =8, Like moderately =7, Like highly =6, Neither like nor dislike =5, Dislike slightly =4, Dislike moderately =3, Dislike very much =2, and Dislike extremely =1.

Appendix C: Rating Score

		N	Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Overall Acceptance of Color	C1	15	6.87	1.457	6.06	7.67	4	9
	C2	15	5.07	.884	4.58	5.56	4	7
	C3	15	5.87	1.302	4.15	5.59	4	7
	Total	45	5.60	1.514	5.15	6.05	4	9
Overall Acceptance of Flavor	C1	15	6.33	1.047	5.75	6.91	4	8
	C2	15	5.80	.941	5.28	6.32	4	7
	C3	15	6.13	1.246	5.44	6.82	5	9
	Total	45	6.09	1.083	5.76	6.41	4	9
Overall Acceptance of Taste	C1	15	6.27	1.387	5.50	7.03	4	8
	C2	15	5.73	.961	5.20	6.27	4	8
	C3	15	5.73	1.280	5.02	6.44	4	8
	Total	45	5.91	1.221	5.54	6.28	4	8
Overall Acceptability	C1	15	6.27	1.223	5.59	6.94	4	8
	C2	15	5.80	.676	5.43	6.17	5	7
	C3	15	5.80	.941	5.28	6.32	4	7
	Total	45	5.96	.976	5.66	6.25	4	8

Appendix C: Statistical data

Panelist	Color			Flavor			Texture			Acceptability		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
1	7	7	9	6	8	8	6	8	9	6	8	8
2	7	8	9	7	6	9	8	9	9	7	8	9
3	6	7	7	6	7	6	6	6	7	6	6	6
4	5	6	4	5	7	7	5	7	9	5	7	7
5	7	5	8	5	6	6	7	6	7	7	6	6
6	7	8	8	8	6	8	7	8	7	8	7	7
7	5	4	5	6	5	8	5	9	9	5	5	9
8	4	6	8	3	6	6	6	6	5	4	6	6
9	7	5	7	3	4	7	8	9	7	6	5	7
10	5	5	7	6	4	8	7	8	7	6	7	7
11	7	7	6	9	8	7	8	7	6	6	7	6
12	7	5	8	4	9	9	5	7	8	5	6	6
13	6	6	9	8	5	8	4	6	8	6	5	6
14	8	7	5	4	6	6	8	7	9	6	7	7
15	7	7	8	6	7	8	4	7	6	4	8	8
Mean	6.3	6.2	7.2	5.7	6.2	7.1	6.2	7.07	7.03	6.2	6.5	6.8

Brief bio-data of the student

Md. Al Imran completed his Secondary School Certificate Examination in 2008 and Higher Secondary Certificate Examination in 2010 from Rajshahi & Dinajpur board respectively. Later he fulfilled his Bachelor of Science (Hons.) in Food Science and Technology from Faculty of Food Science and Technology, Chattogram Veterinary and Animal Sciences University, Khulshi-4225, Chattogram. Now, he is a candidate for the MS degree in Food Chemistry & Quality Assurance under the Department of Applied Chemistry and Chemical Engineering of same faculty. Now he works as a senior nutritionist in KEPZ under YOUNGONE Corporation at anowara, Chattogram. A leading garment and sportswear manufacturer companies in Bangladesh. His research interests are in the areas of analysis and development of chemical ingredient in processing and preservation of local food. Also he interest in studying the food preservation on Bangladeshi native canned fish and vegetables.