INFLUENCE OF PROPORTION OF NANAS (*Ananas comosus* L.) BONGGOL AND SKIN AND CARBAGE CONCENTRATION ON *FRUIT LEATHER* CHARACTERISTICS

DESCRIPTION

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ABSTRACT

Pineapple hulls and peels are waste products that have not been optimally utilized, but still have a fairly high nutritional content including carbohydrates and proteins, and contain phenolic compounds and flavonoids. Efforts to utilize the waste of bongol and pineapple peel is by processing it into *fruit leather* to increase its economic value. The purpose of this study was to determine the effect of the proportion of pineapple stump: pineapple peel and the addition of carrageenan on product quality, and determine the best treatment to produce *fruit leather* with good characteristics and favored by panelists. This study used a Completely Randomized Design (CRD) two-factor factorial pattern with two replicates. Factor I was the proportion of fruit leather : pineapple peel (w/b) 60:40, 50:50, and 40:60. Factor II is carrageenan concentration of 0.6%, 0.8%, and 1%. Based on the results of the study, the best treatment was the treatment of the proportion of pith : pineapple peel 50:50 (b/b) with 1% carrageenan concentration which produced *fruit leather* with 16.26% moisture content, 24.83% reduction sugar content, 15.37 mg/100g vitamin C content, 27.37% antioxidant activity, 3.08% crude fiber content, 3.02 N tensile strength, 20.21% total dietary fiber content, and organoleptic characteristics including color 3.52 (neutral), taste 3.44 (neutral), aroma 3.24 (neutral), and texture 3.36 (neutral).

Keywords: *Fruit leather*, stump, peel, pineapple, carrageenan.

FOREWORD

Praise be to Allah SWT who has given His grace and guidance to the author so that the author can complete the thesis with the title "The Effect of Proportion of Pineapple (*Ananas comosus* L.) Bark and Skin and Carrageenan Concentration on *Fruit Leather* Characteristics". This thesis was prepared to fulfill the requirements for graduation at the undergraduate level (S1) of the Food Technology study program, Faculty of Industrial Technology, National Development University "Veteran" East Java.

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The author realizes that in the process of making this thesis it is not perfect because there are still many shortcomings in it, therefore suggestions and criticism are very much expected by the author to support the perfection of this thesis. Hopefully the writing of this research report can add insight into thinking to be more advanced in the future and can be useful for those concerned.

Surabaya, June 17, 2023

Author

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CHAPTER I
INTRODUCTION

A. Background

Pineapple production in Indonesia in 2021 reached a fairly high figure of 2.89 million tons, while in East Java it reached 198,000 tons (BPS, 2021) with by-products in the form of pineapple hulls and peels in a considerable amount, namely 48.6% of the weight (Marlina, et al, 2018).

Pineapple hulls and skins are waste products that have not been optimally utilized, but they have a fairly high nutritional content including 10.54% carbohydrates and 0.69% protein (Roni, 2013), and contain phenolic compounds (Lobo and Yahia, 2016). The chemical composition of pineapple stump includes moisture content of 83.68%, ash content of 2.13%, pH 4.32, reducing sugar content of 14.38%, pectin content of 1.82% (Efendi, R., et al, 2018), crude fiber at 1.39% (Sengar, et al, 2021), vitamin C at 68.56 mg/100g, and DPPH capture activity of 64.86% (Vrianty, et al, 2019).

Pineapple peel contains 81.72% water, 17.53% carbohydrate, 4.41% protein, 13.65% reducing sugar, 24.4 mg/100g vitamin C, and 59.05% antioxidant inhibition activity (Putri *et. al*, 2018). Pineapple peel also contains crude fiber of 2.41% (Sengar, et al, 2021) and pectin which is quite high at ± 8% (Ezugwu, et al, 2014). Based on the fiber and pectin content, pineapple hump and peel are eligible to be processed into *fruit leather* products. This can open up opportunities for the utilization of pineapple hulls and peels into processed products to increase the economic value of pineapple waste.

Fruit leather is a type of food derived from fruit pulp that has been crushed and dried. Drying can be done using heating which has a temperature of 60 - 70°C. *Fruit leather* has a thin sheet shape like skin, a slightly clayey and compact texture, and has good plasticity so that it can be rolled (not easily broken). According to Febrianto (2011), the requirements of fruits that can be used for making *fruit leather* are fruits that have sufficient maturity, low water content, contain high fiber, and have a strong flavor. The criteria in making *fruit leather are* determined by acid content, sugar content, and high fiber or pectin content (Nurkaya, et al., 2020). The problem that often arises in the manufacture of *fruit leather* is its poor plasticity because the proportion of fruit used can affect the properties and characteristics of

the *fruit leather* produced. The natural pectin content contained in the material is less than optimal in the process of gel formation in *fruit leather*, so it requires the addition of gelling agents that are expected to improve the plasticity of the *fruit leather,* one of which is carrageenan.

Carrageenan is one of the seaweed-derived hydrocolloids and is able to bind water molecules (Sidi, 2014). Carrageenan has the ability to form gels, stabilizers, emulsifiers, suspenders, and dispersers (Anggadireja, et al., 2007). Carrageenan has three types, namely kappa, iota and lambda, among the three types, kappa carrageenan has good gel formation. The concentration of carrageenan will affect the texture of *fruit leather*. Carrageenan can function as a binder, colloid protector, syneresis inhibitor, and *flocculating agent.* Carrageenan will form a *reversible* gel, meaning it can form a gel when cooling and return to liquid when heated (Distantina *et. al,* 2009).

Research conducted by Pulungan, et al (2020) on the manufacture of *fruit leather* from *subgrade* pineapple fruit with the addition of red dragon fruit peel with the proportion of ingredients of 80%: 20%, and the addition of 0.6% carrageenan is the best treatment because it has a moisture content of 9.5%, total acid 1.46%, total sugar 36.25%, and antioxidant activity 73.93%, as well as an overall organoleptic assessment most favored by panelists which includes color, taste, texture, and aroma. Sidi, et al (2014) conducted research on the effect of carrageenan addition on the physicochemical and sensory characteristics of pineapple and carrot *fruit leather* with the proportion of ingredients of 50%: 50%, the best treatment is the addition of 0.6% carrageenan because it has a moisture content of 12.49%, ash content of 2.73%, water activity (Aw) 0.46%, tensile strength of 1.91 N, and food fiber content of 4.15%, as well as overall sensory characteristics most preferred by panelists which include color, taste, aroma, and texture.

Based on the description above, this study was conducted to make *fruit leather* using pineapple stump and skin with the effect of carrageenan concentration on physicochemical and organoleptic characteristics that are good and liked by panelists, and produce *fruit leather* that has more nutritional value so that it is suitable for consumption.

B. Research Objectives

1. To determine the effect of the proportion of pineapple *stump* : pineapple peel and carrageenan concentration on the physicochemical and organoleptic characteristics of pineapple stump - peel *fruit leather*.
2. Determining the best treatment between the proportion of pomace: pineapple peel, and the concentration of carrageenan to produce *fruit leather* with good characteristics and favored by panelists.

C. Research Benefits

1. Increase utilization, extend shelf-life and diversity of pineapple stump and peel.
2. Produce diversified *fruit leather* products with good quality and favorable.

CHAPTER II
LITERATURE REVIEW

A. Pineapple (*Ananas comosus* L.)

Pineapple (*Ananas comosus* L.) is one type of fruit that is widely favored by the public. The outside of the pineapple has a skin consisting of a kind of black spot that protrudes outward. The top of the pineapple is a stiff leaf that sometimes resembles a crown (Indriati, 2016). According to data from the Indonesian Central Bureau of Statistics, pineapple production is increasing every year, pineapple production in 2021 reached 2.89 million tons. This number grew 17.95% compared to 2020 of 2.45 million tons (BPS, 2021).

Pineapple fruit can be consumed directly or processed into other consumer products such as pineapple chips, pineapple jam, and so on. The main nutritional content in pineapple fruit is carbohydrates and water, in addition there are fiber, sugar, organic acids, vitamins (ascorbic acid, niacin, and thiamine) and minerals (especially magnesium, manganese, and copper) and contains a large number of antioxidant compounds known to have beneficial effects on human health (Garcia *et. al*, 2021). The nutritional content in every 100 grams of fresh pineapple fruit can be seen in Table 1.

Table 1. Nutrient Composition of Fresh Pineapple Fruit Per 100 grams BDD

Nutritional Content	Quantity/100 g
Water (g)	88.9
Energy (kcal)	40
Protein (g)	0,6
Fat (g)	0,3
Carbohydrate (g)	9,9
Fiber (g)	0,6
Ash (g)	0,3
Calcium (mg)	22
B-Carotene (mcg)	17
Vitamin C (mg)	22
BDD (%)	**53**

Source: Indonesia Food Composition Table (2017)

a. Pineapple Stump

The part of the pineapple fruit that is widely used is the flesh, from the consumption and processing of pineapple, it also produces by-products in the form of skin and pineapple hump in a considerable amount, namely 48.6% (Marlina, et al., 2018). Pineapple stump is the middle part of the pineapple fruit, which has an elongated shape along the pineapple fruit, a slightly hard texture, and tastes slightly sweet (Effendi, et al., 2012).

According to Effendi, et al (2012), the remaining ingredients of pineapple fruit still contain juice containing sugar and acid. The chemical content of pineapple stump includes 83.68% moisture content; 2.13% ash content; pH 4.32; 14.38% reduction sugar content; 1.82% pectin content (Efendi, R., et al, 2018).

Pineapple bark also contains crude fiber at 1.39% (Sengar, et al., 2021), vitamin C at 68.56 mg/100g, and DPPH capture activity at 64.86% (Vrianty, et al., 2019). Pineapple stump also contains organic acids, such as citric acid, malic acid and oxalic acid (Fitriana, et al., 2017).

b. Pineapple Peel

Pineapple peel is an organic waste that contains many vitamins, nutrients and others. Pineapple peels contain active substances including anthocyanins, vitamin C and flavonoids (Anggraeni and Rahmawati, 2014). In addition, there is the enzyme *bromelin* and *tannin* (Caesarita, 2011). Bromelin is an enzyme that can be isolated from pineapple juice or stem. Bromelin has the ability to break down protein molecular structures into simpler forms (amino acids). Pineapple fruit that is still green or immature contains less bromelin than fresh pineapple fruit that is ripe (Gusriani, 2013).

Bromelin enzyme can be obtained from the stalk, skin, leaves, fruit, and stem of the pineapple plant, as well as the stump or center of the pineapple fruit in different amounts. The highest content of bromelain enzyme is found in the flesh of the ripe fruit. Bromelin is also useful for asthma patients and can also help people who suffer from allergies (Gusriani, 2013).

Pineapple peel contains 81.72% water, 17.53% carbohydrate, 4.41% protein, and 13.65% reducing sugar (Kusuma, et al, 2019), 24.4 mg/100g vitamin C, and 59.05% antioxidant inhibition activity (Putri *et. al,* 2018), and pH 6.3 (Gunawan, 2018). Pineapple peel also contains crude fiber of 2.41%

(Sengar, et al, 2021) and pectin which is quite high at ± 8% (Ezugwu, et al, 2014).

Table 2: Results of Proximate Analysis of Pineapple Peel and Stump Waste

Composition	Average wetness (%)
Water	86,70
Protein	0,69
Fat	0,02
Ash	0,48
Wet fiber	1,66
Carbohydrates	10,54

Source: Sidharta (1989) in Roni (2013)

B. Fruit Leather

Fruit leather is one type of food that can be used as an alternative processed food made from fruits, vegetables and flowers. After the fruit is made in the form of crushed fruits (*puree*) then the fruit is dried in the oven. This product is in the form of thin sheets like leather with a plastic texture, sweet taste but still has the characteristics of the fruit used. *Fruit leather is* a thin sheet that has a distinctive consistency and flavor (Puspasari, et al, 2005).

According to Raab and Oehler (2000), *fruit leather* is one of the food products such as dried sweets with a moisture content of 10-20%, which is in the form of thin sheets with a thickness of 2-3 mm, has a distinctive taste according to the fruits used, high in fiber (Marzelly *et. al*, 2017). Meanwhile, according to Yenrina *et. al*, (2019), the expected criteria of *fruit leather* are having an attractive color, a slightly clayey and compact texture, and having good plasticity so that it can be rolled or not easily broken or torn.

Kwartiningsih and Mulyati (2005) stated that *fruit leather* has several advantages, namely a long shelf life, easy to produce and the nutritional content does not change much. There is no quality requirement from the National Standardization Agency (BSN) for *fruit leather. Therefore*, the quality requirements used refer to the quality requirements of candied dried fruit which can be seen in Table 3**.**

Table 3. Quality Requirements for Candied Fruit

Description	Unit	Requirements
Circumstances		
Smell	-	Typical
Taste	-	Typical

Color	-	Normal
Foreign Objects	-	Not allowed
Moisture Content (w/b)	%	Max. 44
Sugar (Calculated as Sucrose) (w/b)	%	Min. 22
Food Additives		
- Artificial Sweetener	-	Not allowed
- Preservatives	-	As per SNI 01-0222-1995
- Additional Dyes	-	As per SNI 01-0222-1995
Metal Contaminants		
- Timbale (Pb)	mg/kg	Max. 1,0
- Copper (Cu)	mg/kg	Max. 10,0
- Zinc (Zn)	mg/kg	Max. 40.0
- Mercury (Hg)	mg/kg	Max. 0.05
- Arsenic (As)	mg/kg	Max. 0.5
Microbial Contamination		
- Total Plate Number	Colonies/g	Max. 1,0 x 10,2
- Coliform	APM/g	Max. 20
- *E Coli*	APM/g	<3
- Mold	Colonies/g	Max. 5

Source: SNI 01-4443-1998

Making *fruit leather is* done by taking the pulp to separate the fruit and seeds. After that, crushing is carried out until it becomes *puree* and the heating process is carried out. The fruit *puree* that has been heated is then allowed to stand for a while and then poured into a baking sheet that has been coated with plastic and dried at a temperature of 60-70 ^{o} C for ± 24 hours until a dry product is obtained. After drying, then cutting and rolling on the dried product, the finished *fruit leather* product is obtained. The following is a description of the process of making *Fruit Leather* (Ayu, 2016):

1. Raw Material Preparation

   Soursop fruits and carrots were sorted and washed under running water until they were clean from any remaining dirt. Then peeling is done on the soursop fruit to extract the flesh.

2. *Blanching*

   Blanching is done on carrots for 2 minutes.

3. Destruction

   Crushing is done using a blender with water added in a ratio of 1: 1 until the material is completely smooth like porridge. Then coarse filtering is carried out on the soursop pulp until a smooth fruit pulp is obtained, for carrots, filtering is

carried out until the juice is obtained. Crushing is done using a blender at medium speed.

4. Weighing

   Weighed the soursop pulp and carrot juice in the proportion of 50:50 (%), 20% sugar, and 0.6% citric acid.

5. Mixing

   After the ingredients were weighed, they were mixed with carrageenan at 0.6%.

6. Warm up

   The slurry that has been added with sugar, carrageenan and citric acid is then heated on a stove at a temperature of ±70°C for 3 minutes and stirred slowly until homogeneous.

7. Printing

   After the heating process, the dough is poured on a 40 x 40 cm baking sheet that has been coated with LDPE type plastic and a thickness of ± 2-3 mm for the molding process.

8. Drying

   The dough that has been poured into the pan is dried using an oven at 60 ^{o} C for ± 24 hours.

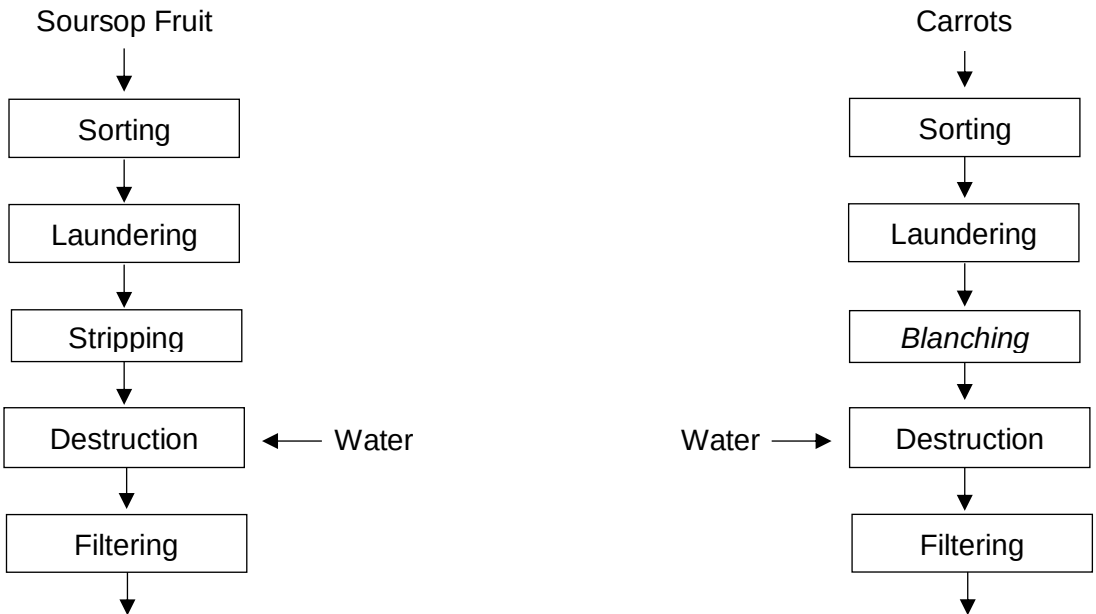
9. Cutting

   After the material is dry, it is then cut with a size of 5 x 5 cm.

10. Rolling

    Then the products that have been cut are rolled into *fruit leather*.

The flowchart for making soursop-carrot *fruit leather* can be seen in Figure 1.

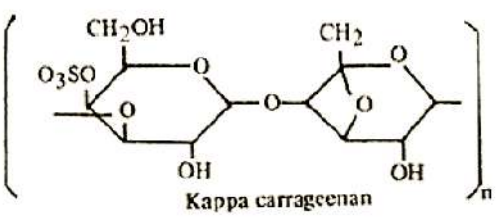


C. Carrageenan

Hydrocolloids can function as adhesives, water binders, emulsifiers, gelling

Flowchart of Sirsak - Carrot *Fruit Leather* Making (Ayu, 2016)

to reduce the free water content in food ingredients. One type of hydrocolloid that is often used is carrageenan. Carrageenan is a hydrocolloid compound consisting of esters of potassium, sodium, magnesium, and potassium sulfate with galactose and 3,6



Kappa carrageenan

anhydrogalactocipolymer (Basuki, et al., 2014). Carrageenan is used because in addition to being hydrophilic, it is more stable in immobilizing water at lower concentrations and stronger in forming gels (Sidi, 2014). Carrageenan is obtained from seaweed that is widely cultivated in Indonesia, namely *Eucheuma denticulatum* (*Eucheuma spinosium*) and *Kappaphycus alvarezii* (Eucheuma *cottoni*) (Wisnu and Rachmati, 2011). According to Fauziah et al (2015), kappa type carrageenan is the best among iota and lambda because kappa type is a carrageenan that can form a gel if it meets with potassium ions, the gel formed is elastic and flexible and the kappa carrageenan gel is stable against acid or does not hydrolyze.

Figure 2. Kappa structure of carrageenan (Rifansyah, 2016)

Kappa carrageenan is a fraction that is able to form a gel in water and is *reversible*, which melts when heated and gels again when cooled. Kappa carrageenan will form the strongest gel with elastic gel properties and is stable in acidic solutions (Imeson, 2010). *Kappaphycus alvarezii* has a fairly complete nutritional content. The composition of *Kappaphycus alvarezii* can be seen in Table 4**.**

Carrageenan has properties including solubility, viscosity, gel formation and pH stability. The solubility of carrageenan in water is influenced by several factors including the type of carrageenan, temperature, pH, the presence of counter ions and other solutes. Carrageenan in solution has maximum stability at pH 9 and will hydrolyze at pH below 3.5. At pH 6 or above, carrageenan solutions can generally maintain the conditions of the carrageenan production process. Acid hydrolysis will occur if carrageenan is in solution form, hydrolysis will increase with increasing temperature (Fahmitasari, 2004).

A decrease in pH causes hydrolysis of the glycosidic bond which results in loss of viscosity. The viscosity of a hydrocolloid is influenced by several factors, namely carrageenan concentration, temperature, type of carrageenan, molecular

weight and the presence of other molecules. If the concentration of carrageenan increases, the viscosity will increase (Fahmitasari, 2004).

Research by Nurainy and Koesoemawardani (2006), showed that the results of soursop *fruit leather* with the addition of seaweed at a concentration of 0.8% was the best treatment and produced soursop *fruit leather* with good physical and chemical characteristics and good acceptance on organoleptic characteristics. Based on research by Fitantri (2014), the function of adding kappa carrageenan in making *fruit leather* can improve plasticity because it can form a gel and enrich the nutritional content of the *fruit leather* produced including minerals and fiber.

D. Mechanism of Carrageenan Gel Formation

Gel formation is a phenomenon of combining or crosslinking polymer chains to form a continuous three-dimensional mesh. Furthermore, this mesh captures or immobilizes water in it and forms a strong and rigid structure. Gel formation is influenced by several factors including: type and type of carrageenan, consistency, presence of ions and solvents that inhibit hydrocolloid formation. Heating process with a temperature higher than the gel formation temperature will cause the carrageenan polymer in the solution to become *random coil*. When the temperature is lowered, the polymers will form a *double helix* structure and if the temperature decrease is continued these polymers will be strongly crosslinked and with increasing helical shape, aggregates will be formed which are responsible for the formation of a strong *gel*. If continued, it is possible that the aggregate formation process will continue and the gel will contract while releasing water. This last process is called syneresis (Fardiaz, 1989 in Nuraini, 2001).

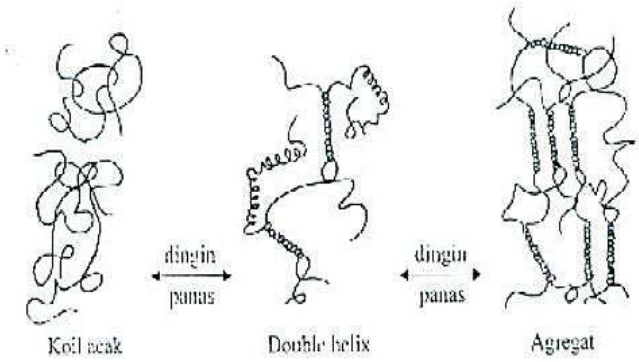


Figure 3. Mechanism of Carrageenan Gel Formation (Thomas, 1992)

In principle, gel formation occurs due to the formation of a three-dimensional mesh or network by primary molecules that stretch over the entire volume of the gel formed by trapping a certain amount of water in it. Cross-linking occurs in polymers consisting of a sufficient number of long-chain molecules, a continuous three-dimensional building will be formed so that a rigid and tough structure is formed that is resistant to certain forces and pressures (Astuti et al., 2015).

The process of carrageenan gel formation begins with the change of carrageenan polymer into a *random coil* shape. This change is due to the heating process with a temperature higher than the carrageenan gel formation temperature. When the temperature is lowered, the carrageenan polymer will form a *double helix* structure and produce *junction* points and polymer chains (Glicksman, 1979 in Pritanova, 2013).

The differences in the amount, type and position of sulfate and the presence of ions will affect the gel formation process. Monovalent ions namely K^+ , NH^{4+} , Rb^+ and Cs^+ help the gel formation. Kappa carrageenan forms a hard and elastic gel. Of all the carrageenans, kappa carrageenan gives the most stable strong gel. Iota carrageenan forms a strong and stable gel when Ca^{2+} ions are present. Na^+ ions are reported to inhibit the formation of kappa and lamda type gels (Angka and Suhartono, 2000). Carrageenan is soluble in hot water and will form a gel at 45ºC and 65ºC, stable to neutral and acidic pH, and strong in gel formation (Mawarni, et al, 2018).

Table 4. Composition of Kappaphycus alvarezi i

Nutritional Content	Quantity/100 g
Carbohydrate (g)	57,3
Protein (g)	4,5
Fat (g)	0,89
Ash (g)	28,9
Calcium (mg)	1068
Phosphorus (mg)	124
Iron (mg)	0,93
Magnesium (mg)	152
Niacin (mg)	2,2

Source: Abirami and Kowsalya (2011)

Table 5. Physical Properties of Carrageenan

Characteristics	Kappa	Iota
Sulfate ester	25-30 %	28-35 %

3,6-anhydro-galactose		28-35 %	-
Solubility	Hot water	Soluble at >70 C^o	Soluble at >70 C^o
	Cold water	Soluble Na^+	Soluble Na^+
	Hot milk	Dissolve	Dissolve
	Cold milk + Tetrasodium Pyrophosphate (TSPP)	Viscous	Viscous
	Sugar solution	Soluble (hot)	Difficult to dissolve
	Salt solution	Insoluble	Insoluble
	Organic solvents	Insoluble	Insoluble
Gel	Effect of cation	Forms a strong gel with K^+	Forms a strong gel with Ca^{2+}
	Gel type	Strong and brittle with syneresis	Elastic and cohesive without syneresis
Stability	Neutral and alkaline Ph	Stable	Stable
	Acidic (pH 3.5)	Hydrolyzed	Hampered with heat
Synergy with other hydrocolloids		Yes	No
Thawing stability		Unstable	Stable

Source: Imeson (2010).

E. Sugar

Sugar is involved in the preservation and manufacture of a wide variety of food products such as jam, *jelly*, *fruit leather* and others. The ability of sugar as a preservative is because it can increase the concentration and pressure in food products, so that there can be movement of water from low to high concentrations (*osmosis*) through the semi permeable membrane of microbes so as to kill microbes. The use of sugar is also due to its high solubility, ability to reduce moisture and bind water so as to inhibit the growth of microorganisms in foodstuffs (Buckle, 1987).

During the cooking of the sucrose solution in the presence of acid in the manufacture of *fruit leather, a* hydrolysis process will occur which produces reducing sugars (glucose and fructose). Sucrose as a preservative is widely used in *fruit leather*, jam, *jelly*, fruit juice, sweets, sweetened condensed milk and so on. The addition of sugar to foodstuffs in high concentrations (at least 40%) makes some of the free water unavailable for the growth of microorganisms and the water activity (*Aw*) of foodstuffs is reduced. The use of sugar at concentrations reaching 65% will cause the cells of microorganisms contained in foodstuffs to dehydrate or plasmolysis. The mechanism of sugar as a preservative is to produce high osmosis pressure so that the microorganism cell fluid is scoured out and as a result inhibits

the cytoplasm from decreasing so that plasmolysis occurs which causes cell death (Winarno, 2004).

The use of sugar is not only as a preservative and sweetness but also functions as a flavor giver, color giver, and surface gloss. Sugar concentration affects the moisture content and texture of food products. Sugar has hygroscopic properties or absorbs water so that bacterial cells will dehydrate and eventually die. Sugar heated with protein will react to form dark-colored lumps resembling caramel in color, smell and taste (Ernie and Lestari, 1992). Caramelization reaction is a browning process that occurs when sugar is heated continuously until the temperature exceeds its melting point. The melting point of sucrose is 160^{o} C (Winarno, 2004). In making *fruit leather,* caramelization does not occur because the temperature used is not too high, only 70^{o} C.

F. Drying on the Quality of *Fruit Leather*

Drying as a method to remove or eliminate water from a material with the aim of keeping the material from microbiological, enzymatic and chemical damage. According to Desrosier (1988), the water content is reduced to a limit so that microbes can no longer grow.

Desrosier (1988) also states that fruits are preserved more by drying than by other food preservation methods. Drying is one of the most widely used food preservation methods. Dehydration is a way to produce dried fruits in a new form and with better quality.

In the manufacture of *fruit leather,* an artificial dryer is used, namely a dryer using a dryer (*Cabinet dryer*). The drying process carried out in the manufacture of *fruit leather* aims to reduce the water content and is expected to preserve quality characteristics such as flavor and nutritional value. With artificial drying, the temperature, air velocity, humidity and drying time can be adjusted according to the commodity being dried. Improper control of these factors can cause *case hardening,* which is a condition where the surface of the material is very dry while the inside is still wet, this occurs when the evaporation of water on the surface of the material is much faster than the diffusion of water and the inside out (Susanto and Saneto, 1994).

According to Susanto and Saneto (1994), some of the advantages of using drying technology on fruits and vegetables include the material becomes more

durable, the volume of the material becomes smaller so as to facilitate and save space for transportation and packing, the weight of the material also becomes reduced so as to facilitate the transportation process, thus it is expected that production costs become cheaper. While the disadvantages include the occurrence of physical changes such as shrinkage, discoloration, hardness, and so on. Changes in chemical quality, including a decrease in Vitamin C content and the occurrence of a browning process, as well as organoleptic quality which includes taste, texture, color and smell.

G. Effect of Heating on *Fruit Leather* Quality

The purpose of cooking is to extract pectin and flavor substances from the *fruit*, help the mixing and unification between pectin, sugar and acid to form a good jam. Cooking is done at 60-70°C until the total soluble solids are 65-68% as measured by a refractometer (Muchtadi, 1997).

According to Desrosier (2008), boiling is an important stage in the manufacture of *fruit leather that* must be thickened quickly to the critical point for carrageenan, which is at a temperature of 70^{o} °C. The purpose of heating is so that gel formation occurs and can bind fibers, water and other compounds contained in the fruit pulp. Prolonged boiling not only causes hydrolysis of pectin and evaporation of acids, but also causes loss of flavor and color. When evaporation is stopped is determined by the high content of dissolved solid matter in the substrate.

H. Decision Analysis

A decision is an action to choose an alternative choice or solution to realize a desire. Decision analysis is the basis for choosing the best alternative determination. Each alternative that is estimated is determined to have the predicted results. The decision made is by evaluating numerical values, this evaluation is generally expressed through financial values, so what is done is to compare aspects of quality, quantity, and financial aspects (Dermawan, 2005).

One of the methods for decision making is the effectiveness test (De Garmo *et al*., 1984) which determines the best treatment by giving weighted values to each parameter with a number 0-1. The weighted values differ depending on the importance of each parameter resulting from the treatment.

I. Theoretical Foundation

According to Febrianto (2011), the requirements of fruits that can be used for making *fruit leather* are fruits that have sufficient maturity, low water content, contain high fiber, and have a strong flavor. Pineapple hull has a moisture content of 83.68%, ash content of 2.13%, pH 4.32, reducing sugar content of 14.38%, pectin content of 1.82% (Efendi, R., et al, 2018), crude fiber at 1.39% (Sengar, et al, 2021), vitamin C of 68.56 mg/100g, and DPPH capture activity of 64.86% (Vrianty, et al, 2019). Meanwhile, pineapple peel contains 81.72% water, 17.53% carbohydrate, 4.41% protein, 13.65% reducing sugar, 24.4 mg/100g vitamin C, and 59.05% antioxidant inhibition activity (Putri *et. al*, 2018). Pineapple peel also contains crude fiber of 2.41% (Sengar, et al, 2021) and pectin which is quite high at ± 8% (Ezugwu, et al, 2014). Pineapple stump and skin also contain phenolic compounds and flavonoids (Lobo and Yahia, 2016). Based on their characteristics, both ingredients are qualified as raw materials for making *fruit leather*.

Fiber content in the ingredients plays a very important role in making *fruit leather*, according to Darojat (2010) fiber is able to bind water and can maintain texture. The amount of fiber will affect the amount of water bound, high fiber content increases the ability to absorb water because in the fiber there are quite a lot of free hydroxyl groups that are polar (Santoso, 2011). This can make the resulting *fruit leather* texture more elastic, compact, and not sticky (Darojat, 2010). If the water content in the material is higher than the fiber content, it will produce a soft and not compact texture because the ability to bind water will be reduced (Lamban, 2017).

Fruit leather is one of the food products such as dried sweets with a moisture content of 10-20% (Raab & Oehler, 2000) which is in the form of thin sheets with a thickness of 2-3 mm, has a distinctive taste according to the fruits used, high in fiber (Marzelly *et. al*, 2017). The expected criteria of *fruit leather* are having an attractive color, a slightly clayey and compact texture, and having good plasticity so that it can be rolled or not easily broken or torn (Yenrina *et. al*, 2019). The criteria for making *fruit leather are* determined by acid content, sugar content, and high fiber or pectin content (Nurkaya et al., 2020). *Fruit leather* has several advantages, namely a long shelf life, easy to produce and the nutritional content does not change much (Kwartiningsih and Mulyati, 2005).

The sugar content in *fruit leather is* not less than 45% and contains soluble solids of not less than 55%. Sugar in the manufacture of *fruit leather* has an important role that is interdependent between acid and pectin, this component is very influential on the formation of gel in *fruit leather* (Alvina, 2015). Semi-solid gel formation can be made from pectin-acid-sugar and water, the optimum conditions for gel formation are pectin content of 0.75-1.5%, sugar content of 67-70% and pH 3.2-3.5 (Buckle, 2009).

The plasticity and texture levels of *fruit leather* will be less good if it only relies on natural pectin contained in the raw materials because it is not optimal in the gel formation process, so it is necessary to add gelling agents such as carrageenan, because carrageenan is included in the hydrocolloid group. According to Sidi (2014), hydrocolloids can function as adhesives, water binders, emulsifiers, gelling agents, and thickeners for processed food products. Carrageenan is used because besides being hydrophilic, it is more stable in immobilizing water at lower concentrations and stronger in gel formation. Carrageenan is soluble in hot water and will form a gel at 45ºC and 65ºC, stable to neutral and acidic pH, and strong in gel formation (Mawarni, et al, 2018).

The process of carrageenan gel formation begins with the change of carrageenan polymer into a *random coil* shape. This change is due to the heating process with a temperature higher than the carrageenan gel formation temperature. When the temperature is lowered, the carrageenan polymer will form a *double helix* structure and produce *junction* points and polymer chains (Glicksman, 1979 in Pritanova, 2013). Kappa carrageenan forms a hard and elastic gel. Of all the carrageenans, kappa carrageenan provides the strongest stable gel (Angka and Suhartono, 2000).

Research on *fruit leather* has been conducted by several researchers including, Pulungan, et al (2020) which shows the best treatment for the ratio of pineapple fruit *puree* and red dragon fruit peel *puree* 80%: 20% and the addition of carrageenan 0.6% and sorbitol 8% with a moisture content of 9.5%; total acid 1.46%; total sugar 36.25%; antioxidant activity 73.93%, and organoleptic testing which includes taste, color, texture, and aroma using the *hedonic scale* method as a whole favored by panelists. Research by Sidi, et al (2014) produced the best proportion of pineapple and carrot *fruit leather* 50%: 50% and the addition of carrageenan 0.6% and sorbitol 9.8% with a moisture content of 12.49%; ash

content 2.73%; water activity (Aw) 0.46%; tensile strength 1.91 N; food fiber content 4.15%, and organoleptic testing which includes taste, color, texture and aroma using the *scoring* method as a whole has a value of 3.96 which indicates that the proportion is preferred by panelists. While the results of Mila's research (2019), showed the best treatment of the proportion of pineapple and red dragon fruit 75: 25 (%) and the addition of 0.4% carrageenan with water content 4.58%; fiber content 6.71%; total sugar 20.73%; vitamin C 53.21 mg/g; texture 1.28 N; *lightness* value 23.54, as well as organoleptic testing which includes taste, color, aroma, and texture using the *hedonic scale* method as a whole favored by panelists.

J. Hypothesis

It is suspected that the treatment of the proportion of pineapple stump : peel and the concentration of carrageenan has an effect on the physicochemical and organoleptic properties of the *fruit leather* produced.

CHAPTER III
MATERIALS AND METHODS

A. Place and Time of Research

This research was conducted in the Food Processing Technology laboratory, Food Analysis laboratory, and Sensory Test laboratory of the Food Technology Study Program of UPN "Veteran" East Java. This research was conducted from May 2023 to June 2023.

B. Research Materials

a. Raw materials

The raw materials used in the manufacture of *fruit leather* are pineapple stem and skin, as well as granulated sugar obtained from Pucang market Surabaya, and kappa carrageenan obtained from Tristar shop Surabaya.

b. Chemicals for analysis

Chemicals for analysis include distilled water, H_2SO_4 1.25 N, 1% amylum, 0.01 mm DPPH (in ethanol), 3.25 N NaOH, K_2SO_4Iodine, and methanol.

C. Research Tools

Tools used in the manufacture of *fruit leather* include scales and processing tools (spoons, plates, knives, blenders, baking sheets, *cabinet dryers*, etc.). Tools used for analysis include weighing bottle, 500 ml volumetric flask, 500 ml erlenmeyer, oven, desiccator, *beaker glass,* dropper pipette, volumetric pipette, tweezers, analytical balance, filter paper, water bath, measuring cup and spectophotometer, burette, pump and *burchner* funnel.

D. Research Methodology

This research was conducted using a completely randomized design (CRD) factorial pattern with two factors and two replicates. The data obtained were analyzed using ANOVA (*Analysis of Variance*) test at the 5% level. To determine the difference, it was continued with DMRT (*Duncan's Multiple Range Test*) test.

1. Changeable Variables

Factor I : Proportion of Tuber: Pineapple Peel (w/b)

A1 = Proportion of Tuber: Pineapple Peel (60:40)

A2 = Proportion of Tuber: Pineapple Peel (50 : 50)

A3 = Proportion of Tuber: Pineapple Peel (40 : 60)

Factor II : Carrageenan Concentration (%)

B1 = 0,6 %

B2 = 0,8 %

B3 = 1,0 %

	B1	B2	B3
A1	A1B1	A1B2	A1B3
A2	A2B1	A2B2	A2B3
A3	A3B1	A3B2	A3B3

Description:

A1B1 = Proportion of Pineapple Tuber:Peel (60:40), carrageenan concentration 0.6%

A1B2 = Proportion of Pineapple Tuber:Peel (60:40), concentration of carrageenan 0.8%

A1B3 = Proportion of Pineapple Tuber:Peel (60:40), carrageenan concentration 1.0%

A2B1 = Proportion of Pineapple Tuber:Peel (50:50), carrageenan concentration 0.6%

A2B2 = Proportion of Pineapple Tuber:Peel (50:50), carrageenan concentration 0.8%

A2B3 = Proportion of Pineapple Tuber:Peel (50:50), carrageenan concentration 1.0%

A3B1 = Proportion of Pineapple Tuber:Peel (40:60), carrageenan concentration 0.6%

A3B2 = Proportion of Pineapple Tuber:Peel (40:60), concentration of carrageenan 0.8%

A3B3 = Proportion of Pineapple Tuber:Peel (40:60), carrageenan concentration 1.0%

According to Yitnosumarto (1993), a statistical model that uses a factorial pattern with 2 factors is as follows:

$$Yijk = \mu + \alpha i + \beta j + (\alpha\beta)ij + \varepsilon ijk$$

Description:

Yijk= the observation value in the kth experiment that received the -ij treatment combination (i-th level of factor A and j-th level of factor B).

M= common mean (actual mean)

αi= the effect of the i-th treatment of factor I

βj= jth treatment effect of factor II

(αβ)ij= interaction effect of i-th level of factor A and j-th level of factor B.

Eijk= use error from the kth experimental unit that received the jth treatment combination.

2. Fixed variables

The fixed variables required in this study are :

a. Weight of 100gr pineapple bark - peel pulp mixture
b. Ingredients and water ratio (1:1)
c. 20% Sugar Addition (w/b)
d. Heating temperature ±70 C^o
e. Drying temperature 70 C^o
f. Cooking time ± 3 minutes
g. Drying time ± 7 hours

E. Research Parameters

The parameters observed in this study were:

1. Raw Material Analysis:
   a. Oven method moisture content (AOAC, 2005)
   b. Vitamin C content analysis (Sudarmadji, 1997)
   c. Crude fiber content analysis (Sudarmadji, 1997)
   d. Antioxidant activity test (Subagio, 2001)
   e. Analysis of reducing sugar content Luff-Schoorl method (Sulaiman, 1994)

2. *Fruit Leather* Analysis:
   a. Oven method moisture content (AOAC, 2005)
   b. Antioxidant activity test (Subagio, 2001)
   c. Tensile strength analysis with *Tenzile Strength* (*Lloyd Universal Testing Instrument 1000S*)
   d. Analysis of sugar content Reduction method Luff-Schoorl (Sulaiman, 1994)
   e. Crude fiber content analysis (Sudarmadji, 1997)
   f. Analysis of Vitamin C content (Sudarmadji, 1997)
   g. Hedonic organoleptic method includes taste, color, and texture (Wulandari *et al*., 2008).
3. Best Treatment Analysis
   a. Analysis of dietary fiber content (AOAC, 2005)

F. Research Procedure

1. Preparation of Pineapple Pith - Peel Porridge

a. Raw Material Preparation

Pineapple hulls and skins obtained from the Pucang Surabaya market were sorted and washed with running water until they were clean from dirt. Then the separation of the eyes of the fruit was carried out until the clean skin was obtained.

b. Destruction

Crushing the ingredients using water in *a* ratio of 1:1 until the ingredients become like porridge. Crushing is done using a blender at medium speed.

c. Filtering

Coarse screening of the pineapple peel was carried out to separate it from the coarse parts until a fine pulp was obtained.

2. *Fruit Leather* Making

a. Weighing

Weighing the proportion of pulp: pineapple peel pulp as 60: 40, 50 : 50, and 40: 60 (w/b).

b. Mixing

Mixing was carried out with the proportion of pulp: Pineapple Peel (60:40, 50:50, and 40:60) and Carrageenan (0.6%; 0.8%; 1%), and 20% sugar.

c. Warm up

The ingredients that have been mixed are then heated on the stove at a temperature of ± 70^{o} C for ± 3 minutes on low heat and stirred until homogeneous.

d. Printing

The heated dough mixture is then poured on a baking sheet that has been coated with plastic with a thickness of ± 2-3 mm for the molding process.

e. Drying

The dough that has been poured into the pan is then dried using a *cabinet dryer* with a temperature of 70^{o} C for ± 7 hours.

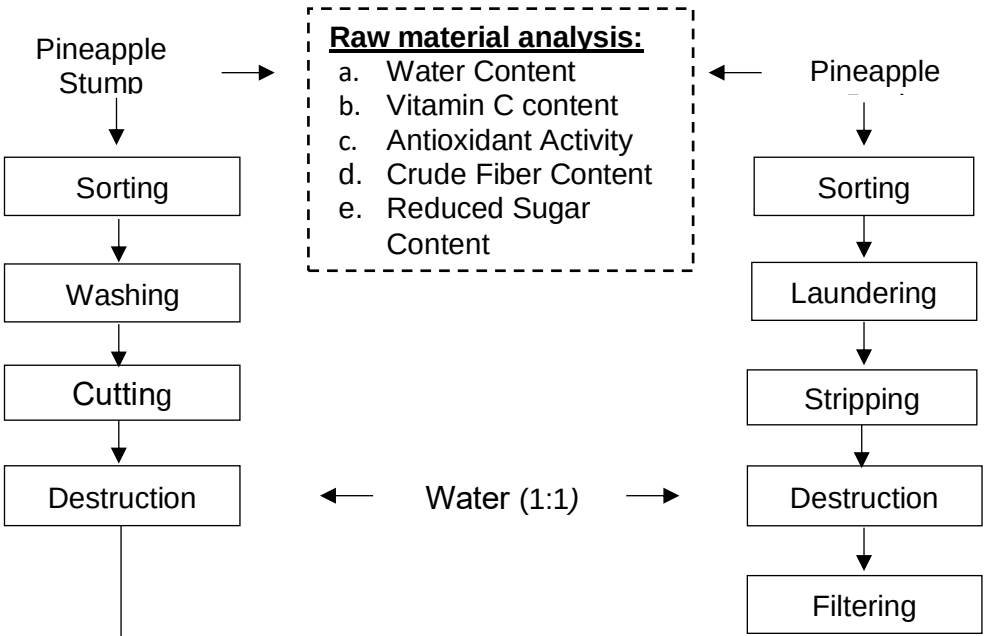
f. Cutting and Rolling

After the dough is dry, it is cut into 5 x 5 cm pieces, then rolled.

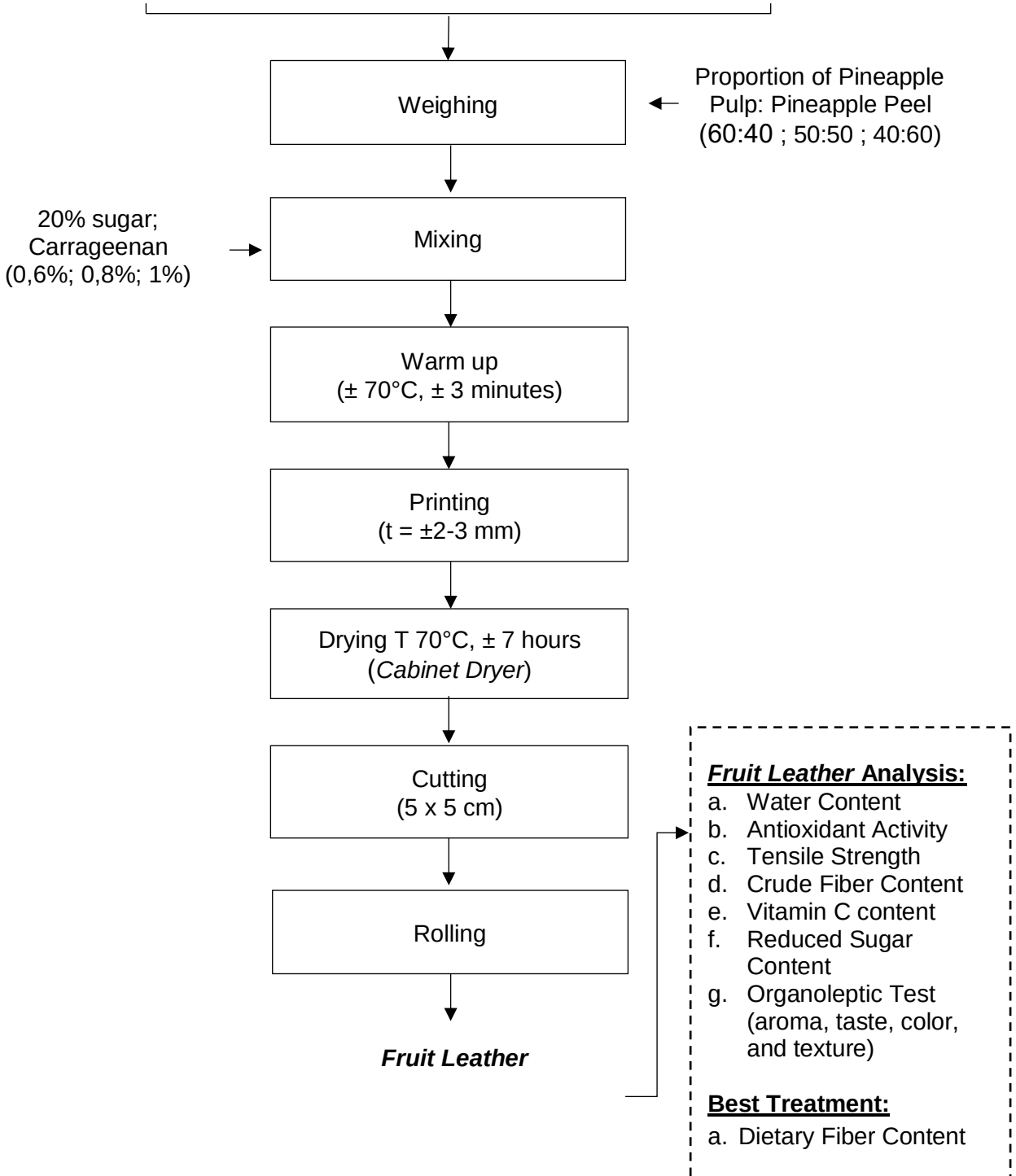
g. Analysis

Analysis is carried out on raw materials and finished products. After analysis, the product is packaged using *polyethylene* plastic.

The flowchart for the preparation of pineapple stump - peel pulp can be seen in **Figure 4** and the flowchart for the preparation of pineapple stump - peel *fruit leather* can be seen in **Figure 5.**



Flowchart of Pineapple Pith - Peel Slurry Preparation**,**
(Ayu, 2016)



CHAPTER IV
RESULTS AND DISCUSSION

The analysis carried out in this study began with the analysis of raw materials in the form of pineapple hulls and peels. Analysis of raw materials includes water content, reducing sugar content, vitamin C content, antioxidant activity, and crude fiber content. Analysis of *fruit leather* products includes water content, reducing sugar content, vitamin C content, antioxidant activity, crude fiber content, and organoleptic including color, taste, aroma, and texture. The best treatment results were obtained with the *de garmo* method and further analysis in the form of dietary fiber content.

A. Raw Material Analysis Results

The results of the analysis of raw materials consisting of raw material analysis of pineapple hulls and peels, which include moisture content, reducing sugar content, vitamin C content, antioxidant activity, and crude fiber content. The analysis results obtained are as follows:

Table 6: Analytical results of pineapple hull and peel raw materials.

Component	Bonggol		Skin	
	Analysis Result	Literature	Analysis Result	Literature
Water Content (%)	80,82 ± 0,18	83,68[a)]	79,08 ± 0,19	81,72[e)]
Reduced Sugar (%)	16,56 ± 0,32	14,38[a)]	14,20 ± 0,15	13,65[e)]
Vitamin C (mg/100g)	72,44 ± 0,92	68,56[b)]	29,70 ± 0,56	24,4[f)]
Antioxidant Activity (%)	68,10 ± 1,15	64,86[c)]	58,06 ± 1,15	59,05[f)]
Crude Fiber (%)	1,53 ± 0,03	1,39[d)]	2,04 ± 0,03	2,41[d)]
pH	4,16 ± 0,04	4,32[a)]	5,83 ± 0,06	6,3[g)]

Source: a) Efendi, R., et al (2018), b) Titin, et al (2011), c) Vrianty, et al (2019), d) Sengar, et al (2021), e) Ezugwu, et al (2014), f) Putri *et. al,* (2018), g) Gunawan (2018)

Based on Table 6. the results of the analysis of pineapple hull and peel raw materials show a slight difference between the results of the analysis of raw materials and the literature, including differences in moisture content, reducing sugar content, vitamin C content, antioxidant activity, and crude fiber content.

The results of the analysis of the moisture content of pineapple pith amounted to 80.82% which was lower than the literature of Efendi, et al (2018), which amounted to 83.68%. The reduced sugar content of pineapple pith is 16.56% which

is higher than the literature of Efendi, et al (2018), which is 14.38%. Vitamin C content of pineapple pith was obtained at 72.44 mg/100g which was higher than the literature of Titin, et al (2011), which was 68.56 mg/100g. The results of the antioxidant activity analysis of pineapple pith amounted to 68.10% which is higher than the literature of Vrianty, et al (2019), which amounted to 64.86%. The crude fiber content of pineapple pith is 1.53% which is higher than the literature of Sengar, et al (2021), which is 1.39%. The pH value of pineapple stem is 4.12 which is lower than the literature of Efendi, et al (2018), which is 4.32. Differences in the results of the analysis of water content, reducing sugar content, vitamin C content, antioxidant activity, and crude fiber content in pineapple pith can be influenced by several factors, namely differences in type, maturity level, climatic conditions, place of growth, and post-harvest fruit storage. This is supported by Mashud and Matana (2014), that the chemical composition of a plant can be influenced by several factors, namely plant age, soil and climate conditions, and the statement of Firmansyah, et al (2016), that the increase in nutrients and phytochemical compounds such as antioxidant activity is also influenced by the level of fruit maturity, the higher the level of fruit maturity, the higher the nutritional content.

The results of the analysis of pineapple peel moisture content of 79.08% which is lower than the literature of Ezugwu, et al (2014), which is 81.72%. The reduced sugar content of pineapple peel is 14.20% which is higher than the literature of Ezugwu, et al (2014), which is 13.66%. Vitamin C content of pineapple peel was obtained at 29.70 mg/100g which is higher than the literature of Putri *et. al,* (2018), which is 24/4 mg/100g. The result of antioxidant activity analysis of pineapple peel is 58.06% which is lower than the literature of Putri *et. al,* (2018), which is 59.05%. Crude fiber content of pineapple peel is 2.04% which is lower than the literature of Sengar, et al (2021), which is 2.41%. The pH value of pineapple peel is 5.83 which is lower than the literature of Gunawan (2018), which is 6.3. Differences in the results of the analysis of water content, reducing sugar content, vitamin C content, antioxidant activity, and crude fiber content in pineapple peels can be influenced by several factors, namely differences in type, maturity level, climatic conditions, place of growth, and post-harvest fruit storage. This is supported by Mashud and Matana (2014), that the chemical composition of a plant can be influenced by several factors, namely plant age, soil and climate conditions and the statement of Firmansyah, et al (2016), that the increase in nutrients and phytochemical

compounds such as antioxidant activity is also influenced by the level of fruit maturity, the higher the level of fruit maturity, the higher the nutritional content.

B. *Fruit Leather* Product Analysis Results

1. Water Content

Based on the results of the analysis of variance (Appendix 4.) showed that there was a real interaction (p≤0.05) between the treatment of the proportion of pineapple stem and peel and the concentration of carrageenan on the moisture content of *fruit leather and* each treatment had a significant effect on the moisture content of *fruit leather*. The average value of *fruit leather* moisture content with the treatment of the proportion of pineapple stem and peel and carrageenan concentration can be seen in Table 7.

Table 7: Average Value of Moisture Content of *Fruit Leather* with Pineapple Peel Treatment: Pineapple Peel and Carrageenan Concentration

Treatment		Water Content (%)	Notation	DMRT
Proportion of Tuber: Pineapple Peel (w/b)	Carrageenan Concentration (%)			
60 : 40	0,6	12,38 ± 0,25	a	-
60 : 40	0,8	12,85 ± 0,20	b	0,34
60 : 40	1,0	13,38 ± 0,04	c	0,35
50 : 50	0,6	14,06 ± 0,05	d	0,36
50 : 50	0,8	15,79 ± 0,13	e	0,37
50 : 50	1,0	16,26 ± 0,09	f	0,37
40 : 60	0,6	16,79 ± 0,13	g	0,37
40 : 60	0,8	17,21 ± 0,18	h	0,37
40 : 60	1,0	17,78 ± 0,15	i	0,37

Table 7 shows that the average moisture content of *fruir leather* ranged from 12.38 - 17.78%. The treatment of the proportion of pineapple pith and peel 40: 60 and carrageenan concentration of 1.0% produced the highest moisture content of 17.78%, while the treatment of the proportion of pineapple pith and peel of 60 : 40 and carrageenan concentration of 0.6% produced the lowest water content of 12.38%. The relationship between the treatment of the proportion of pineapple pith and peel and the concentration of carrageenan in the manufacture of *fruit leather* to the moisture content can be seen in Figure 6.

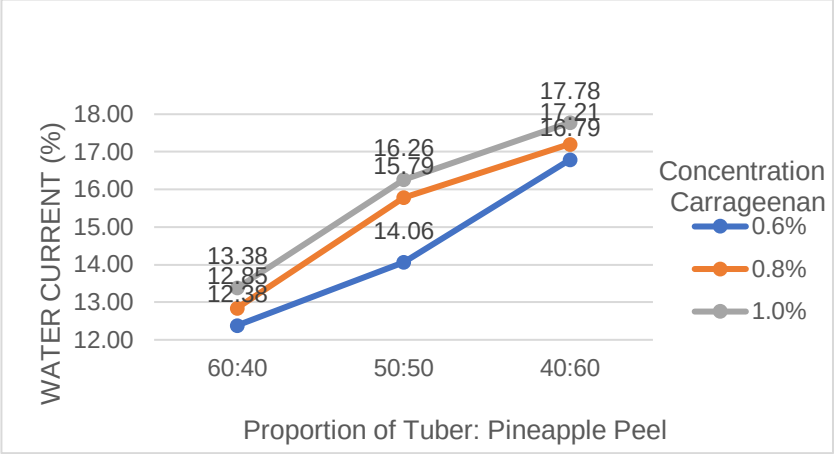


Figure 6: Relationship between the Proportion of Pineapple Peel and the Concentration of Carrageenan on the Moisture Content of Fruit Leather: Pineapple Peel and Carrageenan Concentration on the Moisture Content of *Fruit Leather*.

Figure 6 shows that the lower the proportion of pineapple hull and the higher the proportion of pineapple peel, and the higher the concentration of carrageenan, the moisture content of *fruit leather* increases. This is because pineapple peel contains relatively high fiber which is easy to bind water and carrageenan also has the ability to bind water, the fiber content of pineapple pith is 1.53% and pineapple peel is 2.04%. Fiber content is very important in making *fruit leather*, because the amount of fiber affects the amount of bound water, high fiber content increases the ability to absorb water because there are quite a lot of free hydroxyl groups in the fiber which are polar. Similarly, the higher concentration of carrageenan can increase the moisture content of *fruit leather,* because carrageenan is a hydrocolid that functions as a gelling agent and water binder so that it can increase the moisture content of the final product.

This is supported by Lamban (2017), that if the water content in the material is higher than the fiber content, it will produce a soft and not compact texture because the ability to bind water will be reduced. Fiber is able to bind water and maintain texture (Darojat, 2010). This is also supported by Legowo and Nurwanto (2004), that increasing the concentration of carrageenan causes an increase in the moisture content of *leather* products, because the higher the concentration of hydrocolloids, the *more* water is bound in the hydrocolloid network, and the formation of gels in carrageenan occurs due to the cross-linking of polymer chains so that a three-dimensional mesh is formed that will capture water in it to form a strong and rigid structure (Nuraini, 2001).

In the process of making *fruit leather, the* heating and drying temperatures used have not reached the temperature of evaporation of water content, so not much water is evaporated during the process of making *fruit leather*. This is supported by Sudarmadji, et al (2013), that weakly bound water is water that is absorbed on the surface of macromolecular colloids such as protein, pectin, carrageenan, starch, and cellulose which are easily evaporated by heating at a temperature of 95-110^{o} C.

2. Reduced Sugar Content

Based on the results of the analysis of variance (Appendix 5.) showed that there was a real interaction ($p \leq 0.05$) between the treatment of the proportion of pomace: pineapple peel and carrageenan concentration on the reduction sugar content of *fruit leather*. Similarly, each treatment had a significant effect on the reduction sugar content of *fruit leather*. The average value of reducing sugar content of *fruit leather* with the treatment of proportion of pomace : pineapple peel and carrageenan concentration can be seen in Table 8.

Table 8. Average Value of Reduced Sugar Content of *Fruit Leather* with the Treatment of Pork: Pineapple Peel and Carrageenan Concentration

Treatment		Reduced Sugar (%)	Notation	DMRT
Proportion of Tuber: Pineapple Peel (w/b)	Carrageenan Concentration (%)			
60 : 40	0,6	25,60 ± 0,13	G	0,19
60 : 40	0,8	25,70 ± 0,08	G	0,19
60 : 40	1,0	26,02 ± 0,07	H	0,19
50 : 50	0,6	24,15 ± 0,07	D	0,18
50 : 50	0,8	24,54 ± 0,05	E	0,18
50 : 50	1,0	24,83 ± 0,04	F	0,19
40 : 60	0,6	23,04 ± 0,03	A	-
40 : 60	0,8	23,54 ± 0,05	B	0,17
40 : 60	1,0	23,82 ± 0,10	C	0,18

Table 8 shows that the average reduction sugar content of *fruir leather* ranged from 23.04 - 26.02%. The treatment of the proportion of pomace: pineapple peel 60: 40 and carrageenan concentration of 1.0% resulted in the highest reduction

sugar content of 26.02%, while the treatment of the proportion of pith : pineapple peel 40: 60 and carrageenan concentration of 0.6% produced the lowest reduction sugar content of 23.04%. The relationship between the proportion of pith : pineapple peel with the addition of various concentrations of carrageenan in the manufacture of *fruit leather* to the level of reducing sugar can be seen in Figure 7.

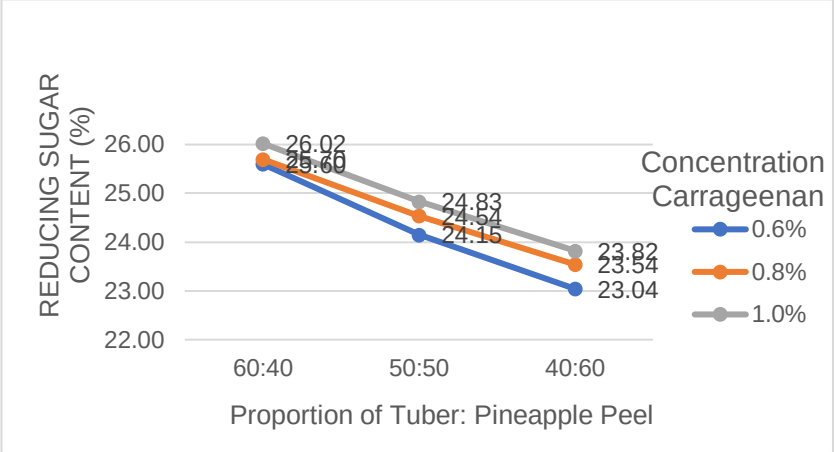


Figure 7: Relationship between the Treatment of Proportion of Pomegranate: Pineapple Peel and Carrageenan Concentration on Reduced Sugar Content of *Fruit Leather*.

Figure 7 shows that the higher the proportion of pineapple pith or the lower the proportion of pineapple peel, and the higher the concentration of carrageenan, the higher the reducing sugar content of *fruit leather*. This is because pineapple pith has a higher reducing sugar content of 16.56%, compared to pineapple peel which is 14.20%. Similarly, carrageenan concentration also influenced the increase in reducing sugar content due to the heating process, because during the heating process the carrageenan polymer will form a gel. The ability of gel formation on carrageenan occurs when the hot solution is allowed to cool down due to the reaction of anhydro-galactose formation which is a gelling group, in the structure of carrageenan there is the presence of galactan molecules with the main unit is galactose which is a class of reducing sugars. So that the higher the concentration of carrageenan, the formation of anhydro-galactose by heating will increase the reducing sugar content in *fruit leather*. This is supported by Distantina, et al (2012), that carrageenan gel is caused by the reaction of anhydro-galactose formation which is a gelling group, and Basuki, et al (2014) also stated that in the structure of carrageenan there is the presence of galactan molecules with the main units

being galactose which contains hydroxyl groups that are reactive and reducing at the end of its wake structure. This is also supported by Efendi, et al (2018) that the reducing sugar content of pineapple stump is 14.38%, while the reducing sugar content in pineapple skin is 13.65% (Ezugwu, et al 2014).

3. Vitamin C content

Based on the results of the analysis of variance (Appendix 6.) shows that there is a real interaction (p≤0.05) between the treatment of the proportion of pith: pineapple peel and carrageenan concentration on vitamin C content of *fruit leather* and each treatment has a significant effect on vitamin C content of *fruit leather*. The average value of vitamin C content of *fruit leather* with the treatment of proportion of pith : pineapple peel and carrageenan concentration can be seen in Table 9.

Table 9: Average Value of Vitamin C Content of *Fruit Leather* with Pineapple Peel Treatment: Pineapple Peel and Carrageenan Concentration

Treatment		Vitamin C (mg/100g)	Notation	DMRT
Proportion of Tuber: Pineapple Peel (w/b)	Carrageenan Concentration (%)			
60 : 40	0,6	15,44 ± 0,08	ef	0,22
60 : 40	0,8	15,64 ± 0,08	f	0,22
60 : 40	1,0	16,15 ± 0,02	g	0,22
50 : 50	0,6	14,84 ± 0,08	c	0,21
50 : 50	0,8	15,19 ± 0,15	d	0,22
50 : 50	1,0	15,37 ± 0,09	de	0,22
40 : 60	0,6	14,42 ± 0,08	a	-
40 : 60	0,8	14,55 ± 0,06	ab	0,20
40 : 60	1,0	14,74 ± 0,09	bc	0,21

Table 8 shows that the average vitamin C content of *fruir leather* ranged from 14.42 - 16.15%. The treatment of the proportion of stump: pineapple peel 60: 40 and carrageenan concentration of 1.0% produced the highest vitamin C content of 16.15%, while the treatment of the proportion of pineapple pith : pineapple peel 40: 60 with the addition of 0.6% carrageenan produced the lowest vitamin C content of 14.42%. The relationship between the treatment of the proportion of pith :

pineapple peel with the addition of various concentrations of carrageenan in the manufacture of *fruit leather* to vitamin C content can be seen in Figure 8.

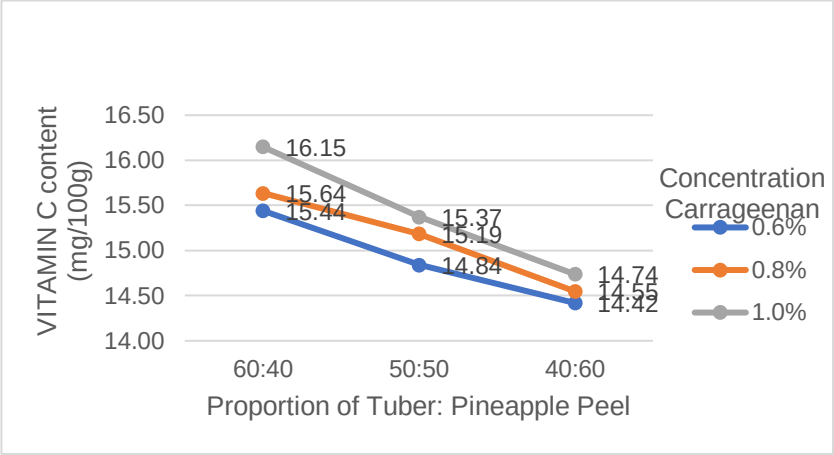


Figure 8: Relationship between the Treatment of Proportion of Pomegranate: Pineapple Peel and Carrageenan Concentration on Vitamin C Content of *Fruit Leather*.

Figure 8 shows that the lower the proportion of pineapple hull or the higher the proportion of pineapple peel, as well as the higher the concentration of carrageenan, with the addition of carrageenan which is water-binding and able to protect the components contained so as to maintain vitamin C levels in *fruit leather*. This is because pineapple stem has a higher vitamin C content of 72.44 mg/100g, compared to pineapple peel of 29.70 mg/100g. Similarly, carrageenan concentration can also maintain vitamin C levels in *fruit leather,* because carrageenan is a hydrocolloid compound that has water-binding properties and can protect vitamin C from heating and avoid the loss of vitamin C content. The higher concentration of carrageenan can maintain vitamin C levels by being coated by a three-dimensional matrix formed by carrageenan so that it is not easily lost during the heating process, because carrageenan has a hydroxyl group, so that it can protect bioactive compounds in a three-dimensional matrix from heat (Masuda, et al., 2004). In addition, during the process of making *fruit leather the* temperature used has not reached a temperature that can cause damage to vitamin C, because vitamin C begins to degrade or damage at temperatures above 80^{o} C (Hok, et al, 2007). This is also supported by Titin, et al (2011), that the vitamin C content of pineapple stem is 68.56 mg/100g, while the vitamin C content of pineapple skin is 24.4 mg/100g.

4. Antioxidant Activity

Based on the results of the analysis of variance (Appendix 7.) showed that there was a significant interaction ($p \leq 0.05$) between the treatment of the proportion of pith : pineapple peel and carrageenan concentration on the antioxidant activity of *fruit leather* and each treatment had a significant effect on the antioxidant activity of *fruit leather*. The average value of antioxidant activity of *fruit leather* with the treatment of proportion of pith : pineapple peel and carrageenan concentration can be seen in Table 10.

Table 10: Average Value of Antioxidant Activity of *Fruit Leather* Treated with Pineapple Peel and Carrageenan Concentration: Pineapple Peel and Carrageenan Concentration

Treatment		Antioxidant Activity (%)	Notation	DMRT
Proportion of Tuber: Pineapple Peel (w/b)	Carrageenan Concentration (%)			
60 : 40	0,6	27,44 ± 0,08	ef	0,22
60 : 40	0,8	27,64 ± 0,08	f	0,22
60 : 40	1,0	28,15 ± 0,02	g	0,22
50 : 50	0,6	26,84 ± 0,08	c	0,21
50 : 50	0,8	27,19 ± 0,15	d	0,22
50 : 50	1,0	27,37 ± 0,09	de	0,22
40 : 60	0,6	26,42 ± 0,08	a	-
40 : 60	0,8	26,55 ± 0,06	ab	0,20
40 : 60	1,0	26,74 ± 0,09	bc	0,21

Table 10 shows that the average antioxidant activity of *fruir leather* ranged from 26.42 - 28.15%. The treatment of the proportion of pomace: pineapple peel 60: 40 and carrageenan concentration of 1.0% resulted in the highest antioxidant activity of 28.15%, while the treatment of the proportion of pith : pineapple peel 40: 60 and carrageenan concentration of 0.6% produced the lowest antioxidant activity of 26.42%. The relationship between the treatment of proportion of pomace : pineapple peel and various concentrations of carrageenan in making *fruit leather* on antioxidant activity can be seen in Figure 9.

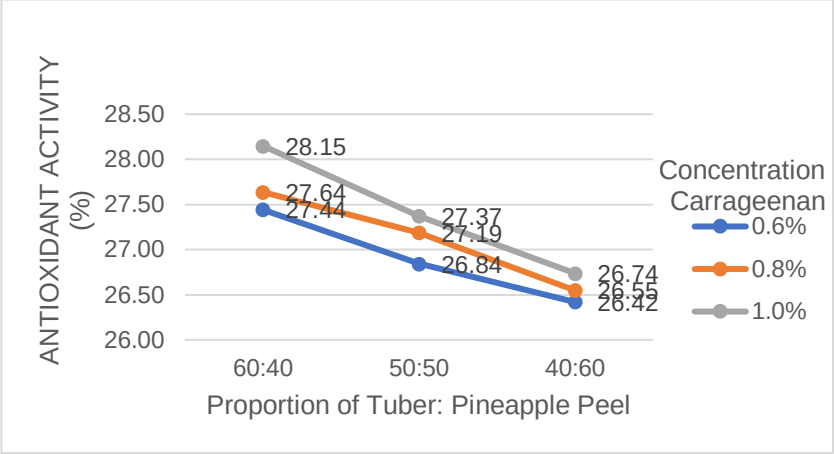


Figure 9: Relationship between the Proportion of Pineapple Peel and the Addition of Carrageenan Concentration to the Antioxidant Activity of Fruit Leather: Pineapple Peel and the Addition of Carrageenan Concentration to the Antioxidant Activity of *Fruit Leather*.

Figure 9 shows that the lower the proportion of pineapple pith or the higher the proportion of pineapple peel, and the higher the concentration of carrageenan, the higher the antioxidant activity of *fruit leather*. This is because pineapple pith has a higher antioxidant activity of 68.10%, compared to pineapple peel of 58.06%, but there is a significant decrease in antioxidant activity in *fruit leather* products compared to the antioxidant activity of the raw materials. This can occur because the catechin compounds in pineapple stem and skin are polyphenols which are polar antioxidants, which are hydrophilic so that during the preparation process of raw materials, these antioxidant compounds decrease due to exposure to water (Putri, et al., 2021). The addition of carrageenan can prevent the oxidation of antioxidant compounds during the heating process in the manufacture of *fruit leather,* because carrageenan is a hydrocolloid compound that has the property of binding water and can protect the components in the material from heating and avoid the loss of antioxidant compounds. The higher concentration of carrageenan can maintain antioxidant compounds by being coated by a three-dimensional matrix formed by carrageenan so that it is not easily lost during the heating process, because carrageenan has a hydroxyl group, so it can protect bioactive compounds in a three-dimensional matrix from heat (Masuda, et al, 2004). This is also supported by Vrianty, et al (2019), that the antioxidant activity of pineapple bark is 64.86%, while the antioxidant activity of pineapple skin is 59.05%.

Antioxidant compounds contained in pineapple hull and skin, namely phenol and flavonoid compounds (Lobo and Yahia, 2016).

5. Crude Fiber Content

Based on the results of the analysis of variance (Appendix 8.) showed that there was a real interaction (p≥0.05) between the treatment of the proportion of pith: pineapple peel and carrageenan concentration on the crude fiber content of *fruit leather and* each treatment had a significant effect on the crude fiber content of *fruit leather*. The average value of crude fiber content of *fruit leather* with the treatment of the proportion of bark: pineapple peel can be seen in Table 11.

Table 11: Average Value of Coarse Fiber Content of *Fruit Leather* with the Treatment of Pineapple Peel and Carrageenan Concentration: Pineapple Peel and Carrageenan Concentration

Treatment		Crude Fiber Content (%)	Notation	DMRT
Proportion of Tuber: Pineapple Peel (w/b)	Carrageenan Concentration (%)			
60 : 40	0,6	2,05 ± 0,08	a	-
60 : 40	0,8	2,33 ± 0,05	b	0,18
60 : 40	1,0	2,49 ± 0,06	c	0,18
50 : 50	0,6	2,62 ± 0,05	c	0,19
50 : 50	0,8	2,82 ± 0,05	d	0,19
50 : 50	1,0	3,08 ± 0,08	e	0,19
40 : 60	0,6	3,22 ± 0,13	e	0,19
40 : 60	0,8	3,72 ± 0,06	f	0,19
40 : 60	1,0	4,04 ± 0,10	g	0,19

Table 11 shows that the average crude fiber content of *fruir leather* ranged from 2.05 - 4.04%. The treatment of the proportion of pomace: pineapple peel 40: 60 and carrageenan concentration of 1.0% produced the highest crude fiber content of 4.04%, while the treatment of the proportion of pith : pineapple peel 60: 40 and carrageenan concentration of 0.6% produced the lowest crude fiber content of 2.05%. The relationship between the treatment of the proportion of pith : pineapple peel and carrageenan concentration in the manufacture of *fruit leather* to crude fiber content can be seen in Figure 10.

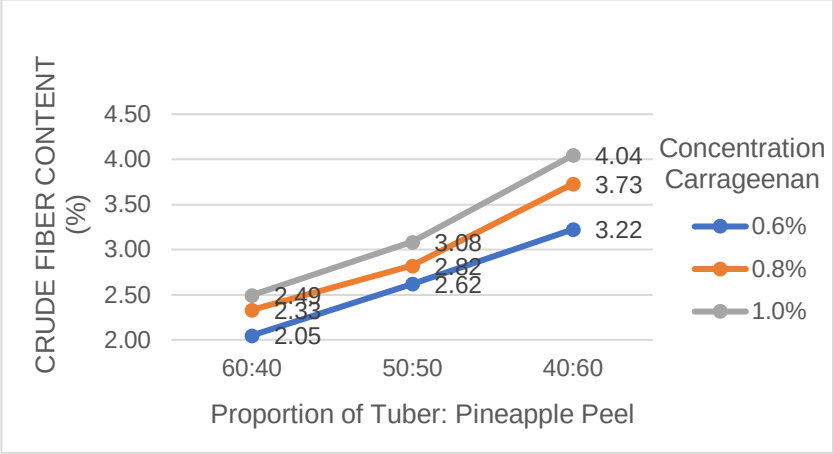


Figure 10: Relationship between the Proportion of Pineapple Peel and the Concentration of Carrageenan on the Coarse Fiber Content of Fruit Leather: Pineapple Peel and Carrageenan Concentration on the Coarse Fiber Content of *Fruit Leather*.

Figure 10 shows that the lower the proportion of pineapple hull or the higher the proportion of pineapple peel, and the higher the concentration of carrageenan, the crude fiber content of *fruit leather* products increases. This is because pineapple peel has a higher crude fiber content of 2.04%, compared to pineapple hull, which is 1.53%. Similarly, the concentration of carrageenan can also affect the crude fiber content due to the presence of crude fiber content of 6.61% in carrageenan (Yasita, 2009), besides that carrageenan is a type of stabilizer that becomes a thickener from the polysaccharide group consisting of two types of monosaccharide units, namely galactose and anhydro-galactose. The use of carrageenan can affect the crude fiber content of *fruit leather*, because carrageenan has the ability to interact with fibers in pineapple stump and peel due to the presence of hydroxyl groups in carrageenan that can form hydrogen bonds with fibers, so as to hold the fiber content in the carrageenan matrix in *fruit leather*. This is supported by Estiasih and Ahmadi (2009), that carrageenan can bind the components contained in the material. Sengar, et al (2021), also stated that the crude fiber content of pineapple peel was 2.41%, while the crude fiber content of pineapple stump was 1.53%.

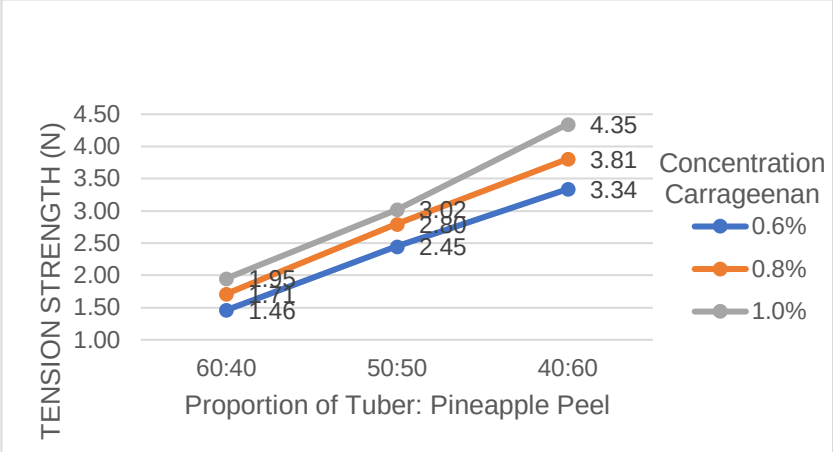
6. Tensile Strength

Based on the results of the analysis of variance (Appendix 9.) showed that there was a real interaction (p≤0.05) between the treatment of the proportion of pith: pineapple peel and carrageenan concentration on the tensile strength of *fruit leather*. Similarly, each treatment had a significant effect on the tensile strength of *fruit leather*. The average value of tensile strength of *fruit leather* with the treatment of proportion of bark: pineapple peel and carrageenan concentration can be seen in Table 12.

Table 12: Average Value of Tensile Strength of *Fruit Leather* with the Treatment of Pineapple Pith: Pineapple Peel and Carrageenan Concentration

Treatment		Tensile Strength (N)	Notation	DMRT
Proportion of Tuber: Pineapple Peel (w/b)	Carrageenan Concentration (%)			
60 : 40	0,6	1,46 ± 0,09	a	-
60 : 40	0,8	1,71 ± 0,08	b	0,22
60 : 40	1,0	1,95 ± 0,05	c	0,23
50 : 50	0,6	2,45 ± 0,11	d	0,23
50 : 50	0,8	2,80 ± 0,04	e	0,24
50 : 50	1,0	3,02 ± 0,09	f	0,24
40 : 60	0,6	3,34 ± 0,04	g	0,24
40 : 60	0,8	3,81 ± 0,11	h	0,24
40 : 60	1,0	4,35 ± 0,17	i	0,24

Table 12. shows that the average tensile strength of *fruir leather* ranged from 1.46 - 4.35 N. The treatment of the proportion of pith: pineapple peel 40: 60 and carrageenan concentration of 1.0% produced the highest tensile strength value of 4.35 N, while the treatment of the proportion of pith : pineapple peel 60: 40 and carrageenan concentration of 0.6% produced the lowest tensile strength value of 1.46 N. The relationship between the treatment of the proportion of pith : pineapple peel and carrageenan concentration in the manufacture of *fruit leather* on tensile strength can be seen in Figure 10.



The relationship between the proportion of pineapple pomace : pineapple peel and carrageenan concentration on the tensile strength of *fruit leather*.

Figure 11 shows that the lower the proportion of pineapple pith or the higher the proportion of pineapple peel, and the higher the concentration of carrageenan, the tensile strength of *fruit leather* increases. This is because the higher the proportion of pineapple peel, the higher the organic acid content. The content of organic acids in pineapple peel includes citric acid, malic acid, and oxalic acid. Oxalic acid and citric acid are a group of strong organic acid compounds, which are able to increase the level of acidity, so that the pH will tend to be low or acidic and can help the formation of a stronger gel. Similarly, increasing the concentration of carrageenan can cause cross-linking of polymers consisting of a sufficient number of long-chain molecules, so that a continuous three-dimensional building will be formed that can form a rigid and tough structure that is resistant to certain forces and pressures (Astuti, et al., 2015).

This is supported by the statement of Suyata (2006), that oxalic acid is a strong organic acid with a pKa value of 1.3 - 4.3, and the statement of Sitorus, et al (2015), that the smaller the pKa value in organic compounds, the higher the acidity level and organic acids are able to form gels faster and provide high gel strength (Nopriantini, 2005). Darmawan, et al (2014), also stated that of all carrageenan, kappa carrageenan provides the strongest and most flexible tensile strength value.

7. Organoleptic Test (Hedonic/Liking Test)

Organoleptic test is conducted to determine the results of panelists' objective measurements of the sensory attributes of a product. The sensory attributes analyzed in the organoleptic test use the sensing system, namely color, taste,

aroma, and texture. Organoleptic testing has an important role in the application of quality. Organoleptic testing can provide an indication of spoilage, quality deterioration and other damage to the product (Winarno, 2004). This test is carried out using the *hedonic scale* method, which is transformed into a numerical scale according to the level of favorability of the panelists, ranging from the smallest number to the largest number.

a. Color Taste Test

Color is one of the parameters that can influence consumers on the acceptance of a food product. If a food product has high nutritional value, good taste, and good texture, but if the color is less attractive, the product is likely to be less desirable (Safitri, et al, 2020). Based on the *Friedman* Test in Appendix 11. shows that the treatment of the proportion of pineapple stump: peel, as well as the concentration of carrageenan, there is no significant difference in the color of *fruit leather*. The average value of *fruit leather* color liking based on the treatment given can be seen in Table 13.

Table 13: Average Value of Color Preference of *Fruit Leather* with the Treatment of Pineapple Peel and Carrageenan Concentration: Pineapple Peel and Carrageenan Concentration

Treatment		Average	Total Rank
Proportion of Tuber: Pineapple Peel (w/b)	Carrageenan Concentration (%)		
60 : 40	0,6	3,36	115,5
60 : 40	0,8	3,64	141
60 : 40	1,0	3,48	127,5
50 : 50	0,6	3,60	141
50 : 50	0,8	3,44	125
50 : 50	1,0	3,52	129,5
40 : 60	0,6	3,68	145,5
40 : 60	0,8	3,16	104
40 : 60	1,0	3,12	96

Description: [1)]The higher the number of ranks, the more favorable it is to the panelists. [2)]Mean value 1 (strongly dislike), 2 (dislike), 3 (neutral), 4 (like), 5 (strongly like).

Based on Table 13. the level of panelists' liking for the color of *fruit leather* with the treatment of the proportion of bongo: pineapple peel and carrageenan concentration obtained an average preference between 3.12 - 3.68. The treatment

of proportion of bongo: pineapple peel 40: 60 and carrageenan concentration of 0.6% produced *fruit leather* color with the highest level of preference with a total ranking of 145.5 and an average of 3.68, this result was liked by panelists because it had a slightly brownish yellow color. In the treatment of the proportion of stump: pineapple peel 40: 60 with the addition of carrageenan concentration of 1.0% produced *fruit leather* color with the lowest level of preference with a total ranking of 96 and an average of 3.12, which has a yellow color tending to brown. In the manufacture of *fruit leather,* there are several raw materials that contain reducing sugars, namely 16.56% of the stem and 14.20% of the skin and the addition of 20% sucrose which can cause the *maillard* reaction.

This is supported by Praseptiangga, et al (2016), which states that discoloration or browning that occurs in *fruit leather is* caused by the *maillard* reaction*. The maillard* reaction occurs due to the reaction between primary or free amino groups from proteins with aldehydes or ketones from reducing sugars and produces brown compounds (Suseno, et al, 2008). Thus, the proportion of pineapple stump : pineapple peel and the addition of carrageenan concentration did not significantly affect the color of *fruit leather*.

b. Taste Test

Taste is one of the factors that influence a person's acceptance of food products. The taste of a food product has an important role, because with taste indicators consumers can know and judge whether the food is delicious or not, the taste of a food product is influenced by the basic ingredients used (Fauziah, 2015). Based on the *Friedman* Test in Appendix 13. shows that the treatment of the proportion of pineapple stump: pineapple peel, as well as the concentration of carrageenan, there is no significant difference in the taste of *fruit leather*. The average value of *fruit leather* flavor preference based on the treatment given can be seen in Table 14.

Table 14: Average Value of *Fruit Leather* Flavor Favorability with the Treatment of Pineapple Peel and Carrageenan Concentration: Pineapple Peel and Carrageenan Concentration

Treatment	Average	Total Rank

Proportion of Tuber: Pineapple Peel (w/b)	Carrageenan Concentration (%)		
60 : 40	0,6	3,36	113
60 : 40	0,8	3,52	124
60 : 40	1,0	3,16	95,5
50 : 50	0,6	3,60	131,5
50 : 50	0,8	3,76	145
50 : 50	1,0	3,44	117,5
40 : 60	0,6	3,80	148
40 : 60	0,8	3,68	136
40 : 60	1,0	3,40	114,5

Description: [1)]The higher the number of ranks, the more favorable it is to the panelists. [2)]Mean value 1 (strongly dislike), 2 (dislike), 3 (neutral), 4 (like), 5 (strongly like).

Based on Table 14. the level of panelists' liking for the taste of *fruit leather* and carrageenan concentration obtained an average liking between 3.16 - 3.80. The treatment of the proportion of fruit leather: pineapple peel 40: 60 and carrageenan concentration of 0.6% produced *fruit leather* flavor with the highest level of liking with a total ranking of 148 and an average of 3.80. In the treatment of the proportion of pith: pineapple peel 60: 40 with the addition of 1.0% carrageenan concentration resulted in the taste of *fruit leather* with the lowest level of preference with a total ranking of 95.5 and an average of 3.16, both of which had a sweet taste. The sweet taste produced is due to the addition of sucrose by 20% in the manufacture of *fruit leather*.

This is supported by Marzelly (2015), which states that the presence of sugar or sucrose can improve the taste of food ingredients. The sweetness of granulated sugar is pure because it does not leave an *after taste in* the food. The addition of carrageenan also does not affect the flavor of *fruit leather,* because carrageenan is a component that has no taste. Sweetness is more dominant in the flavor formed in *fruit leather* due to the addition of sucrose.

c. Aroma Taste Test

Aroma is one of the factors in food products that can be accepted by consumers. Aroma is produced by volatile compounds of a food product, when consuming food products, the aroma of food products will be smelled first (Winarno, 2004). Based on the *Friedman* Test in Appendix 15. shows that the treatment of the proportion

of pineapple stump: peel, as well as the concentration of carrageenan, there is no significant difference in the aroma of *fruit leather*. The average value of *fruit leather* aroma preference based on the treatment given can be seen in Table 15.

Table 15: Mean Aroma Favorability of *Fruit Leather* Aroma: Pineapple Peel and Carrageenan Concentration

Treatment		Average	Total Rank
Proportion of Tuber: Pineapple Peel (w/b)	Carrageenan Concentration (%)		
60 : 40	0,6	2,88	102
60 : 40	0,8	3,08	118,5
60 : 40	1,0	3,12	122,5
50 : 50	0,6	3,40	150,5
50 : 50	0,8	3,08	115
50 : 50	1,0	3,24	133
40 : 60	0,6	3,48	153,5
40 : 60	0,8	2,96	107
40 : 60	1,0	3,16	123

Description: [1)]The higher the number of ranks, the more favorable it is to the panelists. [2)]Mean value 1 (strongly dislike), 2 (dislike), 3 (neutral), 4 (like), 5 (strongly like).

Based on Table 15. the level of panelists' liking for the aroma of *fruit leather* with the treatment of the proportion of pith: pineapple peel and the concentration of carrageenan, the average liking is between 2.88 - 3.48. The treatment of the proportion of pith: pineapple peel 40: 60 and carrageenan concentration of 0.6% produced *fruit leather* flavor with the highest level of liking with a total ranking of 153.5 and an average of 3.48. In the treatment of the proportion of pith: pineapple peel 60: 40 and carrageenan concentration of 0.6% produced *fruit leather* flavor with the lowest level of preference with a total ranking of 102 and an average of 2.88, both of which had pineapple and sugar (sweet/caramel) aroma. In making *fruit leather,* there are ingredients that affect the aroma produced, namely the raw materials used in the form of pineapple stem and skin and the addition of sucrose.

This is supported by Estiasih (2009), which states that the formation of flavor compounds from caramelized sugar forms pyrodextrin and melanoidin, as well as the formation of aromatic compounds consisting of aldehydes, ketones, various esters, acids, and alcohols. The use of pineapple stump and peel also causes a distinctive aroma of pineapple *fruit* in *fruit leather* products.

d. Texture Sensitivity Test

Texture is a sense that is associated with touch or touch. Texture is an important physical property of food products because it has a relationship with the taste when chewing the product (Winarno, 2004). Based on the *Friedman* Test in Appendix 17. shows that the treatment of the proportion of pineapple stump: peel, as well as the concentration of carrageenan, there is a significant difference in the texture of *fruit leather*. The average value of *fruit leather* texture preference based on the treatment given can be seen in Table 16.

Based on Table 16. the level of panelists' liking for the texture of *fruit leather* with the treatment of the proportion of pith: pineapple peel and carrageenan concentration, the average liking is between 2.72 - 3.64. The treatment of the proportion of pith: pineapple peel 40: 60 and carrageenan concentration of 0.6% produced the texture of *fruit leather* with the highest level of preference with a total ranking of 162 and an average of 3.64, which has a soft, soft and sticky texture. In the treatment of the proportion of stump: pineapple peel 60: 40 and carrageenan concentration of 1.0% produced *fruit leather* color with the lowest level of preference with a total rank of 90 and an average of 2.72, which has a clayey and compact texture.

Table 16: Average Value of *Fruit Leather* Texture Favorability with the Treatment of Pineapple Peel and Carrageenan Concentration: Pineapple Peel and Carrageenan Concentration

Treatment		Average	Total Rank
Proportion of Tuber: Pineapple Peel (w/b)	Carrageenan Concentration (%)		
60 : 40	0,6	2,88	99,5
60 : 40	0,8	2,84	101,5
60 : 40	1,0	2,72	90
50 : 50	0,6	3,44	144,5
50 : 50	0,8	3,48	155
50 : 50	1,0	3,36	139
40 : 60	0,6	3,64	162
40 : 60	0,8	3,36	139
40 : 60	1,0	2,84	94,5

Description: [1)]The higher the number of ranks, the more favorable it is to the panelists. [2)]Mean value 1 (strongly dislike), 2 (dislike), 3 (neutral), 4 (like), 5 (strongly like).

The proportion of pineapple pith and peel affects the texture formed in *fruit leather*, the higher the addition of pineapple pith, the more water content and the texture becomes mushy and soft, while the more the addition of peel, the more fiber content and the texture becomes clayey and compact. The addition of carrageenan also affects the texture of *fruit leather, the more* carrageenan is added, the more clayey and hard the texture is.

This is supported by Darojat (2010), which states that fiber is able to bind water and maintain texture, as well as Lamban's (2017) statement, which states that if the water content in the material is higher than the fiber content, it will produce a soft and not compact texture because the ability to bind water will be reduced. Sidi (2014), also stated that hydrocolloids such as carrageenan because they can function as adhesives, water binders, emulsifiers, gelling, and product thickeners.

8. Decision Analysis

Determination of the best treatment for bonggl *fruit leather is* based on the calculation of effectiveness value (De Garmo *et. al*, 1984) on organoleptic and physicochemical characteristics. The table of the results of the analysis of the effectiveness value of physicochemical and organoleptic characteristics can be seen in Table 17.

Based on Table 17. the treatment with the proportion of bonggol: pineapple peel 50: 50 with the addition of 1% carrageenan concentration gets the highest total effectiveness value on physicochemical and organoleptic characteristics with a value of 16.26% moisture content, 24.83% reduction sugar content, 15.37 mg/100g vitamin C content, 27.37% antioxidant activity, 3.08% crude fiber content, and 3.02 N tensile strength and organoleptic characteristics including color 3.52 (neutral), taste 3.44 (neutral), aroma 3.24 (neutral), and texture 3.36 (neutral). The variable weight of the moisture content parameter uses the maximum weight because it is related to the physical value and functional value of *fruit leather*.

Results of Analysis of Effectiveness Value (NE) of Physicochemical and Organoleptic Characteristics of *Fruit Leather*.

Parameters	Total Result Value (NH)									Variable Weight (BV)	Normal Weight (BN)
	A1B1	A1B2	A1B3	A2B1	A2B2	A2B3	A3B1	A3B2	A3B3		
Water Content	0,15	0,16	0,18	0,06	0,11	0,13	0,00	0,02	0,03	1,00	0,18
Reduced Sugar	0,08	0,08	0,09	0,03	0,05	0,05	0,00	0,02	0,02	0,50	0,09
Act. Antioxidant	0,01	0,01	0,02	0,00	0,01	0,01	0,00	0,00	0,00	0,10	0,02
Vitamin C	0,08	0,09	0,13	0,03	0,06	0,07	0,00	0,01	0,02	0,70	0,13
Crude Fiber	0,00	0,01	0,02	0,03	0,05	0,06	0,10	0,11	0,11	0,60	0,11
Tensile Strength	0,00	0,01	0,03	0,06	0,08	0,09	0,11	0,13	0,16	0,90	0,16
Color	0,03	0,07	0,05	0,06	0,04	0,05	0,07	0,01	0,00	0,40	0,07
Taste	0,02	0,03	0,00	0,04	0,05	0,02	0,05	0,04	0,02	0,30	0,05
Aroma	0,00	0,01	0,01	0,03	0,01	0,02	0,04	0,00	0,02	0,20	0,04
Texture	0,03	0,02	0,00	0,11	0,12	0,10	0,15	0,10	0,02	0,80	0,15
Total	**0,39**	**0,50**	**0,53**	**0,45**	**0,57**	**0,61**	**0,52**	**0,44**	**0,41**	**5,50**	**1,00**

Notes: A1 = 60:40, A2 = 50:50, A3 = 40:60, B1 = 0.6%, B2 = 0.8%, B3 = 1.0%

9. Best Treatment Analysis

The best treatment analysis was carried out in the proportion of pineapple stump: pineapple peel 50: 50 : 50 with the addition of 1.0% carrageenan, because it showed the best treatment on organoleptic characteristics. The results of further analysis on the best treatment can be seen in Table 18.

Table 18: Analysis Result of Best Treatment of *Fruit Leather*

Parameters	Analysis Result
Total dietary fiber (%)	20,21
Water Soluble Dietary Fiber (%)	18,02
Water Insoluble Dietary Fiber (%)	2,19

The results of the analysis of the best treatment for *fruit leather* treatment of pineapple *fruit leather* with carrageenan concentration of 1.0% obtained a total food fiber content of 20.21% which included 18.02% water soluble food fiber content and 2.19% water insoluble food fiber content. Food fiber content in *fruit leather is* due to the addition of carrageenan. According to Sidi, et al (2014), that kappa carrageenan has a total dietary fiber content of 69.3 g/100 g with insoluble fiber content of 58.6 g and soluble fiber content of 10.7 g in *dry basis*.

Research conducted by Sidi, et al (2014), also showed that the results of pineapple and carrot *fruit leather* with carrageenan concentrations of 0%, 0.3%, 0.6%, and 0.9% produced food fiber levels in *dry basis of* 1.99%, 3.20%, 4.15%, and 5.74% respectively. This shows that the higher the carrageenan concentration, the higher the dietary fiber content in *fruit leather*.

CHAPTER V
CONCLUSIONS AND SUGGESTIONS

A. Conclusion

Based on the research results, the following conclusions can be drawn:

1. There was a significant interaction between the proportion of pineapple stump : peel with the addition of carrageenan on moisture content, reducing sugar content, vitamin C content, antioxidant activity, crude fiber and tensile strength.
2. The best treatment is the proportion of bonggol: pineapple peel 50: 50 : 50 with the addition of 1% carrageenan concentration, producing 16.26% moisture content, 24.83% reduction sugar content, 15.37 mg/100g vitamin C content, 27.37% antioxidant activity, 3.08% crude fiber content, 3.02 N tensile strength, 20.21% total dietary fiber content and organoleptic characteristics including color 3.52 (neutral), taste 3.44 (neutral), aroma 3.24 (neutral), and texture 3.36 (neutral).

B. Advice

1. Further research is needed to improve the texture of *fruit leather* so that it is more favorable to panelists.
2. Further research needs to be done on the shelf life of *fruit leather* products, so that they can become marketable products.

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APPENDIX

Appendix 1. Analysis Procedure

a. Analysis of Reduced Sugar Content Luff-Schoorl method (Sulaiman, 1994)

1. Take the sample and add distilled water to 100 ml into the measuring flask.
2. Put 1 ml, 2 ml, 3 ml of each sample solution into Erlenmeyer using a pipette.
3. Add 25 ml of Luff-Schoorl reagent and 24 ml, 23 ml, and 22 ml of distilled water respectively (up to 50 ml solution volume).
4. Cover the erlenmeyer with a funnel lined with wet cotton as a counter-cooler.
5. Heat to boiling before 2 minutes, then maintain for 10 minutes, If the volume decreases, then add distilled water through a spray bottle.
6. Note which Erlenmeyer tube produces the best brick red precipitate and the blue solution is balanced. $CuSO_4$solution is balanced.
7. Select the best Erlenmeyer for repetition 3 times, Cool the selected Erlenmeyer quickly (soak in cold water) to room temperature.
8. Add 15 ml of 20% KI and 25 ml of H_2SO_4 26.5% through the wall of the Erlenmeyer (immediately cover with aluminum foil).
9. Titrate with $Na_2S_2O_3$ 0.1N solution to a raw (pale) yellow color.
10. Add 2 ml of 1% amylum and homogenize.
11. Titrate again with $Na_2S_2O_3$ 0.1N until the solution is exactly milk brown in color.
12. Do the same for the blank treatment (25 ml of Luff-Schoorl solution added with distilled water).
13. Determine the reducing sugar content, using the formula:

$$\text{Reduced sugar content (\%)} = \frac{mg\ gula\ reduksi}{mg\ sample}\ x\ FP\ x\ 100\%$$

b. Analysis of Crude Fiber Content (Sudarmadji, 1997)

1. Put the sample as much as 1 g into a 300 ml Erlenmeyer flask then added with H_2SO_4 0,3 N.
2. Under counter-cooling then simmer for 30 minutes with occasional shaking, Filter the suspension with filter paper and wash the residue obtained with boiling water until it is not acidic.
3. Transfer the residue into an Erlenmeyer, wash the residue left on the filter paper using 200 ml boiling NaOH until all the residue enters the Erlenmeyer.
4. Boil the sample again for 30 minutes and filter while washing with 95% alcohol, then dry the filter paper at 110°C until constant weight.

c. Oven Method Moisture Content (AOAC, 2005)

1. Dry the washed petri dishes in an oven for 1 hour and cool in a desiccator for 15 minutes, then weigh them.
2. Weigh the sample material as much as 2 grams using a Petri dish container that has a known weight, then oven at 100-105 ° C for 5 hours.
3. Cool the material in a desiccator, then weigh it.
4. Reheat the material in the oven for 30 minutes, then cool it in a desiccator and weigh it.
5. Repeat the treatment until a constant weight is obtained (consecutive weighing difference of 0.2 mg), Moisture content (KA) is calculated using the formula:

$$\text{Moisture content (\%b)} = \frac{c-(a-b)}{c}\ x\ 100\%$$

Description:

a = weight of cup and final sample (gr)

b = weight of cup (gr)

c = initial sample weight (gr)

d. Antioxidant Activity Test with DPPH Radical (1,1-diphenyl-2-picrylhydrazyl) (Subagio, 2001)

Sample of 0.1 g was suspended with 20 ml ethanol in Erlenmeyer and stirred for ± 10 minutes, then centrifuged at 5000 rpm for 5 minutes. Then take 1 ml of filtrate, add with 0.5 ml of DPPH reagent and let stand for 20 minutes after adding ethanol to a volume of 5 ml. The absorbance was immediately measured at λ =

517 nm. Blank was prepared in the same way but without sample. Antioxidant activity is expressed as the amount of DPPH radicals (mmol) reduced due to quenching by the sample (gram), and calculated based on the absorbance reduction caused by the sample.

$$\text{Antioxidant activity (\%)} = \frac{A,blanko - A,sample}{A,blanko}\ x\ 100\%$$

e. *Tensile* Strength Analysis with *Tensile Strength* (*Lloyd Universal Testing Instrument 1000S*)

1. Turn on the *tensile strength* machine and install tool accessories according to the sample that will be analyzed using pressure or pull.
2. Turn on the computer and enter the software program for the *tensile strength* machine*.*
3. The program appears on the screen after the *tensile strength* machine and computer are connected.
4. Place the cursor on ZERO and turn it ON so that the machine and computer monitor show 0.0 during the test.
5. Place the sample under the pressing accessories or clamp the sample with the pulling accessories.
6. Place the cursor on the [ ] mark and turn it ON so that the computer will automatically record the FORCE (N) and the distance traveled by the pressure or pull on the sample.
7. Tekan tombol [▼] untuk Penekanan (*Compression*) atau tombol [▲] untuk Tarikan (*Tension*) yang terdapat pada mesin *tensile strength.*
8. Once the test is complete press the [ ] b■tton to stop and save the data.
9. Measurement results in the form of graphs can be recorded or printed directly.
10. When finished, turn off the computer and *tensile strength* machine.

f. Vitamin C Content Analysis, Iodine Titration Method (Sudarmadji, 1997)

1. Weighing 200-300 g of material crushed in a *warring blender* until a *slurry is* obtained, weighing 10-30 g of *slurry is* put into a 100 ml volumetric flask

and added with distilled water until the mark. Filter the filtrate with *whatman* 0.4 filter paper or by centrifuge to separate the filtrate.

2. Take 5-25 ml of filtrate with a pipette and put it into a 125 ml Erlenmeyer plus 2 ml of 1% *soluble starch* amylum solution and add 20 ml of distilled water if necessary.
3. Then titrate with 0.01 N iodine standard.
4. Calculation = 1 ml of 0.01 N iodine is equivalent to 0.88 mg of vitamin c.

$$\% \text{ Vitamin C} = \frac{ml\ iodium\ x\ 0{,}88\ x\ fp}{mg\ sample}\ x\ 100\%$$

g. Organoleptic Test of *Fruit* Leather Characteristics, Hedonic Method (Wulandari *et al,* 2008)

1. The panelists were determined to be 25 people.
2. Panelists are required to provide an assessment in the form of a value (score) of the intensity of taste, color, aroma, and texture of each sample presented based on a numerical scale on a questionnaire sheet to indicate how far the level of preference.

Organoleptic Test with Friedman Method

$$x^2 \text{ hitung} = \frac{12}{rp(p+1)} \sum \sum_{i=1}^{p} \left(T1 \frac{r(p-1)}{2} \right)$$

h. Analysis of Food Fiber Content Enzymatic Method (AOAC, 2005)

1. Fresh and boiled samples were oven dried at 60^o for 21 hours.
2. A dry sample of 2 g was extracted with petroleum ether solvent at room temperature for 15 minutes and then the sample was placed in an oven for 12 hours at 105^o C.
3. Sample of 1 g (w) was put into a 500 ml Erlenmeyer.
4. Then 25 ml of 0.1 M sodium phosphate buffer with pH 6 was added.
5. Add 0.1 ml of α-amylase enzyme (termamyl) and cover with aluminum foil.

6. Incubate at 100^{o} C for 15 minutes.
7. 20 ml of distilled water was added and the pH was adjusted to 1.5 by adding 4 M HCl.
8. 100 mg pepsin was added, covered with aluminum foil and incubated at 40^{o} C and agitated for 60 minutes.
9. 20 ml of distilled water was added and the pH was adjusted to 6.8 then 100 mg of pancreatin was added, covered with aluminum foil and incubated at 40^{o} C and agitated for 60 minutes.
10. The pH was adjusted with 4 M HCl to 4.5 M.
11. The solution was then filtered with a weighed G3 Egyptian glass cup and washed twice with distilled water.
12. The residue was washed with 2x10 ml of 78% ethanol and 2x10 ml of acetone, dried in an oven at 105^{o} C for 12 hours, and put into a desiccator and weighed (D1).
13. Fumigated in a furnace at 500^{o} C for 5 hours and put in a desiccator and weighed (I2).
14. The filtrate volume was adjusted by adding distilled water to 100 ml.
15. Added 400 ml of warm 78% ethanol (temperature 60^{o} C), precipitated 1 hour.
16. The solution was filtered using a G3 glass meshed cup and washed with 2x10 ml of 78% ethanol, 2x10 ml of acetone, and dried in an oven for 12 hours at 105^{o} C.
17. Put in a desiccator and weighed (D2).
18. The dried extract was then fumigated in a furnace at 500^{o} C for 5 hours and put into a desiccator and weighed (I2).
19. Total dietary fiber was determined by summing the SDF and IDF values.
20. The blank values for IDF and SDF were obtained in the same way, but without using samples (B1 and B2).

$$\%\text{serat pangan tidak larut (IDF)} = \frac{\mathrm{D1} - \mathrm{I1} - \mathrm{B1}}{\mathrm{W}} \times 100\%$$

$$\%\text{serat pangan yang larut (SDF)} = \frac{\mathrm{D2} - \mathrm{I2} - \mathrm{B2}}{\mathrm{W}} \times 100\%$$

$$\%\text{total serat pangan (TDF)} = \text{Nilai IDF} + \text{Nilai SDF}$$

i. Decision Analysis (De Garmo *et al,* 1984)

Each parameter is given a variable weight of 0-1. The variable weight depends on the importance of each parameter, which is obtained as a result of the treatment. The normal weight of each parameter is determined by the formula :

$$\text{Berat Normal} = \frac{\text{Berat Variabel}}{\text{Berat Total}}$$

After that, the effectiveness value is calculated using the formula :

$$\text{Nilai Hasil} = \frac{\text{Nilai Perlakuan} - \text{Nilai terendah}}{\text{Nilai tertinggi} - \text{Nilai Terendah}}$$

The total value of all treatment combinations was calculated by summing up all the result values of each parameter. The largest total value indicates the best treatment result.

Organoleptic Testing Questionnaire (*Hedonic Scale Scoring*)

Organoleptic Test Sheet

Panelist Name :

Day/Date :

Products tested : *Fruit Leather*

Instructions : Rate the taste, color, aroma, and texture of the following samples according to the following criteria:

1. **Strongly Dislike**
2. **Dislikes**
3. **Neutral**
4. **Like**
5. **Very Favorable**

Sample Code	Parameters			
	Color	Taste	Aroma	Texture
136				
159				
191				
207				
259				
292				
313				
356				
396				

Comments/Suggestions:

Raw Material Analysis Results

a. Water Content

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
Bonggol	80,949	80,693	161,164	80,82	0,18
Skin	79,215	78,944	158,159	79,08	0,19
Total	160,164	159,637	319,801		
Average	80,082	79,819			

b. Reduced Sugar Content

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
Bonggol	16,790	16,338	33,128	16,56	0,32
Skin	14,307	14,093	28,400	14,20	0,15
Total	31,097	30,431	61,528		

Average	15,549	15,216

c. Vitamin C content

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
Bonggol	73,090	71,794	144,884	72,44	0,92
Skin	29,307	30,093	59,400	29,70	0,56
Total	102,397	101,887	204,284		
Average	51,199	50,944			

d. Antioxidant Activity

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
Bonggol	68,907	67,284	136,191	68,10	1,15
Skin	58,879	57,246	116,125	58,06	1,15
Total	127,786	124,530	252,316		
Average	63,893	62,265			

e. Crude Fiber Content

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
Bonggol	1,559	1,510	3,069	1,53	0,03
Skin	2,056	2,016	4,072	2,04	0,03
Total	3,615	3,526	7,141		
Average	1,808	1,763			

f. pH

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
Bonggol	4,180	4,130	8,130	4,16	0,04
Skin	5,870	5,790	11,660	5,83	0,06
Total	10,050	9,920	19,970		
Average	5,025	4,960			

Observation Data of Variety Analysis of Water Content

a. Moisture Content Analysis

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
A1B1	12,563	12,206	24,769	12,38	0,25
A1B2	12,990	12,708	25,698	12,85	0,20
A1B3	13,353	13,407	26,760	13,38	0,04
A2B1	14,099	14,027	28,126	14,06	0,05
A2B2	15,877	15,700	31,577	15,79	0,13
A2B3	16,330	15,197	32,527	16,26	0,09
A3B1	16,877	16,700	33,577	16,79	0,13
A3B2	17,333	17,082	34,415	17,21	0,18

A3B3	17,884	17,673	35,557	17,78	0,15
Total	137,306	135,700	273,006		
Average	15,256	15,078			

b. Two-way Table

PROPORTION (b/b)	CARBAGE (%)			AMOUNT	AVERAGE
	0,6%	0,8%	1,0%		
60:40	24,77	25,70	26,76	77,23	25,74
50:50	28,13	31,58	32,53	92,23	30,72
40:60	33,58	34,42	35,56	103,55	34,52
AMOUNT	86,47	91,69	94,84	273,01	
AVERAGE	28,82	30,56	31,61		

c. Analysis of Variance (ANOVA)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	65.458[a]	8	8.182	365.513	.000
Intercept	4140.682	1	4140.682	184970.234	.000
Treatment	65.458	8	8.182	365.513	.000
Error	.201	9	.022		
Total	4206.342	18			
Corrected Total	65.660	17			

a. R Squared = ,997 (Adjusted R Squared = ,994)

d. DMRT Table of Water Content

Treatment	N	Subset 1	2	3	4	5	6	7	8	9
A1B1	2	12.3845								
A1B2	2		12.8490							
A1B3	2			13.3800						
A2B1	2				14.0630					
A2B2	2					15.7885				
A2B3	2						16.2635			
A3B1	2							16.7885		
A3B2	2								17.2075	
A3B3	2									17.7785
Sig.		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = ,022.

a. Uses Harmonic Mean Sample Size = 2,000.

b. Alpha = .05.

Observation Data of Variety Analysis of Reduced Sugar Content

a. Reduced Sugar Content Analysis

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
A1B1	25,692	25,508	51,200	25,60	0,13
A1B2	25,759	25,640	51,399	25,70	0,08
A1B3	26,071	25,974	52,045	26,02	0,07
A2B1	24,199	24,107	48,306	24,15	0,07
A2B2	24,569	24,501	49,070	24,54	0,05
A2B3	24,866	24,803	49,669	24,83	0,04
A3B1	23,064	23,022	46,086	23,04	0,03
A3B2	23,577	23,509	47,086	23,54	0,05
A3B3	23,897	23,751	47,648	23,82	0,10
Total	221,694	220,815	442,509		
Average	24,633	24,535			

b. Two-way Table

PROPORTION (b/b)	CARBAGE (%)			AMOUNT	AVERAGE
	0,6%	0,8%	1,0%		
60:40	51,20	51,40	52,05	154,64	51,55
50:50	48,30	49,07	49,67	147,05	49,02
40:60	46,09	47,09	47,65	140,82	46,94
AMOUNT	145,59	147,56	149,36	442,51	
AVERAGE	48,53	49,19	49,79		

c. Analysis of Variance (ANOVA)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17.266[a]	8	2.158	380.160	.000
Intercept	10878.568	1	10878.568	1916234.111	.000
Treatment	17.266	8	2.158	380.160	.000
Error	.051	9	.006		
Total	10895.884	18			
Corrected Total	17.317	17			

a. R Squared = ,997 (Adjusted R Squared = ,994)

d. DMRT Table of Reduced Sugar Content

		Subset							
Treatment	N	1	2	3	4	5	6	7	8
A3B1	2	23.0430							
A3B2	2		23.5430						
A3B3	2			23.8240					
A2B1	2				24.1530				
A2B2	2					24.5350			
A2B3	2						24.8345		
A1B1	2							25.6000	
A1B2	2							25.6995	
A1B3	2								26.0225
Sig.		1.000	1.000	1.000	1.000	1.000	1.000	.219	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = ,006.

a. Uses Harmonic Mean Sample Size = 2,000.

b. Alpha = .05.

Appendix 6, Observation Data for Variety Analysis of Vitamin C Content

a. Vitamin C Content Analysis

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
A1B1	15,497	15,387	30,884	15,44	0,08
A1B2	15,583	15,692	31,275	15,64	0,08
A1B3	16,134	16,165	32,299	16,15	0,02
A2B1	14,897	14,788	29,685	14,84	0,08
A2B2	15,077	15,296	30,373	15,19	0,15
A2B3	15,308	15,437	30,745	15,37	0,09
A3B1	14,473	14,365	28,838	14,42	0,08
A3B2	14,593	14,503	29,096	14,55	0,06
A3B3	14,803	14,672	29,475	14,74	0,09
Total	136,365	136,305	272,670		
Average	15,152	15,145			

b. Two-way Table

PROPORTION (b/b)	CARBAGE (%)			AMOUNT	AVERAGE
	0,6%	0,8%	1,0%		
60:40	30,88	31,28	32,30	94,46	31,49
50:50	29,69	30,37	30,75	90,80	30,27
40:60	28,84	29,10	29,48	87,41	29,14
AMOUNT	89,41	90,74	92,52	272,67	
AVERAGE	29,80	30,25	30,84		

c. Analysis of Variance (ANOVA)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5.068[a]	8	.634	82.428	.000
Intercept	4130.496	1	4130.496	537397.390	.000
Treatment	5.068	8	.634	82.428	.000
Error	.069	9	.008		
Total	4135.634	18			
Corrected Total	5.138	17			

a. R Squared = ,987 (Adjusted R Squared = ,975)

d. DMRT Table of Vitamin C Content

		Subset						
Treatment	N	1	2	3	4	5	6	7
A3B1	2	14.4190						
A3B2	2	14.5480	14.5480					
A3B3	2		14.7375	14.7375				
A2B1	2			14.8425				
A2B2	2				15.1865			
A2B3	2				15.3725	15.3725		
A1B1	2					15.4420	15.4420	
A1B2	2						15.6375	
A1B3	2							16.1495
Sig.		.175	.059	.262	.063	.448	.053	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = ,008.

a. Uses Harmonic Mean Sample Size = 2,000.

b. Alpha = .05.

Observation Data for Variance Analysis of Antioxidant Activity

a. Antioxidant Activity Analysis

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
A1B1	27,497	27,387	58,884	27,44	0,08
A1B2	27,583	27,692	55,275	27,64	0,08
A1B3	28,134	28,165	56,299	28,15	0,02
A2B1	26,897	27,788	53,685	26,84	0,08
A2B2	27,077	27,296	53,373	27,19	0,15
A2B3	27,308	27,437	54,745	27,37	0,09
A3B1	26,473	26,365	52,838	26,42	0,08
A3B2	26,593	26,503	53,096	26,55	0,06
A3B3	26,803	26,672	53,475	26,74	0,09
Total	244,365	244,305	488,670		
Average	27,152	27,145			

b. Two-way Table

PROPORTION (b/b)	CARBAGE (%)			AMOUNT	AVERAGE
	0,6%	0,8%	1,0%		
60:40	54,88	55,28	56,30	166,46	55,49
50:50	53,69	54,37	54,75	162,80	54,27
40:60	52,84	53,10	53,48	159,41	53,14
AMOUNT	161,41	162,74	164,52	488,67	
AVERAGE	53,80	54,25	54,84		

c. Analysis of Variance (ANOVA)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5.068[a]	8	.634	82.428	.000
Intercept	13266.576	1	13266.576	1726045.312	.000
Treatment	5.068	8	.634	82.428	.000
Error	.069	9	.008		
Total	13271.714	18			
Corrected Total	5.138	17			

a. R Squared = ,987 (Adjusted R Squared = ,975)

d. DMRT Table Antioxidant Activity

Treatment	N	Subset 1	2	3	4	5	6	7
A3B1	2	26.4190						
A3B2	2	26.5480	26.5480					
A3B3	2		26.7375	26.7375				
A2B1	2			26.8425				
A2B2	2				27.1865			
A2B3	2				27.3725	27.3725		
A1B1	2					27.4420	27.4420	
A1B2	2						27.6375	
A1B3	2							28.1495
Sig.		.175	.059	.262	.063	.448	.053	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = ,008.

a. Uses Harmonic Mean Sample Size = 2,000.

b. Alpha = .05.

Observation Data of Variety Analysis of Crude Fiber Content

a. Crude Fiber Content Analysis

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
A1B1	2,108	1,988	4,096	2,05	0,08
A1B2	2,295	2,368	4,663	2,33	0,05
A1B3	2,453	2,536	4,989	2,49	0,06
A2B1	2,586	2,652	5,238	2,62	0,05
A2B2	2,782	2,859	5,641	2,82	0,05
A2B3	3,027	3,138	6,165	3,08	0,08
A3B1	3,134	3,312	6,446	3,22	0,13
A3B2	3,687	3,767	7,454	3,73	0,06
A3B3	4,117	3,972	8,089	4,04	0,10
Total	26,189	26,592	52,781		
Average	2,910	2,955			

b. Two-way Table

PROPORTION (b/b)	CARBAGE (%)			AMOUNT	AVERAGE
	0,6%	0,8%	1,0%		
60:40	4,10	4,66	4,99	13,75	4,58
50:50	5,24	5,64	6,17	17,04	5,68
40:60	6,45	7,45	8,09	21,99	7,33
AMOUNT	15,78	17,76	19,24	52,78	
AVERAGE	5,26	5,92	6,41		

c. Analysis of Variance (ANOVA)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.767[a]	8	.846	150.008	.000
Intercept	155.297	1	155.297	27542.221	.000
Treatment	6.767	8	.846	150.008	.000
Error	.051	9	.006		
Total	162.114	18			
Corrected Total	6.817	17			

a. R Squared = ,993 (Adjusted R Squared = ,986)

d. DMRT Table of Crude Fiber Content

Treatment	N	Subset 1	2	3	4	5	6	7
A1B1	2	2.0480						
A1B2	2		2.3315					
A1B3	2			2.5395				
A2B1	2			2.6190				
A2B2	2				2.8205			
A2B3	2					3.0825		
A3B1	2					3.2230		
A3B2	2						3.7270	
A3B3	2							4.0445
Sig.		1.000	1.000	.317	1.000	.094	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = ,006.

a. Uses Harmonic Mean Sample Size = 2,000.

b. Alpha = .05.

Observation Data for Variety Analysis of Tensile Strength

a. Tensile Strength Analysis

Treatment	Repeat 1	Repeat 2	Total	Average	STDEV
A1B1	1,395	1,525	2,920	1,46	0,09
A1B2	1,770	1,655	3,425	1,71	0,08
A1B3	1,988	1,915	3,903	1,95	0,05
A2B1	2,525	2,375	4,900	2,45	0,11
A2B2	2,825	2,765	5,590	2,80	0,04
A2B3	3,088	2,955	6,043	3,02	0,09
A3B1	3,365	3,310	6,675	3,34	0,04
A3B2	3,725	3,885	7,610	3,81	0,11
A3B3	4,225	4,465	8,690	4,35	0,17
Total	24,906	24,850	49,756		
Average	2,767	2,761			

b. Two-way Table

PROPORTION (b/b)	CARBAGE (%)			AMOUNT	AVERAGE
	0,6%	0,8%	1,0%		
60:40	2,92	3,43	3,90	10,25	3,42
50:50	4,90	5,59	6,04	16,53	5,51
40:60	6,68	7,61	8,69	22,98	7,66
AMOUNT	14,50	16,63	18,64	49,76	
AVERAGE	4,83	5,54	6,21		

c. Analysis of Variance (ANOVA)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	15.088[a]	8	1.886	205.170	.000
Intercept	137.537	1	137.537	14961.561	.000
Treatment	15.088	8	1.886	205.170	.000
Error	.083	9	.009		
Total	152.708	18			
Corrected Total	15.171	17			

a. R Squared = ,995 (Adjusted R Squared = ,990)

d. DMRT Table of Tensile Strength

		Subset								
Treatment	N	1	2	3	4	5	6	7	8	9
A1B1	2	1.4600								
A1B2	2		1.7125							
A1B3	2			1.9515						
A2B1	2				2.4500					
A2B2	2					2.7950				
A2B3	2						3.0215			
A3B1	2							3.3375		
A3B2	2								3.8050	
A3B3	2									4.3450
Sig.		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = ,009.

a. Uses Harmonic Mean Sample Size = 2,000.

b. Alpha = .05.

Organoleptic Test Data Color

Panelists	Sample Code																	
	136	R	159	R	191	R	207	R	259	R	292	R	313	R	356	R	398	R
1	4	6,5	5	8,5	3	3,5	5	8,5	3	3,5	3	3,5	4	6,5	2	1	3	3,5
2	4	6	4	6	4	6	4	6	3	2	5	9	3	2	4	6	3	2
3	4	8	4	8	4	8	3	3,5	3	3,5	3	3,5	3	3,5	3	3,5	3	3,5
4	3	3	5	8,5	4	6,5	4	6,5	3	3	3	3	5	8,5	3	3	3	3
5	4	6,5	4	6,5	4	6,5	4	6,5	4	6,5	3	2	3	2	4	6,5	3	2
6	3	2	4	6,5	4	6,5	4	6,5	4	6,5	3	2	4	6,5	3	2	4	6,5
7	2	3	2	3	3	6,5	2	3	2	3	4	8,5	3	6,5	2	3	4	8,5
8	2	2	3	5,5	3	5,5	2	2	2	2	4	8,5	3	5,5	4	8,5	3	5,5
9	4	6	4	6	4	6	4	6	4	6	4	6	3	1,5	4	6	3	1,5
10	2	1	3	3	3	3	5	8,5	5	8,5	4	6	4	6	4	6	3	3
11	4	7,5	3	3,5	3	3,5	4	7,5	3	3,5	4	7,5	3	3,5	4	7,5	2	1
12	3	4	3	4	3	4	3	4	3	4	3	4	4	8,5	4	8,5	3	4
13	4	6,5	4	6,5	4	6,5	4	6,5	4	6,5	3	2	3	2	3	2	4	6,5
14	4	5,5	3	2	4	5,5	5	8,5	5	8,5	4	5,5	4	5,5	3	2	3	2
15	3	2,5	3	2,5	3	2,5	4	7	3	2,5	4	7	4	7	4	7	4	7
16	3	4	3	4	3	4	3	4	5	9	3	4	4	8	3	4	3	4
17	2	2	3	5,5	2	2	3	5,5	4	8,5	4	8,5	3	5,5	2	2	3	5,5
18	5	8,5	5	8,5	4	6,5	3	4	3	4	2	1,5	4	6,5	2	1,5	3	4
19	2	1,5	3	4	3	4	4	7,5	4	7,5	4	7,5	4	7,5	2	1,5	3	4
20	4	6,5	4	6,5	4	6,5	3	3	3	3	5	9	4	6,5	2	1	3	3
21	4	8,5	4	8,5	3	4,5	3	4,5	3	4,5	3	4,5	3	4,5	2	1	3	4,5
22	2	1,5	2	1,5	3	5	3	5	3	5	3	5	4	8,5	4	8,5	3	5
23	5	7,5	5	7,5	5	7,5	3	3	3	3	3	3	5	7,5	3	3	3	3
24	3	2,5	4	7	3	2,5	4	7	4	7	3	2,5	4	7	4	7	3	2,5
25	84	3	91	8	87	5	90	7	86	4	88	6	92	9	79	2	78	1
Total	164	115,5	178	141	170	127,5	176	141	169	125,0	172	129,5	180	145,5	154	104	153	96,0
Average	6,56	4,62	7,12	5,64	6,8	5,1	7,04	5,64	6,76	5	6,88	5,18	7,2	5,82	6,16	4,16	6,12	3,84

Appendix 11. Calculation of Color Organoleptic Test with *Friedman Test* (Setyaningsih, 2010)

Formula

X^2 count = $\frac{12}{r\,p,(p+1)}$ x [$\sum T_i^2$] - 3 r (p+1)

Description :

r= Number of panelists

p= Number of treatments

$\sum T_i^2$ = Sum of the powers of the i-th treatment

Db x^2 = p-1

$X^2 = \frac{12}{25x9(9+1)}$ x [(115.5^2) + (141^2) + (127.5^2) + (141^2) + (125^2) + (129.5^2) + (145.5^2) + (104^2) + (96^2)] - (3 x 25 (9+1))

= 12,432

X^2 calculated (12.432 ≥ X^2 table at 5% level (15.507)→ then there is no significant difference between treatments on color at the 5% level.

Organoleptic Test Data for Taste

Panelists	Sample Code																	
	136	R	159	R	191	R	207	R	259	R	292	R	313	R	356	R	398	R
1	4	5,5	4	5,5	4	5,5	4	5,5	4	5,5	3	1	4	5,5	4	5,5	4	5,5
2	3	4	4	8	3	4	3	4	2	1	3	4	4	8	4	8	3	4
3	2	1,5	3	4,5	3	4,5	3	4,5	3	4,5	4	8	4	8	4	8	2	1,5
4	4	8	3	3,5	3	3,5	4	8	3	3,5	3	3,5	3	3,5	3	3,5	4	8
5	3	3	3	3	3	3	4	7	4	7	5	9	3	3	4	7	3	3
6	2	1	5	9	4	6	3	2,5	4	6	4	6	4	6	4	6	3	2,5
7	4	7	3	2,5	4	7	3	2,5	4	7	4	7	3	2,5	3	2,5	4	7
8	2	1,5	3	3,5	4	6,5	5	9	4	6,5	2	1,5	3	3,5	4	6,5	4	6,5
9	3	4,5	3	4,5	2	1,5	3	4,5	4	8	2	1,5	4	8	4	8	3	4,5
10	3	5	3	5	2	1,5	3	5	4	8,5	2	1,5	3	5	4	8,5	3	5
11	3	4,5	3	4,5	2	1,5	3	4,5	4	8	2	1,5	4	8	4	8	3	4,5
12	3	5	3	5	2	1,5	3	5	4	8,5	2	1,5	3	5	4	8,5	3	5
13	4	4	4	4	3	1	5	8	4	4	5	8	5	8	4	4	4	4
14	4	8	2	1,5	3	4,5	4	8	2	1,5	3	4,5	4	8	3	4,5	3	4,5
15	4	4	4	4	4	4	4	4	5	8,5	4	4	5	8,5	4	4	4	4
16	4	6	2	1	4	6	5	9	4	6	3	2,5	4	6	4	6	3	2,5
17	4	3,5	5	7,5	3	1	4	3,5	4	3,5	5	7,5	5	7,5	4	3,5	5	7,5
18	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5
19	2	1,5	4	6	4	6	2	1,5	4	6	4	6	4	6	4	6	4	6
20	3	2	4	6,5	4	6,5	4	6,5	4	6,5	4	6,5	4	6,5	3	2	3	2
21	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5
22	2	1,5	4	6,5	4	6,5	2	1,5	4	6,5	4	6,5	3	3	4	6,5	4	6,5
23	5	9	3	4,5	2	1	3	4,5	3	4,5	4	8	3	4,5	3	4,5	3	4,5
24	5	8,5	4	6	2	1,5	5	8,5	4	6	3	3,5	4	6	3	3,5	2	1,5
25	3	4,5	4	8	2	1,5	3	4,5	4	8	3	4,5	4	8	2	1,5	3	4,5
Total	84	113,0	88	124	79	95,5	90	131,5	94	145,0	86	117,5	95	148	92	136	85	114,5
Average	3,36	4,52	3,52	4,96	3,16	3,82	3,6	5,26	3,76	5,8	3,44	4,7	3,8	5,92	3,68	5,44	3,4	4,58

Appendix 13. Calculation of Organoleptic Taste Test with *Friedman Test* (Setyaningsih, 2010)

Formula

X^2 count = $\frac{12}{r\,p,(p+1)}$ x [$\sum T_i^2$] - 3 r (p+1)

Description :

r= Number of panelists

p= Number of treatments

$\sum T_i^2$ = Sum of the powers of the i-th treatment

Db x^2 = p-1

$X = ^2 \frac{12}{25x9(9+1)}$ x [(113^2) + (124^2) + (95.5^2) + (131.5^2) + (145^2) + (117.5^{22}) + (148^2) + (136^2) + (114.5^2)] - (3 x 25 (9+1))

= 12,128

X^2 calculated (12.128) ≥ X^2 table at 5% level (15.507)→ then there is no significant difference between treatments on flavor at 5% level,

Aroma Organoleptic Test Data

Panelists	Sample Code																	
	136	R	159	R	191	R	207	R	259	R	292	R	313	R	356	R	398	R
1	3	5	3	5	3	5	3	5	3	5	3	5	3	5	3	5	3	5
2	2	1,5	3	5,5	2	1,5	3	5,5	3	5,5	3	5,5	4	9	3	5,5	3	5,5
3	2	1,5	3	5,5	3	5,5	2	1,5	3	5,5	3	5,5	4	9	3	5,5	3	5,5
4	4	9	3	4,5	3	4,5	3	4,5	3	4,5	3	4,5	3	4,5	3	4,5	3	4,5
5	4	8	3	3,5	3	3,5	4	8	3	3,5	4	8	3	3,5	3	3,5	3	3,5
6	3	3,5	3	3,5	3	3,5	4	8	3	3,5	3	3,5	4	8	4	8	3	3,5
7	3	3	4	6,5	3	3	2	1	3	3	5	9	4	6,5	4	6,5	4	6,5
8	3	4	2	1,5	4	7	4	7	5	9	3	4	4	7	3	4	2	1,5
9	2	1	3	4,5	3	4,5	4	8,5	3	4,5	3	4,5	4	8,5	3	4,5	3	4,5
10	2	1,5	3	5	3	5	4	8,5	3	5	3	5	4	8,5	2	1,5	3	5
11	2	1,5	3	5,5	3	5,5	4	9	3	5,5	3	5,5	3	5,5	2	1,5	3	5,5
12	2	1,5	3	5,5	3	5,5	4	9	3	5,5	3	5,5	3	5,5	2	1,5	3	5,5
13	3	2,5	4	7	4	7	4	7	3	2,5	3	2,5	4	7	4	7	3	2,5
14	4	9	3	6	3	6	3	6	2	2	2	2	3	6	2	2	3	6
15	3	4	3	4	4	8,5	3	4	3	4	3	4	3	4	4	8,5	3	4
16	2	2	2	2	3	6	3	6	2	2	3	6	3	6	3	6	4	9
17	4	8,5	4	8,5	3	4	3	4	3	4	3	4	3	4	3	4	3	4
18	3	5,5	3	5,5	3	5,5	3	5,5	3	5,5	3	5,5	3	5,5	2	1	3	5,5
19	2	1	3	4	3	4	4	8	3	4	4	8	4	8	3	4	3	4
20	3	3,5	3	3,5	4	8	4	8	3	3,5	4	8	3	3,5	3	3,5	3	3,5
21	4	7,5	3	3	3	3	3	3	4	7,5	4	7,5	3	3	4	7,5	3	3
22	2	1	3	4	3	4	4	8	3	4	4	8	3	4	3	4	4	8
23	4	7,5	3	3	4	7,5	3	3	4	7,5	3	3	4	7,5	3	3	3	3
24	4	6	5	9	3	2	4	6	3	2	4	6	4	6	3	2	4	6
25	2	3	2	3	2	3	3	6,5	3	6,5	2	3	4	8,5	2	3	4	8,5

Total	72	102,0	77	119	78	122,5	85	150,5	77	115,0	81	133,0	87	153,5	74	107	79	123,0
Average	2,88	4,08	3,08	4,74	3,12	4,9	3,4	6,02	3,08	4,6	3,24	5,32	3,48	6,14	2,96	4,28	3,16	4,92

Calculation of Aroma Organoleptic Test with *Friedman Test*

(Setyaningsih, 2010)

Formula

X^2 count = $\frac{12}{r\,p,(p+1)}$ x [$\sum T_i^2$] - 3 r (p+1)

Description :

r= Number of panelists

p= Number of treatments

$\sum T_i^2$ = Sum of the powers of the i-th treatment

Db x^2 = p-1

$X = ^2 \frac{12}{25x9(9+1)}$ x [(102^2) + (119^2) + (122.5^2) + (150.5^2) + (115^2) + (133^{22}) + (153.5^2) + (107^2) + (123^2)] - (3 x 25 (9+1))

= 13,504

X^2 calculated (13.504) ≥ X^2 table at 5% level (15.507)→ then there is no significant difference between treatments on aroma at 5% level.

Organoleptic Test Data for Texture

Panelists	Sample Code																	
	136	R	159	R	191	R	207	R	259	R	292	R	313	R	356	R	398	R
1	3	4	2	1,5	3	4	3	4	4	7,5	4	7,5	4	7,5	4	7,5	2	1,5
2	3	5	2	2	2	2	3	5	3	5	4	7,5	5	9	4	7,5	2	2
3	3	4,5	2	2	2	2	3	4,5	4	7,5	4	7,5	4	7,5	4	7,5	2	2
4	3	4,5	2	1,5	3	4,5	3	4,5	4	8	4	8	3	4,5	4	8	2	1,5
5	3	3	4	7,5	3	3	3	3	4	7,5	3	3	4	7,5	3	3	4	7,5
6	3	2,5	3	2,5	2	1	4	6,5	4	6,5	4	6,5	4	6,5	4	6,5	4	6,5
7	3	3,5	3	3,5	3	3,5	4	8	4	8	3	3,5	4	8	3	3,5	3	3,5
8	3	7	3	7	2	3	2	3	3	7	2	3	2	3	2	3	4	9
9	4	8	3	6	3	6	2	2,5	3	6	2	2,5	2	2,5	2	2,5	5	9
10	3	2,5	3	2,5	3	2,5	4	7	4	7	4	7	4	7	4	7	3	2,5
11	3	5,5	3	5,5	2	2	5	8,5	3	5,5	2	2	5	8,5	2	2	3	5,5
12	3	4,5	3	4,5	2	1,5	3	4,5	3	4,5	4	8	4	8	4	8	2	1,5
13	3	4,5	3	4,5	3	4,5	3	4,5	3	4,5	3	4,5	3	4,5	3	4,5	5	9
14	3	2,5	3	2,5	3	2,5	4	7	4	7	4	7	4	7	4	7	3	2,5
15	3	2,5	3	2,5	3	2,5	5	8,5	4	6	4	6	5	8,5	4	6	3	2,5
16	2	2	3	6,5	2	2	3	6,5	3	6,5	3	6,5	3	6,5	3	6,5	2	2
17	3	5	3	5	2	1,5	5	9	3	5	3	5	4	8	3	5	2	1,5
18	2	2,5	3	6	4	8,5	4	8,5	2	2,5	2	2,5	3	6	2	2,5	3	6
19	2	1,5	3	4	3	4	3	4	4	6,5	5	8,5	4	6,5	5	8,5	2	1,5
20	3	5,5	2	2,5	4	8	4	8	3	5,5	2	2,5	4	8	2	2,5	2	2,5
21	2	2	2	2	3	5	3	5	4	8	4	8	3	5	4	8	2	2
22	2	2	2	2	3	5,5	3	5,5	3	5,5	4	8,5	3	5,5	4	8,5	2	2
23	3	6	4	9	3	6	3	6	3	6	2	2	3	6	2	2	2	2
24	4	5	4	5	2	1	3	2,5	5	8	5	8	3	2,5	5	8	4	5
25	3	4	3	4	3	4	4	8,5	3	4	3	4	4	8,5	3	4	3	4
Total	72	99,5	71	102	68	90,0	86	144,5	87	155,0	84	139,0	91	162	84	139	71	94,5
Average	2,88	3,98	2,84	4,06	2,72	3,6	3,44	5,78	3,48	6,2	3,36	5,56	3,64	6,48	3,36	5,56	2,84	3,78

Appendix 17. Calculation of Organoleptic Texture Test with *Friedman Test* (Setyaningsih, 2010)

Formula

X^2 count = $\frac{12}{r\,p,(p+1)}$ x [$\sum T_i^2$] - 3 r (p+1)

Description :

r= Number of panelists

p= Number of treatments

$\sum T_i^2$ = Sum of the powers of the i-th treatment

Db x^2 = p-1

$X = ^2 \frac{12}{25x9(9+1)}$ x [(99.5^2) + (102^2) + (90^2) + (144.5^2) + (155^2) + (139^2) + (162^2) + (139^2) + (94.5^2)] - (3 x 25 (9+1))

= 34,128

X^2 calculated (34.128) ≥ X^2 table at 5% level (15.507)→ then there is a significant difference between treatments on texture at 5% level,

Appendix 18. Research Images