COMPREHENSIVE PRACTICUM REPORT
AGRICULTURAL PROCESSING TECHNIQUES AND TECHNICAL MATERIAL KNOWLEDGE
(19G04122401)

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FOREWORD

We express our gratitude and praises to the Almighty God for granting the author the opportunity to complete this comprehensive report on Agricultural Product Processing Techniques and Technical Material Knowledge. This report was crafted to the best of our ability to yield a comprehensive final report based on current and factual data, derived from practical experiments and observations made by the author in the field. During the compilation of this report, various challenges hindered its completion. However, with the assistance from various parties, these obstacles were overcome.

The author extends their gratitude and appreciation to the Almighty God, the course instructor, Kak Selpiah as the assistant coordinator, and Kak Dwi Mentari Thamsyul as the assistant, for facilitating and aiding the author with materials and information. Lastly, the author would like to express their gratitude to friends who provided mutual support and to parents who offered prayers and assistance to ensure the success of this endeavor."

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1. INTRODUCTION

1.1. Background

Drying of food materials is one of the preservation methods that has been utilized for centuries. Its primary purpose is to reduce the moisture content in food items, thus helping to prevent microbial growth and extend the shelf life of the products. Drying food materials can also enhance nutritional values and product quality, such as taste, aroma, and color. In the field of agriculture, particularly in food processing involving the drying stage, it holds significant importance in daily life.

Solar energy, a radiant light and heat originating from the sun, is harnessed through various evolving technologies like solar heating, photovoltaics, and solar thermal energy. Solar radiation is a form of thermal radiation in the electromagnetic wave spectrum. The utilization of solar energy, aimed at drying and other purposes, has been recognized since ancient times, such as direct sun drying. Direct sun drying is a simple and cost-effective method for the drying process, although upon closer examination, it is found to be time-consuming.

Drying agricultural food materials is a crucial stage in food processing. This drying process is carried out to eliminate the moisture content in food items, thus extending their shelf life and improving product quality. The goal of drying is to prevent food products from easily succumbing to spoilage, thereby ensuring their longevity. Drying also slows down the undesirable activity of microorganisms, making it possible to store food products for a longer duration.

Based on the aforementioned explanations, a Solar Drying practical is conducted to comprehend the drying process using solar energy (sunlight) and to apply drying techniques in daily life, particularly within the realm of agriculture.

1.2. Objectives and Benefits

The purpose of the Solar Drying laboratory practice is to understand the basic principles of drying a food material, calculate the changes that occur in the wet basis and dry basis moisture content of a material during the drying process, and explain the drying process based on the drying rate curve of a material.

The significance of conducting the Solar Drying laboratory practice is to comprehend the fundamental principles of drying a material, understand the changes in moisture content (wet basis and dry basis) during the drying process, extend the shelf life of food material products, and apply this knowledge in everyday life, especially in the field of agriculture.

2. LITERATURE REVIEW

2.1 Solar energy

Solar energy is an unlimited source of energy on Earth that is not only easily accessible but also environmentally friendly, as it doesn't cause pollution. Solar energy comes in the form of light and heat from the sun. This energy can be harnessed using a series of different methods. Given the current era of increasing population growth, the demand for energy is rising while natural resources are depleting (Azeez et al., 2017).

One common application of solar radiation energy is as a solar drying tool. Solar-powered drying systems, such as the cabinet-type solar dryer, are used for drying agricultural products like coffee beans, bananas, and cassava. Solar drying systems offer advantages over conventional methods as they protect the materials from external dirt, dust, strong winds, and rain. Solar drying devices come in various types, depending on the design specifications and models. One design model is the cabinet-type dryer with an inclined cover, which serves as an example of renewable solar energy utilization (Azeez et al., 2017).

2.2 Drying

Solar drying is a method of drying that harnesses solar energy by using collectors as heat absorbers, maximizing the utilization of solar energy. Drying is a process of gradual reduction of moisture content in a material. A solar drying system consists of two main parts: the solar collector and the drying chamber. Solar drying methods are divided into two categories: direct sun drying, where the material to be dried is exposed to sunlight, and solar drying, where the material is placed inside a drying device (Syane et al., 2017).

Drying is an essential process in post-harvest handling. It can preserve a material, allowing food items to last longer. Drying is a process of reducing relatively small amounts of moisture from a substance continuously. This process aligns with Azeez et al.'s statement (2017) that drying aims to reduce moisture content in food materials, decrease water activity, and inhibit microbial activity, thereby enhancing product shelf life and achieving certain economic goals such as weight reduction, flavor enhancement, and more (Azeez et al., 2017).

The utilization of solar energy for drying agricultural products, including fruits such as bananas, can help improve the efficiency of the drying process. Traditional methods, like sun drying, are dependent on weather conditions and can be less effective due to contamination and dust exposure. Solar-powered drying involves using a collector to capture sunlight and heat, which is then directed into the drying chamber to evaporate the moisture content in the fruit (Novitasari et al., 2017).

2.3 Moisture Content

Advancements in technology have become increasingly crucial in various industries, including agriculture, where measurements play a pivotal role. Measurement involves comparing the value of a quantity to a predefined unit of the same kind. Moisture content measurement is common in agricultural fields and is often conducted using instruments like ovens. The principle of moisture content measurement using an oven involves evaporating water from a substance when heated at specific temperatures and durations. The weight of the material before and after drying is used to determine moisture content (Prasetyo et al., 2019).

According to Prasetyo et al. (2019), moisture content indicates the amount of water per unit weight of a substance. There are two methods to determine moisture content: dry basis moisture content and wet basis moisture content. Dry basis moisture content compares the weight of water in the material to its dry weight, while wet basis moisture content compares the weight of water in the material to the weight of the wet material. Moisture content has a significant role, especially in food preservation, where it affects microbial, chemical, and enzymatic processes.

2. 4 Oven

Drying agricultural materials using an oven is considered advantageous due to its ability to significantly reduce moisture content in a short amount of time. The drying process using an oven can be influenced by temperature. Drying at low temperatures leads to longer drying times, potentially resulting in spoilage and decreased antioxidant activity. On the other hand, high-temperature heating over extended periods can also reduce antioxidant activity in the material (Khatulistiwa et al., 2020).

2. 5 Digital Scale

Measurement is an activity aimed at obtaining the value of a quantity for a given object. Accuracy in measurement is crucial to determine the closeness of measurement results to the true value. Measurement often involves the use of measuring tools, such as digital scales, to quantify a parameter accurately (Hulu, 2018).

3. METHODOLOGY

3.1 Time and Location

The Solar Drying Energy Practicum will be conducted on Friday, May 12, 2023, starting at 10:00 AM WITA, at the Soil and Water Engineering Laboratory, Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, Makassar

3.2 Tools and Materials

The tools used in the Solar Drying Energy Practicum are a digital scale, oven, knife, ruler, desiccator, silica gel, aluminum foil container, zip lock plastic bags, stationery, laptop, and a smartphone camera.

The materials used in the Solar Drying Energy Practicum are bananas and A4 size bond paper.

3.3 Working Procedure

The working procedure for the Solar Drying Energy Practicum is as follows:

a. Sample Drying
   1. Prepare the tools and materials to be used.
   2. Cut the banana fruit into slices of 0.5 cm thickness and 5 cm length, with a total of 3 pieces.
   3. Weigh the initial weight of the samples.
   4. Place the samples on bond paper and label each sample with its name.
   5. Dry the samples under sunlight for 5 hours.
   6. Weigh the sample at every 30-minute time interval, after placing the sample in a desiccator for 10 minutes to reduce the sample temperature.
   7. Record the measurement results of the samples.
   8. Document the entire practical activity.

b. Solid Sample Weight Measurement
   1. Prepare the tools and materials to be used.
   2. Transfer the sample from the desiccator to the drying oven, which has been preheated to a temperature of 105°C.
   3. Weigh the sample at every 30-minute interval for 2 hours.
   4. Record the measurement results of the samples.
   5. Stop the oven process when the sample weight becomes constant.

6. Record the final weight of the dried sample.
7. Document the practical activity.

3.4 Formula used

The formula used in the Solar Drying Energy Practicum is as follows:

a. Drying Rate

$$\text{Drying Rate} = \frac{W_2 - W_1}{W_d} \times \frac{1}{30}$$

Explanation :

W_2 = Weight of water in the second material (g)

W_1 = Weight of water in the first material (g)

W_d = Weight of the solid material (g)

b. Wet Basis Moisture Content

$$KA_{bb} = \frac{W_m - W_d}{W_m} \times 100$$

Explanation :

W_m = Weight of water in the material (g)

W_d = Weight of solid in the material (g)

c. Dry Basis Moisture Content

$$KA_{bk} = \frac{W_m - W_d}{W_d} \times 100$$

Explanation :

W_m = Weight of water in the material (g)

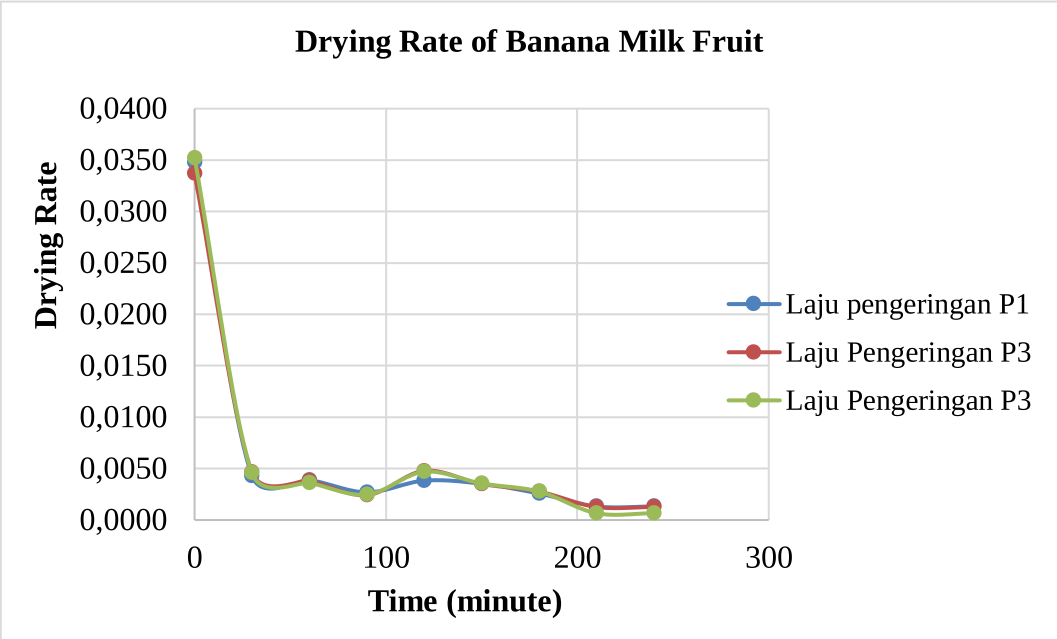
W_d = Weight of solid in the material (g)

4. RESULT AND DISCUSSION

4.1 Result

Table 1. Data of Sample Calculation Results P1

Time (minute)	P2	Solid Weight Final Value	Drying Rate	KaBb	KaBk
0	15,08	2,94	0,035	80,50	412,925
30	9,27	2,94	0,004	68,28	215,306
60	8,55	2,94	0,004	65,61	190,816
90	7,9	2,94	0,003	62,78	168,707
120	7,45	2,94	0,004	60,54	153,401
150	6,81	2,94	0,004	56,83	131,633
180	6,22	2,94	0,003	52,73	111,565
210	5,79	2,94	0,001	49,22	96,939
240	5,57	2,94	0,001	47,22	89,456



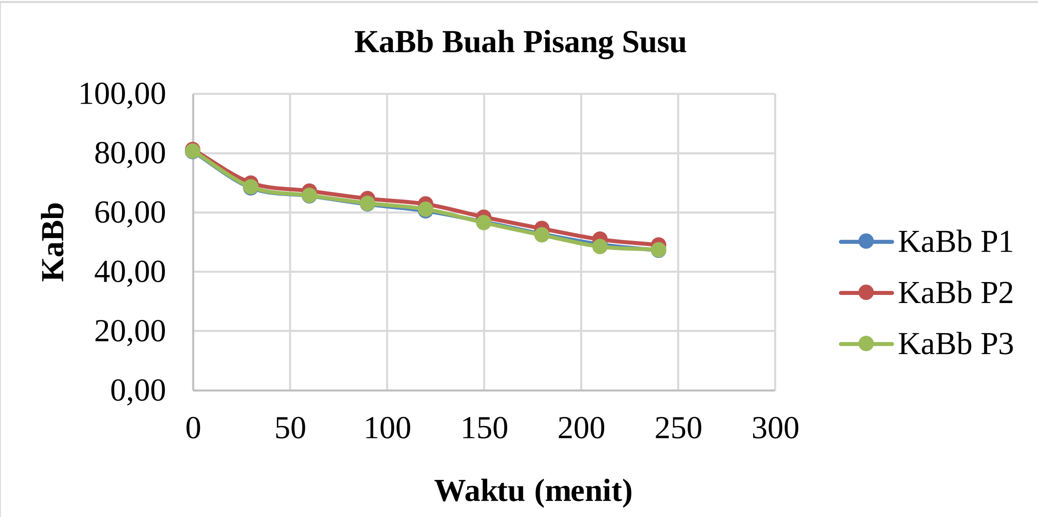
Picture 1. Drying Rate Graph of Banana Milk Fruit

Based on the Solar Drying practical that has been conducted, it can be concluded that Solar Drying is a drying process that utilizes solar energy by employing collectors as heat absorbers, thereby maximizing the use of solar energy. Drying is a process of gradual reduction of moisture content in a material. This is in line with the statement by Azeez et al. (2017), which asserts that the drying process aims to reduce the moisture content in food materials, lower the water activity within them, and inhibit microbial activity, thereby enhancing the shelf life of a product.

The results in the drying rate graph of milk banana show that the third sample, with lower moisture content compared to samples 1 and 2, exhibits a more significant decrease in drying rate over time. As the time used increases, the drying rate process becomes longer, and the moisture content becomes lower. This corresponds to the statement by Panggabean et al. (2017), which indicates that optimal drying rate occurs when the rate of water diffusion from within the product or material to the surface is equal to the rate of evaporation of water vapor from the surface.

Table 2. Data of Sample Calculation Results P2

Time (minute)	P2	Solid Weight Final Value	Drying Rate	KaBb	KaBk
0	15,67	2,95	0,0337	81,174	431,186
30	9,82	2,95	0,0047	69,959	232,881
60	9,01	2,95	0,0038	67,259	205,424
90	8,35	2,95	0,0024	64,671	183,051
120	7,93	2,95	0,0048	62,799	168,814
150	7,1	2,95	0,0035	58,451	140,678
180	6,49	2,95	0,0028	54,545	120,000
210	6,01	2,95	0,0013	50,915	103,729
240	5,79	2,95	0,0333	49,050	96,271

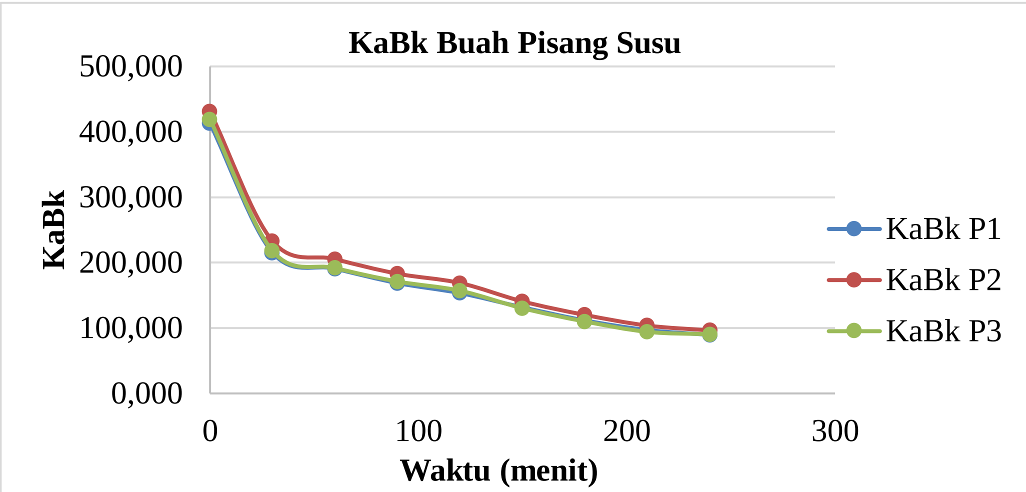


Picture 2. Graph of Wet Basis Moisture Content of Banana Milk Fruit.

The results in the second graph show the relationship between wet basis moisture content and time, where the second sample has a higher water content compared to samples 1 and 3. The third sample, depicted in the graph, decreases from 80% to 50% due to its lower water content in the banana material. As a result, samples 1 and 3 have greater mass compared to sample 2, and the drying process takes longer because time is inversely proportional to moisture content. The longer the drying process, the lower the moisture content, which aligns with the statement by Panggabean et al. (2017), stating that wet basis moisture content is the ratio of the weight of water in the material to the weight of the wet material. The weight of the material before undergoing heating can lead to a decrease in the wet basis moisture content contained in the material, and when wet basis moisture content is still present in the material, it is more prone to spoilage.

Tabel 3. Data of Sample Calculation Results P3.

Time (minute)	P2	Solid Weight Final Value	Drying Rate	KaBb	KaBk
0	15,1	2,91	0,0352	80,728	418,900
30	9,25	2,91	0,0046	68,541	217,869
60	8,49	2,91	0,0036	65,724	191,753
90	7,89	2,91	0,0025	63,118	171,134
120	7,48	2,91	0,0047	61,096	157,045
150	6,7	2,91	0,0035	56,567	130,241
180	6,11	2,91	0,0028	52,373	109,966
210	5,65	2,91	0,0007	48,496	94,158
240	5,54	2,91	0,0333	47,473	90,378



Picture 3. Graph of Dry Basis Moisture Content of Banana Milk Fruit.

Based The results in the third graph show the relationship between dry basis moisture content and time. Samples 1 and 3 from the used banana material, where the moisture content decreases from 400% to 95% after undergoing a drying process involving two stages: solar drying and oven drying. Drying agricultural materials using an oven is considered more advantageous as it can significantly reduce moisture content in a short amount of time. This is consistent with the statement by Khatulistiwa et al. (2020), which suggests that the drying process using an oven can be influenced by temperature. Drying at low temperatures will result in longer drying times, leading to spoilage and reduced production of antioxidants.

5. CONCLUSION

Based on the Solar Drying practical that has been conducted, it can be concluded that drying can preserve a material, allowing food items to last for an extended period. Drying is a process of reducing moisture from a substance using heat energy, resulting in a decrease in the moisture content of the food material. The material used in solar drying is bananas. Dry basis moisture content is the ratio of the weight of water in the material to its dry weight. Determining the moisture content of a food material is crucial in the processing process. Wet basis moisture content is the ratio of the weight of water in the material to the weight of the wet material. The weight of the material before undergoing heating can lead to a decrease in the wet basis moisture content contained in the material

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ATTACHMENT

ATTACHMENT 1. Table of Measurement Results for Banana Fruit Samples.

Table 4. Measurement Results of Banana Fruit Samples with Solar Drying.

Time	P1	P2	P3
0	9.27	9.82	9.25
30	8.55	9.01	8.49
60	7.90	8.35	7.89
90	7.45	7.93	7.48
120	6.81	7.10	6.70
150	6.22	6.49	6.11
180	5.79	6.01	5.65
210	5,57	5.79	5.44

Table 5. Measurement Results of Banana Fruit Samples with Oven Drying.

Time	P1	P2	P3
0	4.07	4.03	3.78
30	3.39	3.40	3.24
60	3.09	3.09	3.00
90	2.94	2.95	2.91

ATTACHMENT 2. Documentation of Solar Drying Experiment.

Picture 4. Documentation of Solar Drying Experiment.

1. INTRODUCTION

1.1 Background

Bananas have become one of the widely cultivated commodities in Indonesia due to their ease of cultivation and ability to thrive in various soil conditions. The fruit of bananas is widely used for various purposes, particularly as a food ingredient. Banana products have seen significant development, ranging from simple processing like banana fritters to being transformed into flour and cream. Utilizing bananas in this manner requires proper handling to maintain their quality and standard. The processing of banana fruits includes drying, frying, and cooling, resulting in different output products.

Drying is an effort or process carried out to remove the moisture content from a food material with the aim of preserving or protecting it from microbial attacks. Drying of food materials can be done in various ways, either naturally or artificially. Natural drying involves drying a food material with the help of sunlight radiation to eliminate the moisture content in the material. Artificial drying is done using drying equipment such as an oven, which utilizes electric energy to produce heat that reduces the water content in the material.

Drying process needs to be carefully observed and controlled to ensure that the food material does not undergo any damage during the drying process. Calculations of drying rate and moisture content of the material can be performed to determine the appropriate temperature and duration required for the food material to reach optimal dryness conditions. Determining the moisture content of the material is necessary to understand the amount of water present, thus enabling the selection of suitable drying temperatures based on the moisture content of the material.

Based on the above description, the Drying laboratory practice is essential to comprehend the fundamental principles of drying, drying methods, how to calculate wet basis and dry basis moisture content of materials, and how to determine the drying rate of materials using a desiccator.

1.2 Objectives and Benefits

The purpose of the Solar Drying laboratory practice is to understand the basic principles of drying a food material, calculate the changes that occur in the wet basis and dry basis moisture content of a material during the drying process, and explain the drying process based on the drying rate curve of a material.

The significance of conducting the Solar Drying laboratory practice is to comprehend the fundamental principles of drying a material, understand the changes in moisture content (wet basis and dry basis) during the drying process, extend the shelf life of food material products, and apply this knowledge in everyday life, especially in the field of agriculture.

2. LITERATURE REVIEW

2.1 Banana (*Musa Paradisiaca*)

Bananas are a fruit that is widely consumed in its fresh form. The problem with consuming fresh bananas is that they are easily damaged and quickly undergo changes in quality after harvesting, due to their high water content and increased metabolic processes after being harvested. The production of bananas in Indonesia is quite high, but it is not proportional to the level of consumption by the population, resulting in a significant amount of unused bananas due to their relatively short shelf life. The criteria for good-quality bananas for sale are a maximum moisture content of 40%, distinctive taste, normal smell, absence of metal contamination, and absence of microorganisms on the bananas, making them ready for consumption (Putri *et al*., 2018).

2.2 Drying

Drying is a process of evaporating water from wet materials using a drying medium (which can be air or gas) through the application of heat. A simple example is sun drying, where the outside air, heated by the sun, comes into contact with the wet materials placed in an open area. When the wet materials come into contact with the warm or hot air, the water within them evaporates, resulting in the materials becoming drier, depending on the speed of the air (in this case, the wind), relative humidity, and local air temperature. A similar phenomenon is applied in industries, but in this process, the air as the drying medium is controlled for its flow rate, temperature, and humidity to achieve standardized dry materials with a specific moisture content (Djaeni *et al*., 2016).

In general, the drying process consists of two steps: preparing the drying medium, which can be air, and the actual drying of the material. The preparation of the drying medium involves heating the air, which can be achieved through natural heat sources like the sun and geothermal heat, or artificial sources such as electric energy, burning wood, charcoal, coal, natural gas, and oil fuels. Based on microscopic aspects, there are two important phenomena in the drying process: heat transfer from the drying medium to the material and mass transfer of water from the material to the drying medium. The evaporation of water from the material occurs in three stages: preheating or adjusting the temperature of the material to be dried, drying at a constant rate, and drying at a decreasing rate (Djaeni dkk., 2016).

Drying with sunlight is very simple and does not require fossil fuels to generate heat, but this system needs a large space, long heating time, high labor costs, the drying product's quality is not uniform, and it heavily depends on the weather. The products become unhygienic because they are placed in an open space, so sometimes sun-dried products cannot be sold in the market. Improvements have been made to the process with a tunnel dryer model under sunlight to collect more heat and maintain product hygiene (Djaeni et al., 2016).

Convective heating dryers (ovens) where hot air is generated through the heating process using steam, electricity, or combustion gases are more reliable than solar dryers. In this system, the operation time is shorter, product contamination is low, moisture content in the product can be controlled, there is no dependence on seasons, and labor costs can be reduced. However, the product quality decreases due to heat introduction, and the drying efficiency is low or energy-consuming. Vacuum dryers and freeze dryers can work at temperatures of -20 to 0 °C with a pressure of 0.0006-0.006 atm. The principle of these drying tools is to evaporate water at low temperatures by conditioning the tool at low pressure (vacuum). These dryers are very useful for producing high-quality products and minimizing the loss of aroma, active and volatile substances, as well as preserving nutrients, preventing protein denaturation, browning of materials, and enzymatic reactions. However, these drying tools are energy-consuming due to the vacuum and cooling room conditioning and still require a long drying time (Djaeni et al., 2016).

2.3 Factors Affecting Drying

In drying, factors affecting the quality of the material include the surface area of the food material, drying temperature, airflow, water vapor pressure, energy source used, and the type of material to be dried. Drying will cause changes in the color, texture, and aroma of the food material. It reduces the moisture content of the food material, which also leads to a higher concentration of substances such as proteins, fats, carbohydrates, and minerals present in the food material. Drying can be divided into two categories: natural drying and artificial drying, also known as mechanical drying. Natural drying utilizes sunlight, which can result in case hardening (surface hardening). Artificial drying is carried out using equipment and can be manipulated by humans (Huriawati et al., 2019).

2.4 Solar Energy

Solar energy is one of the types of renewable energy emitted by the sun and can be harnessed through specific devices to become a resource in various forms, serving as an alternative energy source. Solar cells are devices that convert sunlight into electrical energy through the photovoltaic process. One of the technologies used to harness solar energy is photovoltaic solar energy technology. Photovoltaic technology combines multiple solar cells connected in series and parallel to increase the voltage and current generated, making it sufficient for powering the load system. Photovoltaic solar energy technology is one of the promising solar energy technologies with significant potential to become an alternative energy source to meet society's electricity needs (Lubna et al., 2021).

2.5 Moisture Content

The simple concept of moisture content in food materials states that food materials consist of dry matter plus a certain amount of water. Water in food materials is an integral part of the food itself. This water can be found between cells and within cells. Free water is present in tissues, while bound water is usually found within cells. Measuring moisture content is necessary before and after drying to determine the amount of water evaporated. Conversely, by knowing the moisture content before drying and the desired reduction in water, the limit of drying moisture content can be determined (Prasetyo et al., 2019).

Moisture content is the amount of water contained in a substance, such as soil, rocks, and agricultural materials. Moisture content is widely used in scientific and engineering fields and is expressed as a ratio, ranging from the total dryness to the saturation point where all pores are filled with water. It can be measured volumetrically or gravimetrically (by mass) and on a wet or dry basis (Prasetyo et al., 2019).

The total amount of water in food materials is usually expressed as a percentage of the weight of the food material and referred to as moisture content. Moisture content can be expressed on a wet basis or a dry basis. The water content in food materials varies depending on the location and bonding formed by water with other compounds in the food material. Water in food materials can be classified based on its freedom level, such as free water, physically bound water, and chemically bound water. The decrease in moisture content in food materials occurs through evaporation from the saturated vapor at the surface of the solid, followed by gradual evaporation from the solid's surface and, finally, evaporation from the interior of the solid. The evaporation rate is the amount of water evaporated from dry food materials per unit time per unit drying area. The drying rate increases as the water content decreases (Hariyadi, 2018).

2.6 Desiccator

A desiccator, commonly known as a desiccator, is a glass device shaped like a jar or pot with a lid. The bottom part of the desiccator contains a drying agent such as silica gel, which functions to absorb water and moisture from the objects placed inside the desiccator. Inside the desiccator, there is a porous plate made of porcelain used to hold glassware. Beneath the porcelain plate, there is the drying agent, commonly made of silica gel, concentrated sulfuric acid, phosphorus pentoxide, or calcium oxide. The function of the desiccator is to cool down materials or glassware after heating and weighing, as well as to store substances or materials that need to be protected from atmospheric humidity (Sahab, 2022).

The term "desiccator" is derived from the word "desiccation," which means the process of drying solid, liquid, and gaseous substances containing water. Desiccation is the drying process where one substance absorbs water from another substance. The substances used for absorption are called drying agents or desiccants. The desiccator is a sealed vessel commonly used to store a substance in a dry state. It is usually placed near drying equipment like an oven. Placing the desiccator close to the oven aims to facilitate and minimize the substance's contamination with air (Sahab, 2022).

2.7 Drying Rate

Drying rate is the ratio between the initial weight and the final weight of the dried material over the drying time. In the drying process, there are two main stages of drying rate, namely constant drying rate and falling drying rate. Constant drying rate occurs on the free water layer present on the surface of grains. This drying rate occurs very quickly during the drying process, and the speed of water evaporation in this stage is equivalent to the speed of free water evaporation. The magnitude of this drying rate depends on the exposed layer, the difference in humidity between the airflow and the wet area, mass transfer coefficient, and the speed of the drying airflow (Hadi, 2015).

The drying process is achieved through water evaporation, where the absolute humidity of the air is reduced by flowing hot air around the material, causing the vapor pressure of the material to be higher than the vapor pressure of the air. This pressure difference causes water vapor to flow from the material to the air. Factors affecting evaporation include the rate of heating, the time heat energy is transferred to the material, and the amount of heat required to vaporize water. Other changes may occur within the material during the evaporation process. The events that occur during drying include two processes: the process of evaporating water from within the material, which is the process of changing from liquid to gas form, and the mass transfer process, which is the process of transferring water vapor mass from the material's surface to the air, resulting in a reduction in the weight of the food material due to the loss of some water vapor mass (Hadi, 2015).

3. METHODOLOGY

3.1 Time and Location

The Solar Drying Energy Practicum will be conducted on Friday, May 12, 2023, starting at 10:00 AM WITA, at the Soil and Water Engineering Laboratory, Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, Makassar

3.2 Tools and Materials

The tools used in the Solar Drying Energy Practicum are a digital scale, oven, knife, ruler, desiccator, silica gel, aluminum foil container, zip lock plastic bags, stationery, laptop, and a smartphone camera.

The materials used in the Solar Drying Energy Practicum are bananas and A4 size bond paper."

3.3 Working Procedure

The working procedure for the Solar Drying Energy Practicum is as follows:

A. Sample Drying

1. Prepare the tools and materials to be used.
2. Cut the banana fruit into slices of 0.5 cm thickness and 5 cm length, with a total of 3 pieces.
3. Weigh the initial weight of the samples.
4. Place the samples on bond paper and label each sample with its name.
5. Dry the samples under sunlight for 5 hours.
6. Weigh the sample at every 30-minute time interval, after placing the sample in a desiccator for 10 minutes to reduce the sample temperature.
7. Record the measurement results of the samples.
8. Document the entire practical activity.

B. Solid Sample Weight Measurement

1. Prepare the tools and materials to be used.
2. Transfer the sample from the desiccator to the drying oven, which has been preheated to a temperature of 105°C.
3. Weigh the sample at every 30-minute interval for 2 hours.
4. Record the measurement results of the samples.

5. Stop the oven process when the sample weight becomes constant.
6. Record the final weight of the dried sample.
7. Document the practical activity.

3.4 Formula used

The formula used in the Solar Drying Energy Practicum is as follows:

a. Drying Rate

$$\text{Drying Rate} = \frac{W_2 - W_1}{W_d} \times \frac{1}{30}$$

Explanation :

W_2 = Weight of water in the second material (g)

W_1 = Weight of water in the first material (g)

W_d = Weight of the solid material (g)

3.4 Wet Basis Moisture Content

$$KA_{bb} = \frac{W_m - W_d}{W_m} \times 100$$

Explanation :

W_m = Weight of water in the material (g)

W_d = Weight of solid in the material (g)

3.5 Dry Basis Moisture Content

$$KA_{bk} = \frac{W_m - W_d}{W_d} \times 100$$

Explanation :

W_m = Weight of water in the material (g)

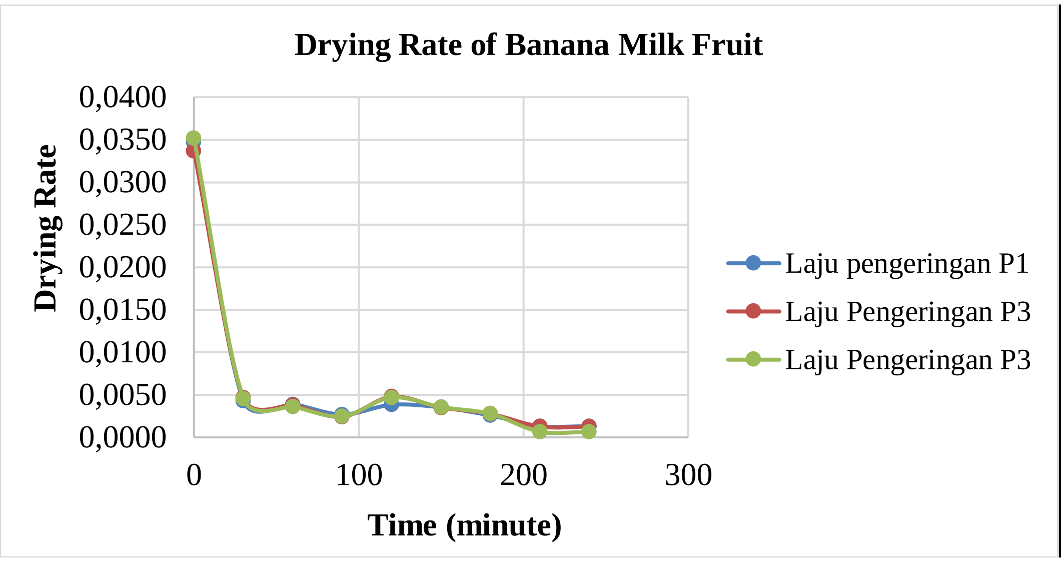
W_d = Weight of solid in the material (g)

4. RESULT AND DISCUSSION

4.1 Result

Table 6. Data of Sample Calculation Results P1

Waktu (menit)	P1	Berat Padatan nilai akhir	Laju Pengeringan	KaBb	KaBk
0	15,08	2,94	0,035	80,50	412,925
30	9,27	2,94	0,004	68,28	215,306
60	8,55	2,94	0,004	65,61	190,816
90	7,9	2,94	0,003	62,78	168,707
120	7,45	2,94	0,004	60,54	153,401
150	6,81	2,94	0,004	56,83	131,633
180	6,22	2,94	0,003	52,73	111,565
210	5,79	2,94	0,001	49,22	96,939
240	5,57	2,94	0,001	47,22	89,456



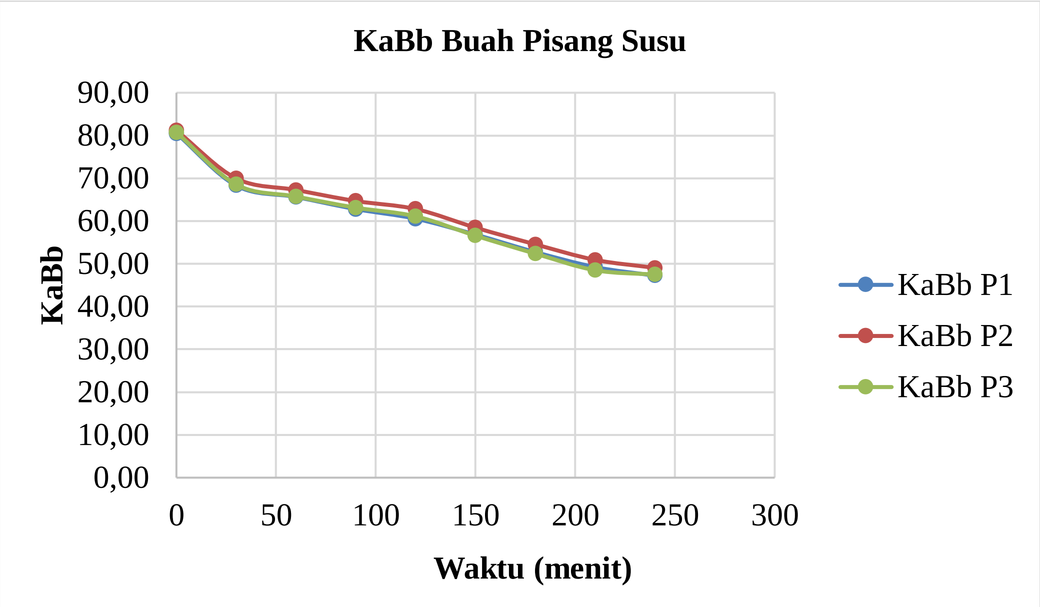
Picture 5. Drying Rate Graph of Banana Milk Fruit

Based on the drying experiment conducted, the results show that the drying rate decreases as the drying time increases. Picture 5, which illustrates the comparison of the drying rate of banana fruit over time, indicates a significant decrease in the drying rate with increasing drying time. The drying rate of the banana drops drastically after 30 minutes of drying, from 0.035 to 0.004, then further decreases to 0.004 after 120 minutes of heating, and finally reaches 0.001 after 240 minutes of heating. This decrease is due to the reduction in the moisture content of the banana caused by heating. The lower the moisture content in a material, the faster the drying rate. The initial significant drop in the drying rate of the banana after 30 minutes is attributed to the rapid evaporation of water from the surface of the banana. This evaporation process begins from the outer surface and proceeds inward.

Additionally, the decrease in the drying rate is accompanied by a reduction in the weight of the banana, with the weight decreasing from 15.08 grams to 5.57 grams, resulting in a final solid weight of 2.94 grams during the heating process. This decrease in weight is influenced by the gradual loss of water from the banana due to the applied heating. This is in line with Hariyadi's statement (2018) that the decrease in moisture content in food materials occurs through evaporation from the saturated vapor at the surface of the solid, followed by gradual evaporation from the solid's surface and, finally, evaporation from the interior of the solid. The evaporation rate is the amount of water evaporated from dry food materials per unit time per unit drying area. The drying rate increases as the water content decreases.

Table 7. Data of Sample Calculation Results P2

Waktu (menit)	P2	Berat Padatan nilai akhir	Laju Pengeringan	KaBb	KaBk
0	15,67	2,95	0,0337	81,174	431,186
30	9,82	2,95	0,0047	69,959	232,881
60	9,01	2,95	0,0038	67,259	205,424
90	8,35	2,95	0,0024	64,671	183,051
120	7,93	2,95	0,0048	62,799	168,814
150	7,1	2,95	0,0035	58,451	140,678
180	6,49	2,95	0,0028	54,545	120,000
210	6,01	2,95	0,0013	50,915	103,729
240	5,79	2,95	0,0333	49,050	96,271



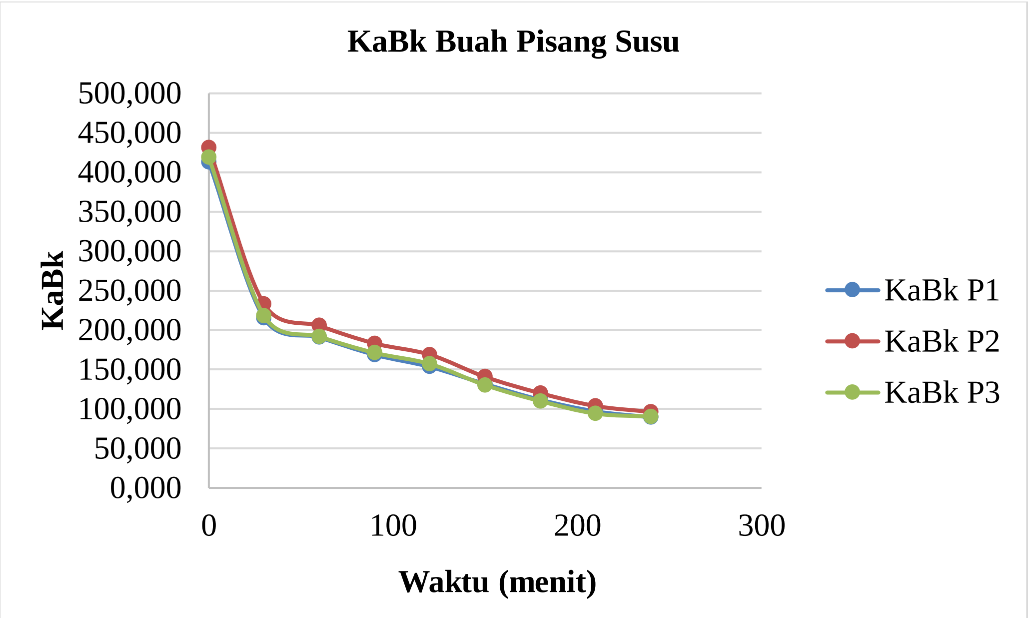
Picture 6. Graph of Wet Basis Moisture Content of Banana Milk Fruit.

Based on Picture 6, which illustrates the comparison of wet basis moisture content over drying time, it shows a decrease in wet basis moisture content as the heating time increases.

The wet basis moisture content value experiences a significant decrease in the first 30 minutes of heating, from 81% to 69%, then gradually decreases, reaching a final wet basis value of 49%. The decrease in wet basis moisture content indicates a reduction in the amount of water in the material, resulting in a decrease in the total weight of the material. Wet basis moisture content represents the total amount of water contained in a material, so a smaller wet basis moisture content value indicates that the water content in the material is decreasing due to the drying process applied to the bananas. The decrease in wet basis moisture content shows that the drying process is proceeding well. This aligns with Hariyadi's statement (2018) that the total amount of water in food materials is usually expressed as a percentage of the weight of the food material and is referred to as moisture content. Moisture content can be expressed on a wet basis or a dry basis.

Tabel 8. Data of Sample Calculation Results P3.

Waktu (menit)	P3	Berat Padatan nilai akhir	Laju Pengeringan	KaBb	KaBk
0	15,1	2,91	0,0352	80,728	418,900
30	9,25	2,91	0,0046	68,541	217,869
60	8,49	2,91	0,0036	65,724	191,753
90	7,89	2,91	0,0025	63,118	171,134
120	7,48	2,91	0,0047	61,096	157,045
150	6,7	2,91	0,0035	56,567	130,241
180	6,11	2,91	0,0028	52,373	109,966
210	5,65	2,91	0,0007	48,496	94,158
240	5,54	2,91	0,0333	47,473	90,378



Picture 7. Graph of Dry Basis Moisture Content of Banana Milk Fruit.

Based on Picture 7, which shows the comparison of dry basis moisture content over drying time, it indicates a decrease in dry basis moisture content as the heating time increases. The dry basis moisture content value experiences a significant decrease in the first 30 minutes of heating, from 418% to 217%, then gradually decreases, reaching a final measurement of 90% dry basis moisture content. Dry basis moisture content represents the ratio between the total amount of water and the weight of the dry material in the sample. Thus, the smaller or lesser the amount of water in the material, the lower the value of dry basis moisture content. The decrease in dry basis moisture content shows that the amount of water in the material is decreasing with increasing heating time, resulting in a decrease in the total weight of the material. Dry basis moisture content indicates the amount of solid content in the banana fruit after losing water through evaporation during the drying process. The remaining solids contain the concentrated nutrients of the banana fruit after water loss. This aligns with Huriawati et al.'s statement (2019) that drying reduces the moisture content of food materials, causing substances such as proteins, fats, carbohydrates, and minerals in the food material to become more concentrated.

Based on the Drying experiment conducted, the results show that drying is a process of reducing or eliminating the water content from a material, making the material preserved or resistant to microbes. Drying the banana fruit indicates that the drying rate, wet basis moisture content, and dry basis moisture content decrease with increasing drying time, indicating that the drying rate is directly proportional to the drying time. The decrease occurs because the water content in the material reduces due to the increase in heat during the drying process.

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ATTACHMENT

ATTACHMENT 3. Table of Measurement Results for Banana Fruit Samples.

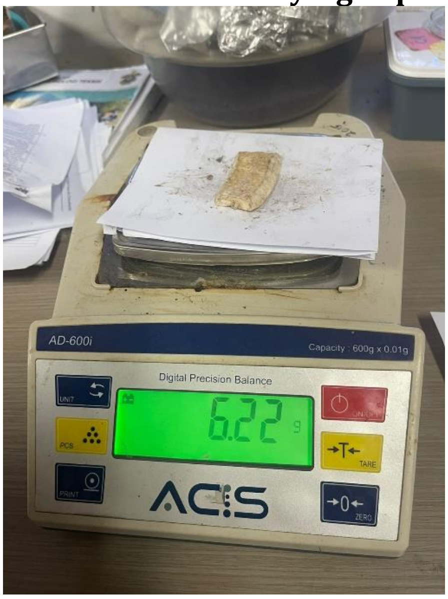
Table 9. Measurement Results of Banana Fruit Samples with Solar Drying.

Time	P1	P2	P3
0	9.27	9.82	9.25
30	8.55	9.01	8.49
60	7.90	8.35	7.89
90	7.45	7.93	7.48
120	6.81	7.10	6.70
150	6.22	6.49	6.11
180	5.79	6.01	5.65
210	5,57	5.79	5.44

Table 10. Measurement Results of Banana Fruit Samples with Oven Drying.

Time	P1	P2	P3
0	4.07	4.03	3.78
30	3.39	3.40	3.24
60	3.09	3.09	3.00
90	2.94	2.95	2.91

ATTACHMENT 4. Documentation of Solar Drying Experiment.



Picture 8. Documentation of Solar Drying Experiment.

1. INTRODUCTION

1.1 Background

Drying is one of the essential processes in everyday life that involves various sectors. One important application of drying is in the field of food preservation. Drying food materials can significantly reduce the moisture content, inhibiting the growth of microorganisms and spoilage. As a result, food can last longer and be accessible beyond the harvest season, providing benefits in terms of food security and supply stability.

Drying plays a crucial role in preventing spoilage of fruits and vegetables in the agricultural sector. After harvest, vegetables or fruits have high moisture content, and this excess moisture can trigger the growth of microorganisms, spoilage, and a decline in product quality. The drying process is conducted to significantly reduce the moisture content in fruits and vegetables. Reducing moisture content in food materials inhibits the activity of microorganisms and slows down the spoilage process. Additionally, drying also helps reduce the activity of enzymes involved in color, flavor, and texture changes. Drying helps maintain the quality and shelf life of agricultural products, enabling broader distribution and consumption, as well as providing economic benefits to farmers.

Various drying methods are used in the agricultural field, such as natural sun drying or using drying equipment. Natural sun drying, also known as solar drying, is often used for materials like fruits and vegetables with thin skins, such as chili peppers, tomatoes, or oranges. Meanwhile, drying equipment such as tray dryers or drying rooms can be used for mass drying with better temperature and humidity control.

Based on the above description, conducting a Solar Drying experiment is necessary to understand and directly experience how solar energy can be utilized for drying in the agricultural sector.

1.2. Objectives and Benefits

The purpose of the Solar Drying laboratory practice is to understand the basic principles of drying a food material, calculate the changes that occur in the wet basis and dry basis moisture content of a material during the drying process, and explain the drying process based on the drying rate curve of a material.

The significance of conducting the Solar Drying laboratory practice is to comprehend the fundamental principles of drying a material, understand the changes in moisture content (wet basis and dry basis) during the drying process, extend the shelf life of food material products, and apply this knowledge in everyday life, especially in the field of agriculture.

2. LITERATURE REVIEW

2.1 Solar energy

Solar energy is an unlimited source of energy on Earth that is not only easily accessible but also environmentally friendly, as it doesn't cause pollution. Solar energy comes in the form of light and heat from the sun. This energy can be harnessed using a series of different methods. Given the current era of increasing population growth, the demand for energy is rising while natural resources are depleting (Azeez et al., 2017).

One common application of solar radiation energy is as a solar drying tool. Solar-powered drying systems, such as the cabinet-type solar dryer, are used for drying agricultural products like coffee beans, bananas, and cassava. Solar drying systems offer advantages over conventional methods as they protect the materials from external dirt, dust, strong winds, and rain. Solar drying devices come in various types, depending on the design specifications and models. One design model is the cabinet-type dryer with an inclined cover, which serves as an example of renewable solar energy utilization (Azeez et al., 2017).

2.2 Banana (Musa sp.)

Banana (Musa sp.) is one of the most widely cultivated cultivars worldwide and can be found in tropical countries, even categorized as one of the most important global food crops after rice, wheat, and maize. However, the perishable nature of this climacteric fruit can lead to significant post-harvest waste and losses. The effectiveness of drying treatment to extend fruit stability during storage has long been recognized. In addition to preservation, drying can also promote the development of value-added products, such as dried banana flour, with equal or improved quality. Banana flour is one of the main products obtained from banana fruit drying treatment. Drying, or dehydration, refers to the process of removing moisture from food materials, resulting in dried products with reduced water activity. The drying process can be categorized based on moisture removal approach, including thermal drying (Adawiyah et al., 2023).

Pisang Susu, also known as Milk Banana, has green fruit when young and turns bright yellow when ripe. The fruit has a curved shape with almost inconspicuous angles, and the fruit's flesh is milky white. Pisang Susu has a herbaceous habit, reaching a height of 4.23-5.1 meters. The pseudostem is green with brown spots. The leaves of Pisang Susu are dark green, with both the upper and lower surfaces appearing dull. The heart of Pisang Susu typically has a lanceolate shape, tapering towards the tip. Pisang Susu is a popular type of banana in Indonesia, especially in regions with a tropical climate. This banana has milky white flesh with a soft and sweet texture (Mukhoyyaroh and Hakim, 2020)

The utilization of solar energy for drying agricultural products, including fruits such as bananas, can help improve the efficiency of the drying process. Traditional methods, like sun drying, are dependent on weather conditions and can be less effective due to contamination and dust exposure. Solar-powered drying involves using a collector to capture sunlight and heat, which is then directed into the drying chamber to evaporate the moisture content in the fruit (Novitasari et al., 2017).

2.3 Drying

Drying is defined as the removal or extraction of moisture content from a material until a specific moisture content is reached. The drying of food materials serves two main purposes: as a means to extend shelf life by reducing the moisture content to prevent the growth of spoilage microorganisms and to minimize the distribution costs of food materials due to their reduced weight and size. Furthermore, the drying process must be carefully controlled to prevent damage to the quality of food materials or products, such as changes in taste, color, and texture. Food drying is a common preservation technique, especially for perishable and high-moisture content food materials like fruits, vegetables, and meat (Kameo et al., 2022).

Farmers typically use conventional methods for drying, such as sun-drying in open fields. This approach has several drawbacks, including being weather-dependent, resulting in prolonged drying times, and potential lack of cleanliness in the grain. Drying processes that involve drying equipment require significant energy consumption, utilizing electricity and fuel. A cost-effective approach for drying involves the use of solar energy (sunlight) and biomass as drying energy sources. Various drying equipment, ranging from simple to modern designs, have been developed and researched, but there are still many shortcomings in terms of cost, utility, and efficiency (Panggabean et al., 2017).

Drying using sunlight as a heat transfer process to evaporate moisture is facilitated by solar radiation as the heat source for drying media. Solar drying can be categorized into two methods: Direct Sun Drying and Solar Drying. The purpose of drying is to reduce the moisture content of materials to a point where the development of microorganisms and enzymatic activities causing spoilage is hindered or halted. However, improper drying can lead to damage to materials and even pose health risks. For instance, excessive drying time or high temperatures can result in the loss of nutrients and flavor in the food, necessitating careful supervision for optimal results (Ridwan et al., 2018).

Several factors influence the rate of drying, including ambient temperature and humidity, airflow velocity in the drying chamber, percentage of moisture content, drying power, drying machine efficiency, and drying capacity. During the drying process, the transfer of material from the bulk to the air occurs in the form of vapor, or drying occurs at the material's surface. Subsequently, the vapor pressure on the material's surface decreases. After the temperature rise affects the entire material, water moves through diffusion from the material to its surface, and the process of material evaporation on the surface is repeated until equilibrium is reached with the surrounding air (Hatta et al., 2019).

2.4 Moisture content

Moisture content, as one of the important laboratory testing methods in the field of food industry, plays a crucial role in determining the quality and resilience of food products against potential deterioration. Moisture content refers to the amount of water present in a substance or material, measured as a weight percentage of the total material. It can be calculated by comparing the weight of water contained in a substance to the total weight of the material. Higher moisture content in a food material increases the likelihood of deterioration, either due to internal biological activity (metabolism) or the entry of degrading microorganisms. Appropriate moisture content in food materials can influence organoleptic properties (taste, aroma, texture), nutritional value, and the material's resistance to microbial growth. Reducing the moisture content in food materials results in decreased availability of water to support microorganism life and physicochemical reactions. The growth of microorganisms and physicochemical reactions in food materials will be hindered, thus extending the material's resistance against deterioration (Daud et al., 2019).

Measurement of moisture content can be performed using measuring instruments and techniques such as the oven method. Measurement using the oven method, or drying, is one approach used to determine the moisture content in a food product. The principle involves heating the material at 105°C for a specific time, causing the water contained within the material to evaporate. The difference in weight before and after heating corresponds to the moisture content of the material (Prasetyo et al., 2019).

Precision and accuracy in determining moisture content values (both on a wet basis and dry basis) using the oven method have become the reference in the Indonesian National Standards. However, it is worth noting that the determination of moisture content using the oven method is relatively complex and time-consuming. As a result, digital technology has introduced moisture content measuring instruments that are faster and easier to operate compared to analog devices. All food materials contain water, and consumers or industry stakeholders need to be aware of the water content's significance as an essential element in food materials. While not a source of nutrition, its presence is crucial for the continuity of biochemical processes in living organisms (Prasetyo et al., 2019)

2.5 Drying Rate

The energy required in the drying process involves heat energy to raise the temperature and facilitate the transfer of water. The duration of the drying process is closely related to the drying rate and the controlled level of damage resulting from the drying process. Drying rate is measured by calculating the amount of water leaving the food material within a specific time frame. Drying rate is divided into several periods: the first period of decreasing drying rate, the constant drying rate period, and the decreasing drying period. The drying rate period will continue until the free water on the surface of the food material is removed. The drying rate curve during the decreasing drying rate period varies depending on the type of food material. The higher the rate of water evaporation from within the food material, the greater the decrease in drying rate (Priyanti, 2018).

Control of the drying rate is an essential aspect of the drying process to produce high-quality dried products. Excessively rapid drying rate can lead to physical and chemical damage to the food material. The drying rate decreases as the moisture content decreases during the drying process. The amount of bound water decreases over time. The transition from a constant drying rate to a decreasing drying rate varies with different moisture content levels (Soekarno et al., 2022).

3. METHODOLOGY

3.1 Time and Location

The Solar Drying Energy Practicum will be conducted on Friday, May 12, 2023, starting at 10:00 AM WITA, at the Soil and Water Engineering Laboratory, Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, Makassar

3.2 Tools and Materials

The tools used in the Solar Drying Energy Practicum are a digital scale, oven, knife, ruler, desiccator, silica gel, aluminum foil container, zip lock plastic bags, stationery, laptop, and a smartphone camera.

The materials used in the Solar Drying Energy Practicum are bananas and A4 size bond paper.

3.3 Working Procedure

The working procedure for the Solar Drying Energy Practicum is as follows:

b. Sample Drying

1. Prepare the tools and materials to be used.
2. Cut the banana fruit into slices of 0.5 cm thickness and 5 cm length, with a total of 3 pieces.
3. Weigh the initial weight of the samples.
4. Place the samples on bond paper and label each sample with its name.
5. Dry the samples under sunlight for 5 hours.
6. Weigh the sample at every 30-minute time interval, after placing the sample in a desiccator for 10 minutes to reduce the sample temperature.
7. Record the measurement results of the samples.
8. Document the entire practical activity.

b. Solid Sample Weight Measurement

1. Prepare the tools and materials to be used.
2. Transfer the sample from the desiccator to the drying oven, which has been preheated to a temperature of 105°C.
3. Weigh the sample at every 30-minute interval for 2 hours.

4. Record the measurement results of the samples.
5. Stop the oven process when the sample weight becomes constant.
6. Record the final weight of the dried sample.
7. Document the practical activity.

3.4 Formula used

The formula used in the Solar Drying Energy Practicum is as follows:

a. Drying Rate

$$\text{Drying Rate} = \frac{W_2 - W_1}{W_d} \times \frac{1}{30}$$

Explanation :

W_2 = Weight of water in the second material (g)

W_1 = Weight of water in the first material (g)

W_d = Weight of the solid material (g)

b. Wet Basis Moisture Content

$$KA_{bb} = \frac{W_m - W_d}{W_m} \times 100$$

Explanation :

W_m = Weight of water in the material (g)

W_d = Weight of solid in the material (g)

c. Dry Basis Moisture Content

$$KA_{bk} = \frac{W_m - W_d}{W_d} \times 100$$

Explanation :

W_m = Weight of water in the material (g)

W_d = Weight of solid in the material (g)

4. RESULT AND DISCUSSION

4.1 Result

Table 6. Data of Sample Calculation Results P1

Time				Time	
0	15,08	2,94	0,035	80,50	412,925
30	9,27	2,94	0,004	68,28	215,306
60	8,55	2,94	0,004	65,61	190,816
90	7,9	2,94	0,003	62,78	168,707
120	7,45	2,94	0,004	60,54	153,401
150	6,81	2,94	0,004	56,83	131,633
180	6,22	2,94	0,003	52,73	111,565
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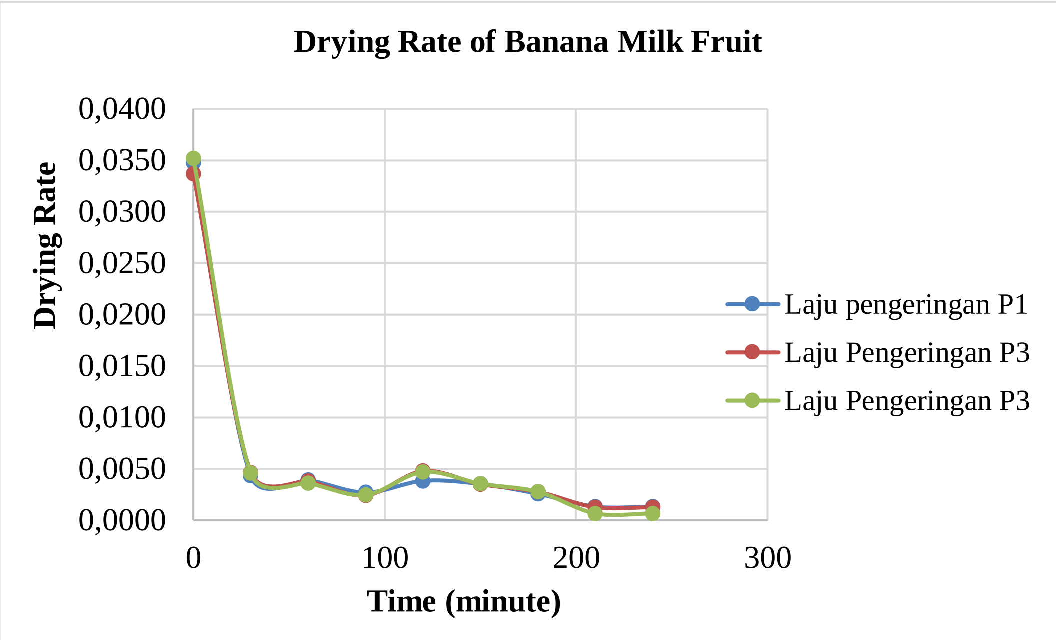
240	5,57	2,94	0,001	47,22	89,456

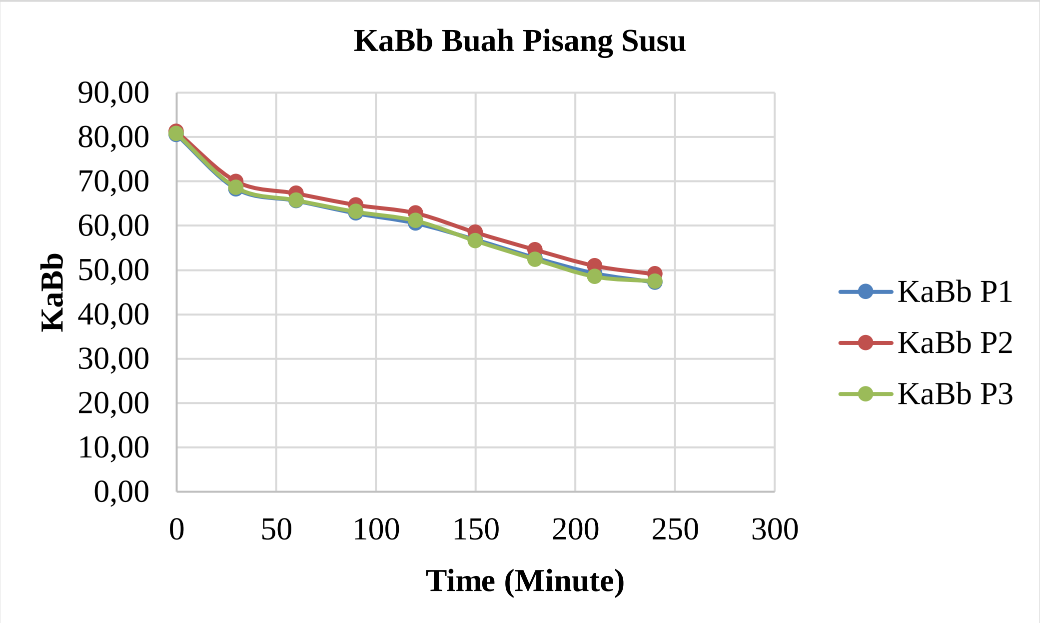


Picture 9. Drying Rate Graph of Banana Milk Fruit

The results obtained in Picture 1 show the drying rate graph. In sample 1 of banana susu, at minute 0, the drying rate was 0.0348%, and it gradually decreased to 0.0013% at minute 240. In sample 2 of banana susu, the drying rate was 0.0337% at minute 0, and it reached 0.0013% at minute 240. For sample 3 of banana susu, the drying rate was 0.0352% at minute 0, and it decreased to 0.0007% at minute 240. This indicates that at the beginning of the drying process (minute 0), the drying rate is relatively high. However, over time, the drying rate gradually decreases. By minute 240, the drying rate reaches its lowest point, indicating a slower or decreased drying process. This is influenced by factors such as air humidity, sunlight intensity, temperature, and the characteristics of the food material itself, which affect the drying rate. This is consistent with the statement by Priyanti (2018), which states that the drying rate curve during the decreasing drying rate period varies depending on the type of food material. The higher the rate of water evaporation from within the food material, the greater the decrease in drying rate.

Table 2. Data of Sample Calculation Results P2

Time (minute)	P2	Solid Weight Final Value	Drying Rate	KaBb	KaBk
0	15,67	2,95	0,0337	81,174	431,186
30	9,82	2,95	0,0047	69,959	232,881
60	9,01	2,95	0,0038	67,259	205,424
90	8,35	2,95	0,0024	64,671	183,051
120	7,93	2,95	0,0048	62,799	168,814
150	7,1	2,95	0,0035	58,451	140,678
180	6,49	2,95	0,0028	54,545	120,000
210	6,01	2,95	0,0013	50,915	103,729
240	5,79	2,95	0,0333	49,050	96,271



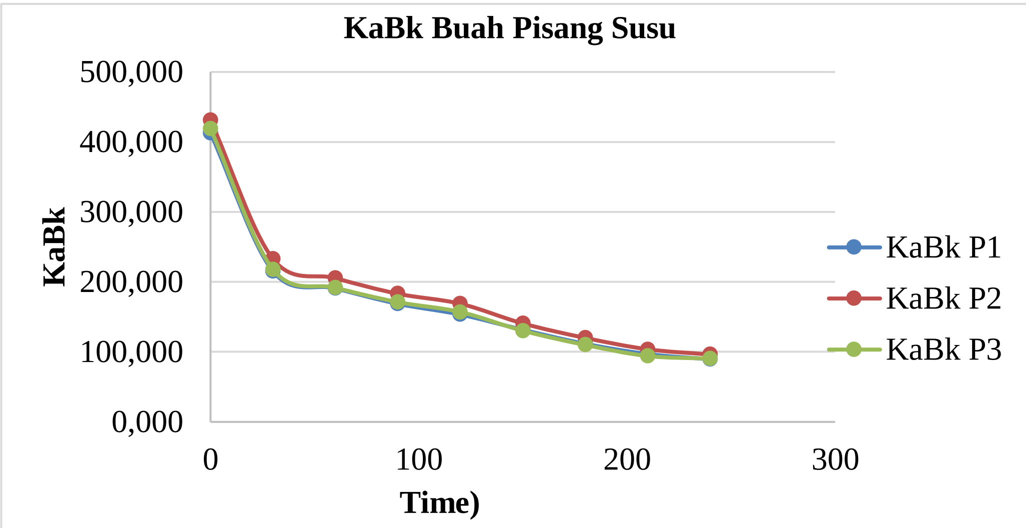
Picture 10. Graph of Wet Basis Moisture Content of Banana Milk Fruit.

The results obtained in Picture 2, the graph of wet basis moisture content of banana susu, show that for sample 1, at the initial minute or minute 0, the Wet Basis Moisture Content (WbMC) is 80.5%, and at minute 240, it is 47.22%. For sample 2, at minute 0, the WbMC value is 81.174%, and at minute 240, it is 49.050%. For sample 3, at minute 0, the WbMC value is 80.728%, and at minute 240, it is 47.473%. This indicates that as the banana susu is dried with solar radiation or solar energy for a longer duration, the wet basis moisture content decreases. This is due to the evaporation of water from the banana susu caused by the heat of sunlight. During the drying process, bananas have high water content. When exposed to sunlight, the heat from the sun causes water to evaporate from the bananas. Over time, the water within the bananas moves into the surrounding atmosphere as water vapor, leading to a decrease in the wet basis moisture content of the bananas.

This demonstrates that drying with solar radiation or using solar energy is effective in reducing the wet basis moisture content of bananas, thereby extending their shelf life and enhancing product stability. This aligns with the statement by Daud et al. (2018), that reducing the moisture content in food materials leads to a decrease in the availability of water to support the life of microorganisms and the occurrence of physicochemical reactions

Tabel 13. Data of Sample Calculation Results P3.

Time (minute)	P3	Solid Weight Final Value	Drying Rate	KaBb	KaBk
0	15,1	2,91	0,0352	80,728	418,900
30	9,25	2,91	0,0046	68,541	217,869
60	8,49	2,91	0,0036	65,724	191,753
90	7,89	2,91	0,0025	63,118	171,134
120	7,48	2,91	0,0047	61,096	157,045
150	6,7	2,91	0,0035	56,567	130,241
180	6,11	2,91	0,0028	52,373	109,966
210	5,65	2,91	0,0007	48,496	94,158
240	5,54	2,91	0,0333	47,473	90,378



Picture 11. Graph of Dry Basis Moisture Content of Banana Milk Fruit.

The results obtained in Picture 3, the graph of dry basis moisture content of banana susu, show that for sample 1, at the initial minute or minute 0, the Dry Basis Moisture

Content (DbMC) value is 412.925%, and at minute 240, it is 89.456%. For sample 2, the DbMC value at the initial minute is 431.186%, and at the final minute, it is 96.271%. For sample 3, the DbMC value at minute 0 is 418.900%, and at minute 240, the DbMC value is 90.378%. This indicates that the longer the banana is dried under sunlight, the lower its dry moisture content becomes. This is due to the ongoing drying process that reduces the remaining water content in the banana. As time passes and the drying process continues, the remaining water in the banana continues to evaporate and exit the fruit, resulting in a reduction in the dry moisture content of the banana. As a result, the graph of dry basis moisture content shows a consistent decrease over time.

This aligns with the statement by Hatta et al. (2019), which states that several factors influence the drying rate, including the temperature and humidity of the environment, the speed of the drying airflow, the percentage of moisture content, drying power, drying machine efficiency, and drying capacitypengeringannya.

5. Closure

Based on the conducted Solar Drying experiment, it can be concluded that a fundamental principle of a food material is the presence of moisture content within that material. Moisture content is one of the crucial components in food materials and affects their quality, stability, and shelf life. Changes observed in both wet basis moisture content and dry basis moisture content during the drying process reveal that as the food material is dried using solar energy for a longer duration, its wet basis moisture content decreases, while its dry basis moisture content also decreases. This phenomenon is influenced by factors such as the drying method, drying temperature, drying time, material characteristics, and the surrounding environment. lead to a decrease in the wet basis moisture content contained in the material

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ATTACHMENT

ATTACHMENT 5. Table of Measurement Results for Banana Fruit Samples.

Table 14. Measurement Results of Banana Fruit Samples with Solar Drying.

Time	P1	P2	P3
0	9.27	9.82	9.25
30	8.55	9.01	8.49
60	7.90	8.35	7.89
90	7.45	7.93	7.48
120	6.81	7.10	6.70
150	6.22	6.49	6.11
180	5.79	6.01	5.65
210	5,57	5.79	5.44

Table 15. Measurement Results of Banana Fruit Samples with Oven Drying.

Time	P1	P2	P3
0	4.07	4.03	3.78
30	3.39	3.40	3.24
60	3.09	3.09	3.00
90	2.94	2.95	2.91

ATTACHMENT 6. Documentation of Solar Drying Experiment.

Picture 12. Documentation of Solar Drying Experiment.

1. INTRODUCTION

1.1 Background

Agriculture is Wrong One sector economy Which very important as source material food. Processing results agriculture can done with various method, start from processing with help technology nor processing in the traditional way. Processing of agricultural products carried out with Good And sustainable can. Technique processing results agriculture WrongOne method utilization in field technology For help in simplify and improve the quality and quantity of a processing agricultural product. The advantage of processing agricultural products is agricultural products processed will definitely be preserved and can last longer. One of example in preserving food by drying. Drying using solar energy is referred to as drying solar energy. The benefits of processing agricultural products reduce the water content in the material as well prevent appearance microorganisms.

Solar energy drying can be carried out in a place where it is directly exposed with ray sun. Media addition Which used on method This drying can use a tarpaulin mat or can be directly placed on the floor over concrete. The advantages of this drying do not require large costs, does not require special skills and equipment. Lack of draining energysolar energy requires large areas of land and is highly dependent on the weather. Long time do drying with use solar energy3-4 days, depending on the material being dried and saw sun exposure conditions. Solar energy drying can also be helped with oven. For example after drying in the sun can next with use tool oven in drying material food.

Based on the description above, it is necessary to do practicum Drying Energy Sun so that can know various technique drying specifically drying energy Sun For help reduce rate water on materialfood, help slow down growth microorganisms And capable preserve yield food agriculture.

1.2 Objective And Utility

As for objective practice Drying Energy Sun that is, can understand basic principles of food drying, calculating changes in moisture content which occurs on the moisture content of the wet basis and dry basis of the material during dryingas well as can explain How process from drying based on curverate drying an ingredient.

As for utility practice is carried out Drying Energy Sun that is, can know the basic principles of drying a material, can know change rate water wet And dry during process drying, can extend the shelf life of food products and can be applied in life daily specifically in the field agriculture.

2. LITERATURE REVIEW

2.1 Banana (*Moses paradisiaca*)

Bananas are rich in vitamins and fiber when compared to apples, bananas has more than double the carbohydrates and five times the vitamin A. Bananasalso rich in magnesium and potassium. Bananas have colored skin yellow when ripe and green when unripe. Banana plant one of the leading plants in Indonesia, because of the large volume of production national ones exceed commodity other. Production banana in Indonesia which quite high not in proportion to the level of consumption society, so resulting in lots of bananas No used for storage fruit banana Which relatively short. Wrong One solution from problem This with making bananas into processed products, namely selling bananas. Banana sale is made from banana ripe with method drying sun (Solar And Aratama, 2020).

2.2 Drying

Drying can defined as something method For emit or removes most of the water from the material by using heat energy. Base drying ie happening evaporation water to air Because exists difference content steam water between air with material Which dried. The purpose of removing water from the material is done to prevent or slow down emergence of microorganisms, fungi, enzymes, microorganisms and insects can damage to no active (Hanafi *et al* ., 2017).

Process drying as Wrong One handling material food Forimprove the quality and extend the shelf life of foodstuffs. Every Foodstuffs to be dried have different drying characteristics different. Process drying own a number of variable Which can affect the quality of the products produced. Drying one step final in Suite processing product Which Ready For dried then done final packaging. Factor which can affect the rate of drying namely the temperature and humidity of the air around the environment and percentage of water content (Benefit *et al* ., 2019).

Process drying consists from two stages that is setup mediadryer (air) and material drying process. Preparation of heating media candone through warmup air with use source hot fromnatural (sun, hot earth) or artificial (electricity, burning wood, charcoal, coal, natural gas and fuel oil). The heating medium (air) has been heated the, furthermore used For evaporate water from material with utilise hot sensitive (hot For raise temperature without change phase) and latent heat (heat to change phase or vaporize water). Viewed microscopically, during the drying process there are phenomenon displacement hot And mass Which happen in a manner simultaneous that is heat transfer from the drying medium to the material and water mass transfer from material to media dryer (Asia and Djaeni, 2021).

Drying is divided into two namely natural drying (using sunlight) and artificial drying (using tools). Dryingexperience can done with drying in a manner direct in lower ray sun wich one use means drying like floor drying, road paved or mat. Drying artificial can defined as drying Which source the heat from tool dryer, Good with source electricity or other energy. Artificial drying is carried out with using combustion products. The air medium is blown through heating or direct contact with the product being dried. Air heating can be done directly (*direct*) and indirectly (*indirect*). Process This drying is done by placing the product to be dried onto in a dryer (Panggabean *et al* ., 2017).

Both of these drying can help in drying onprocessing of agricultural food. Natural drying and drying Each has its own advantages and disadvantages. The advantages of natural drying that does not require special skills and equipment and they cost less. The disadvantage of natural drying is that it requires land broad And very dependent on the weather. Drying artificial have excess ie temperature And Genre the air can arranged so that time drying can be determined (Ramdani *et al* ., 2018).

2.3 Solar Energy

Power Sun can defined as source energy Which overflow, renewable and sustainable. One of the dryers that is often used in daily life namely drying solar energy. This drying is used for drying agricultural products which not only can save energy but also save a lot of time, occupy less area and can improve product quality. This solar energy drying system does just that rely on solar energy but also assist the latest advances in process drying Which combine form other from source heating addition with energy sun For reduce consumption material burn. Solar dryer can be done directly, solar dryer indirectly,hybrid solar dryers and other drying applications. Dryer energy Sun (*solar dryer*) Also can used For optimizing the use of sunlight in the drying process, by converting sunlight into heat energy which is done by using a heat collector or collector. This drying can be used in scale *home industry* Because the tool Which economical And hygienic (Kumar *et al.* , 2016).

2.4 Method Drying

Sun drying ie method drying with utilise source energy sun by using a collector as a heat sink that makesmaximum use of solar energy. *Sun drying* is done with spread food or commodities on tarpaulin or other bedding and dried directly in the sun. Areas suitable for the *sun methodDrying* is an area that has dry air with daily air temperatures around 30-33 °C. Drying duration by method *sun drying* is approx 3-4 day, depends with condition radiation sun And condition material food Which want to dried (Tamaheang *et al.*, 2017).

2.5 Water content

Water content can be interpreted as the amount of water contained in an object objects such as land, agricultural materials and so on. The principle of determining the water content with drying ie something evaporation water Which There is in material with The heating process is then carried out by weighing the ingredients until they are heavy constant which indicates that all the water is contained in the material Already evaporate all. Process drying on something material can cause depreciation. shrinkage happen when decrease volume, changes in shape and which can affect the hardness of the material the. The process of heating and loss of water in the drying process can cause pressure to structure cell something material can seen from change form And diminution on the ingredients. Decline rate water need known to in process postharvest processing when there is a large loss of water on content something material can quick handled (Amaliah *et al* ., 2017).

Conventionally, water in foodstuffs can be divided into three types namely chemically bound water, physically bound water and free water. Water content in food ingredients also determines the freshness and durability of food ingredients the. Content water in groceries follow determine acceptability, freshness And Power stand material That. Water Also is component importantin foodstuffs because water can affect the appearance, texture and food taste. The percentage of water content that is too high in food ingredients will make it easy for bacteria, mold and yeast to multiplyso that will result change on foodstuffs. Rate heavy water Wet can be interpreted as a comparison between the weight of water present in the material by the total weight of the material. The dry basis moisture content can be defined as weight material after experiencing drying in a certain time so that it weighs constant. Plant dry weight is the weight of a plant after passing through several stages of the drying process. The wet weight is the current weight of a plant Still contain water content in it (Budi *et al.*, 2020).

2.6 Benefit Drying

Benefit other from drying is lower cost handling And transport product. Weakness from operation drying is happendamage to the dried material such as decreased organoleptic taste and aroma, reduced content nutrition material consequence warmup on temperature tall one. Drying with the vacuum method is a drying method in which space dryer is at on condition vacuum that is pressure in in room dryer more low from pressure atmosphere. On moment mechanism drying takes place, the water vapor that is in the material will come out to the environment as a resultthere is a difference in water vapor pressure, where the water vapor pressure inside the material is more greater than the vapor pressure of water in the environment. If the drying chamber is located condition vacuum will push process evaporation going on more easy due to a decrease in the boiling point of water. The advantages of drying with method vacuum is can avoid damage material dry from use dryer temperature Which tall (Nusa, 2020).

2.7 Rate Drying

Drying rate can be interpreted as the amount of water evaporated perunit time. Rate drying can influenced by form, size And composition of the material as it dries, temperature, humidity and airflow velocity dryer. Temperature is a very important factor important in the process drying. Process drying needed temperature Which relatively tall For evaporate the water present in the material. Evaporation rate material water in drying very determined by increase temperature. The more tall temperature And the speed of the drying air flow the faster also process drying going on. The higher the drying air temperature, the greater the energy the heat carried by the air and the greater the amount of liquid mass that is evaporated from the surface of the dried material. The size of the material after drying shrink or shrink, where the longer the drying time, the more shrink the size of the dried material. The arrangement of materials while doing Drying also needs to be considered so that the spread of drying on the material which is dried acceptable and evenly distributed. Airflow rate where, the air contained in the drying process has a function as giver hot on material, so that can cause happening evaporation of water. Another function of this air is to transport water vapour released by the material being dried. Material surface area Where, the more big wide surface material Which will dried so the more fast drying. Rate water material Where, the more tall temperature drying, the faster evaporation occurs, so that the water content in in lower material (Murad *et al* ., 2019).

3. METHODOLOGY

3.1 Time and Location

The Solar Drying Energy Practicum will be conducted on Friday, May 12, 2023, starting at 10:00 AM WITA, at the Soil and Water Engineering Laboratory, Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, Makassar

3.2 Tools and Materials

The tools used in the Solar Drying Energy Practicum are a digital scale, oven, knife, ruler, desiccator, silica gel, aluminum foil container, zip lock plastic bags, stationery, laptop, and a smartphone camera.

The materials used in the Solar Drying Energy Practicum are bananas and A4 size bond paper.

3.3 Working Procedure

The working procedure for the Solar Drying Energy Practicum is as follows:

A. Sample Drying
   1. Prepare the tools and materials to be used.
   2. Cut the banana fruit into slices of 0.5 cm thickness and 5 cm length, with a total of 3 pieces.
   3. Weigh the initial weight of the samples.
   4. Place the samples on bond paper and label each sample with its name.
   5. Dry the samples under sunlight for 5 hours.
   6. Weigh the sample at every 30-minute time interval, after placing the sample in a desiccator for 10 minutes to reduce the sample temperature.
   7. Record the measurement results of the samples.
   8. Document the entire practical activity.

B. Solid Sample Weight Measurement
   1. Prepare the tools and materials to be used.
   2. Transfer the sample from the desiccator to the drying oven, which has been preheated to a temperature of 105°C.
   3. Weigh the sample at every 30-minute interval for 2 hours.
   4. Record the measurement results of the samples.

5. Stop the oven process when the sample weight becomes constant.
6. Record the final weight of the dried sample.
7. Document the practical activity.

3.4 Formula used

The formula used in the Solar Drying Energy Practicum is as follows:

a. Drying Rate

$$\text{Drying Rate} = \frac{W_2 - W_1}{W_d} \times \frac{1}{30}$$

Explanation :

W_2 = Weight of water in the second material (g)

W_1 = Weight of water in the first material (g)

W_d = Weight of the solid material (g)

d. Wet Basis Moisture Content

$$KA_{bb} = \frac{W_m - W_d}{W_m} \times 100$$

Explanation :

W_m = Weight of water in the material (g)

W_d = Weight of solid in the material (g)

e. Dry Basis Moisture Content

$$KA_{bk} = \frac{W_m - W_d}{W_d} \times 100$$

Explanation :

W_m = Weight of water in the material (g)

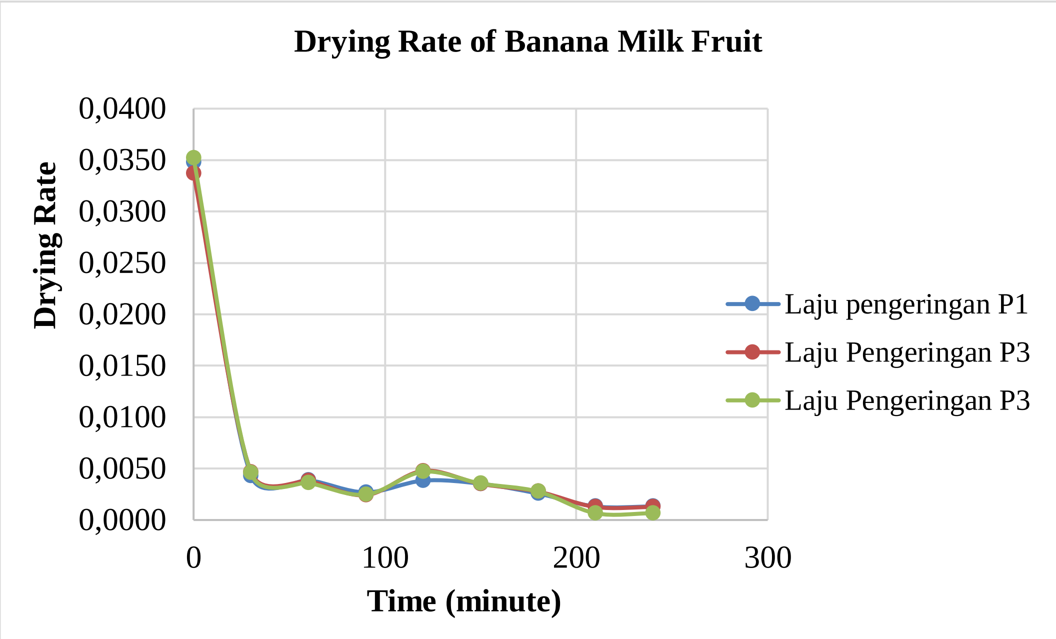
W_d = Weight of solid in the material (g)

4. RESULT AND DISCUSSION

4.1 Result

Table 6. Data of Sample Calculation Results P1

Time (minute)	P2	Solid Weight Final Value	Drying Rate	KaBb	KaBk
0	15,08	2,94	0,035	80,50	412,925
30	9,27	2,94	0,004	68,28	215,306
60	8,55	2,94	0,004	65,61	190,816
90	7,9	2,94	0,003	62,78	168,707
120	7,45	2,94	0,004	60,54	153,401
150	6,81	2,94	0,004	56,83	131,633
180	6,22	2,94	0,003	52,73	111,565
210	5,79	2,94	0,001	49,22	96,939
240	5,57	2,94	0,001	47,22	89,456

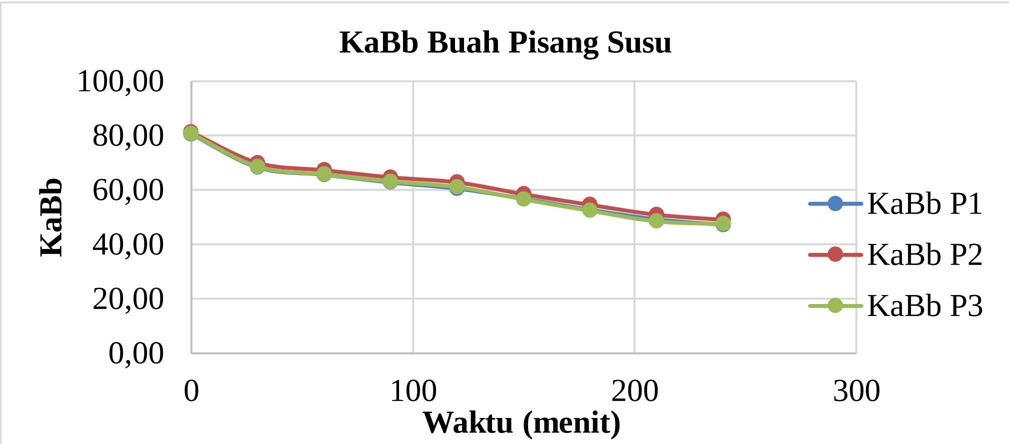


Picture 13. Drying Rate Graph of Banana Milk Fruit

The results obtained in Picture 1 show the drying rate graph. In sample 1 of banana susu, at minute 0, the drying rate was 0.0348%, and it gradually decreased to 0.0013% at minute 240. In sample 2 of banana susu, the drying rate was 0.0337% at minute 0, and it reached 0.0013% at minute 240. For sample 3 of banana susu, the drying rate was 0.0352% at minute 0, and it decreased to 0.0007% at minute 240. This indicates that at the beginning of the drying process (minute 0), the drying rate is relatively high. However, over time, the drying rate gradually decreases. By minute 240, the drying rate reaches its lowest point, indicating a slower or decreased drying process. This is influenced by factors such as air humidity, sunlight intensity, temperature, and the characteristics of the food material itself, which affect the drying rate. This is consistent with the statement by Priyanti (2018), which states that the drying rate curve during the decreasing drying rate period varies depending on the type of food material. The higher the rate of water evaporation from within the food material, the greater the decrease in drying rate.

Table 17. Data of Sample Calculation Results P2

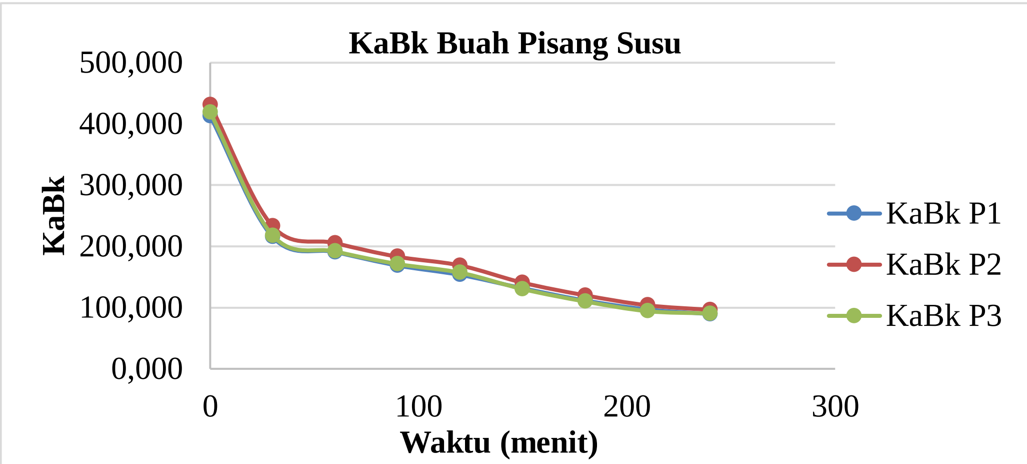
Time (minute)	P2	Solid Weight Final Value	Drying Rate	KaBb	KaBk
0	15,67	2,95	0,0337	81,174	431,186
30	9,82	2,95	0,0047	69,959	232,881
60	9,01	2,95	0,0038	67,259	205,424
90	8,35	2,95	0,0024	64,671	183,051
120	7,93	2,95	0,0048	62,799	168,814
150	7,1	2,95	0,0035	58,451	140,678
180	6,49	2,95	0,0028	54,545	120,000
210	6,01	2,95	0,0013	50,915	103,729
240	5,79	2,95	0,0333	49,050	96,271



Picture 14. Graph of Wet Basis Moisture Content of Banana Milk Fruit.

The results obtained from Picture 14, the Wet Basis Moisture Content (KaBb) graph of milk banana, show that in sample 1, the KaBb value was 80.50% at the beginning and 47.22% at the final minute. Sample 2 started with a KaBb value of 81.174% at the initial minute and reached 49.050% at the final minute. Sample 3 had a KaBb value of 80.728% at the initial minute and 47.473% at the final minute. This indicates that the wet basis moisture content of milk banana gradually decreases over time during solar drying due to the influence of solar radiation, which evaporates the moisture in the fruit. Solar radiation provides the necessary heat energy for water evaporation from the material. This aligns with Amaliah et al.'s statement (2017) that the principle of moisture content determination through drying involves the evaporation of water from the material through heating, followed by weighing the material until a constant weight is reached, indicating that all the water content in the material has been evaporated.Tabel 18. Data of Sample Calculation Results P3.

Waktu (menit)	P3	Berat Padatan nilai akhir	Laju Pengeringan	KaBb	KaBk
0	15,1	2,91	0,0352	80,728	418,900
30	9,25	2,91	0,0046	68,541	217,869
60	8,49	2,91	0,0036	65,724	191,753
90	7,89	2,91	0,0025	63,118	171,134
120	7,48	2,91	0,0047	61,096	157,045
150	6,7	2,91	0,0035	56,567	130,241
180	6,11	2,91	0,0028	52,373	109,966
210	5,65	2,91	0,0007	48,496	94,158
240	5,54	2,91	0,0333	47,473	90,378



Picture 15. Graph of Dry Basis Moisture Content of Banana Milk Fruit.

The results obtained from the Dry Basis Moisture Content (KaBk) graph of milk banana show that in sample 1, the initial KaBk value was 412.925%, and it decreased to 89.456% at the final minute. Sample 2 started with a KaBk value of 431.186% at the initial minute, and it reached 96.271% at the final minute. Sample 3 had an initial KaBk value of 418.900%, and it decreased to 90.378% at the final minute. These results indicate an inverse relationship between time and KaBk, where the longer the drying time, the lower the KaBk of milk banana. This is influenced by factors such as the drying method, where solar drying using solar radiation as an energy source reduces the dry basis moisture content of milk banana. This aligns with Hanafi et al.'s statement (2017) that drying can be defined as a method of removing or eliminating a significant portion of moisture from a material using heat energy.

5. Closure

The conclusion from the Solar Energy Drying practicum are the basic principles Drying of food can be known by doing energy drying solar which in the drying process uses sunlight in a manner direct. Change rate water clean And base dry material during Drying can be known by weighing the sample weight beginning to carry out the drying process of solar energy followed by Weigh the sample at the specified time and then dry it with oven on sample.

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ATTACHMENT

ATTACHMENT 5. Table of Measurement Results for Banana Fruit Samples.

Table 19. Measurement Results of Banana Fruit Samples with Solar Drying.

Time	P1	P2	P3
0	9.27	9.82	9.25
30	8.55	9.01	8.49
60	7.90	8.35	7.89
90	7.45	7.93	7.48
120	6.81	7.10	6.70
150	6.22	6.49	6.11
180	5.79	6.01	5.65
210	5,57	5.79	5.44

Table 20. Measurement Results of Banana Fruit Samples with Oven Drying.

Time	P1	P2	P3
0	4.07	4.03	3.78
30	3.39	3.40	3.24
60	3.09	3.09	3.00
90	2.94	2.95	2.91

ATTACHMENT 8. Documentation of Solar Drying Experiment.

Picture 16. Documentation of Solar Drying Experiment.

1. INTRODUCTION

1.1 Background

Agricultural materials are continually exposed to forces throughout the food processing stages, starting from harvesting, packaging, processing, transportation, and storage. Therefore, knowledge of rheological properties is crucial to prevent damage and streamline the handling of agricultural materials. One of the agricultural products is food items. Both finished food products and those still in the processing stage exhibit various forms and textures. There are food products that are in liquid, solid, semi-solid forms, and even those with elastic and viscous characteristics. These different-textured food products respond differently when subjected to forces. The rheological properties of a particular food product can change after being processed again.

Food processing aims to extend the shelf life and enhance the utility of these food materials. The transfer of products from one place to another is a fundamental and essential operation. The transportation system for liquid food materials is crucial before packaging. This is essential to maintain product hygiene and ensure good quality. Rheology, encompassing discussions about fluid flow, is highly significant for agricultural food processing.

In food processing plants, liquid food materials are processed using various methods, including thickening processes. These processes often utilize pumps to transfer materials from one stage to another, even if gravity-based systems are used. This depends on the speed of the fluid and the viscosity of the material, where different flow characteristics are obtained under varying flow conditions.

Based on the above description, a Rheological Characteristics of Liquid Materials practicum is conducted to understand the rheological properties of food materials or food products. This is aimed at optimizing production processes for these products, and rheology can also be applied across various fields, such as agriculture and the food industry.

1.2 Objectives and Benefits

The purpose of conducting the Rheological Characteristics of Liquid Materials practicum is to determine rheological parameters of materials based on the power law model and to understand the rheological properties of materials based on the obtained rheological parameters.

The significance of conducting the Rheological Characteristics of Liquid Materials practicum lies in its ability to aid in the development of food products, evaluating the characteristics of liquid food products, and its practical applications in everyday life, particularly in the field of agriculture.

2. LITERATURE REVIEW

2.1 Dragon fruit (*Selenicereus Undatus*)

Dragon fruit (Selenicereus undatus) is a tropical fruit with red skin and purple flesh. Originating from Mexico and Central America, dragon fruit was later introduced to Vietnam and cultivated in Indonesia. Dragon fruit offers various health benefits due to its bioactive components such as dietary fiber and antioxidants, which can help prevent diseases like colon cancer, diabetes, high cholesterol, and high blood pressure. The numerous health benefits of dragon fruit have led to a growing demand in the market. This, in turn, has fueled the expansion of dragon fruit cultivation, thereby boosting the dragon fruit processing industry. One of the most favored forms of food processing using fruits and vegetables is juice production. The process of making fruit juice often starts with crushing, followed by separating the pulp from the fruit juice. The physical properties of fruit in the form of puree differ from its original state. Understanding the physical properties of fruit puree is essential as fundamental data for designing handling and processing methods and equipment. One relevant physical property of fruit puree for this purpose is its viscosity value. This physical property is greatly influenced by processing conditions, including temperature and concentration of dragon fruit puree (Budilaksono dkk., 2017).

2.2 Papaya (*Carica Papaya* L)

Papaya (Carica papaya L). Papaya is widely cultivated by people both as a hobby and for commercial purposes. This is because papaya has several advantages, including being able to be grown in yards or gardens, quick and abundant fruiting, sweet taste, low-maintenance growth, and a significant nutritional content. Papaya is considered a popular and well-liked fruit by nearly all inhabitants of the Earth. Its soft flesh comes in red and yellow hues, and its sweet and refreshing taste is due to its high water content. The nutritional value of papaya is relatively high, containing a significant amount of provitamin A, vitamin C, and calcium. Fruits play an important role as sources of vitamins, minerals, and other substances in supporting nutritional adequacy (Nishanthi and Anuradha, 2018).

Papaya is one of the tropical fruits with great potential for development. It has the potential to be a supplementary food as fresh fruit due to its relatively affordable price, easy availability, and high content of vitamins A, C, and minerals, especially calcium.

Papaya cultivation is well-established in Indonesia. Cultivating papaya is straightforward, as this plant is well-adapted to tropical regions and is non-seasonal. Successful papaya cultivation begins with the use of high-quality seedlings to produce quality fruits. The development and growth of seedlings are influenced by the type of planting medium. A suitable planting medium should provide the necessary nutrients for the plant, maintain root zone moisture, and ensure adequate airflow. Therefore, efforts are needed to find the appropriate planting medium for papaya seedlings (Nishanthi and Anuradha, 2018)

2.3 Rheology

Rheology is the science that studies the physical properties of a fluid material. When a fluid is subjected to a certain force, the resulting flow can be categorized into two groups: fluids with Newtonian flow and non-Newtonian fluids that exhibit forces in deformation and flow, as well as other mechanical properties, known as rheological properties. Other mechanical properties of rheological properties of a material are usually related to the movement of a material under force. Examples include drag coefficients, terminal velocity, and material flow in stacks. Ideally, the deformation of a material can be divided into three types: elastic deformation, plastic deformation, and viscous (thick) deformation (Farikha et al., 2018).

Rheology is utilized in product development by studying rheological properties, which allows us to understand the structure of each product. This can be correlated with engineering processes involving mass transfer, heat, and momentum exchange. Knowing the rheological properties of a product or material enables proper processing of those materials. In the food industry, rheological data is needed for engineering calculations (pipelines, pumps, mixing, heat exchange, and coating), quality control of both final and intermediate products, evaluating food texture by correlating sensor data, and establishing material functions in product development (Farikha et al., 2018).

Non-Newtonian fluids can be classified as time-dependent or time-independent. Fluids whose rheological properties depend only on shear stress (at a constant temperature) are classified as time-independent. Time-independent fluids have viscosity that depends not only on shear stress but also on the time given at a constant temperature. Non-Newtonian fluids have viscosity as a function of applied shear rate. These fluids tend to become less viscous with increasing shear rate (shear thinning), or conversely, become more viscous with increasing shear rate, and some exhibit an initial shear stress (Farikha et al., 2018).

The pseudoplastic fluid flow of a liquid food product is categorized as pseudoplastic when its viscosity decreases with increasing applied force to flow. The greater the force applied, the smoother or thinner the fluid flow becomes. Pseudoplastic fluid flow is also considered a model approach to non-Newtonian fluid flow, where viscosity tends to decrease while shear stress of the fluid tends to increase (Mujiman, 2018).

Dilatant flow is a liquid food product that is categorized as dilatant if its viscosity increases with increasing stirring force. Dilatant flow is associated with an increase in volume. Dilatant flow is exhibited by highly concentrated suspensions with approximately 50% of flocculated particles, where viscosity increases with an increasing rate of shear (Yohana, 2020).

2.4 Viscosity

Viscosity is a measure of a fluid's thickness, indicating the level of friction within the fluid. The larger the viscosity of a fluid, the more challenging it is for the fluid to flow, and the more difficult it is for an object to move within the fluid. In liquids, viscosity is a result of cohesive forces between the molecules of the liquid, while in gases, viscosity arises from collisions between gas molecules. Viscosity is one of the physical properties of a liquid or fluid material. It also represents the resistance to flow in a fluid, defined as the ratio of shear stress to shear rate. Viscosity is closely related to the ability of a fluid to flow; some fluids flow quickly, while others flow slowly. Fluids that flow rapidly, like water and gasoline, have low viscosity, whereas fluids that flow slowly, such as glycerin, castor oil, and honey, have high viscosity. Viscosity determines the rate of flow of a liquid (Girard and Awira, 2020).

The flow of viscous fluids can be seen as either laminar or turbulent flow, depending on the Reynolds number. Viscosity is a physical property that can be tested in food materials, such as snake fruit juice, where higher viscosity values indicate higher concentrations of the material. This change occurs because adding more water to the extract reduces the viscosity of the product, and conversely, adding less water to the extract increases its viscosity (Afani, 2017).

Viscosity is caused by the cohesive forces between particles of the liquid substance. Ideal liquids have no viscosity. Thick liquids like syrup or oil have high viscosity, while thin liquids like water have low viscosity. Liquid viscosity can be categorized into two types: dynamic viscosity (μ) or absolute viscosity, and kinematic viscosity. The fundamental principle of applying viscosity is used in the fluid flow properties or rheology. Rheology is involved in manufacturing, packaging, usage, consistency, stability, and the bioavailability of formulations. Newton's law of viscosity states the relationship between the mechanical forces of viscosity in fluid flow. Shear stress in viscosity (fluid) is constant concerning friction. This relationship holds true for Newtonian fluids, where the ratio of shear stress (s) to shear rate (g) is constant. This parameter is referred to as viscosity.

Viscous flow can be depicted using two planes. A lower surface plane, held constant by a fluid layer with thickness h, parallels the lighter upper surface, which means it does not impose a load on the fluid layer below it (Girard and Awira, 2020).

2.5 Viscometer

A viscometer is a measuring instrument for viscosity based on the principle of rotational force between two plates filled with fluid. A viscometer is a device used to measure the viscosity of a fluid, accommodating fluids with varying viscosity under different flow conditions. Commonly used models of viscometers include the falling ball viscometer, capillary tube viscometer, and rotational system. The concentric cylinder rotational viscometer is constructed based on two standards: firstly, the Searele system where the inner cylinder rotates while the outer cylinder remains stationary, and secondly, the Couette system where the outer cylinder rotates while the inner cylinder is fixed. The fluid to be measured is placed in the gap between the two cylinders (Mujiman, 2018).

Certain characteristics of a fluid are not dependent on fluid motion but rather on the inherent properties of the fluid itself. One such characteristic is viscosity, where each fluid possesses a different coefficient of viscosity. Viscosity can be defined as the resistance to fluid flow, which involves the friction between fluid molecules. A fluid that flows easily is considered to have low viscosity, while a substance that flows with difficulty is said to have high viscosity. The measuring instrument used to determine the viscosity of a liquid is a viscometer. This instrument accurately and specifically measures the level of viscosity of a liquid in accordance with established standards. If the volume of fluid flowing through a cross-sectional area per unit time is referred to as flow rate (Q), a viscometer is the tool for measuring the viscosity of a fluid. Commonly used viscometers include the falling ball viscometer, capillary tube viscometer, and rotational system (Regina et al., 2018).

3. METHODOLOGY

3.1 Time and Location

The Rheological Characteristic Practicum for Liquid Materials will be held on Friday, May 19, 2023, starting at 15:00 WITA until completion at the Processing Laboratory, Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, Makassar.

3.2 Tools and Materials

The tools used in the Rheological Characteristic Practicum for Liquid Materials are a viscometer & spindle set, a 250 ml beaker glass, a digital thermometer, writing tools, and a smartphone camera.

The materials used in the Rheological Characteristic Practicum for Liquid Materials are dragon fruit juice, papaya juice, and water.

3.3 Working Procedure

The work procedure in the Rheological Characteristic Practicum for Liquid Materials is as follows:

1. Prepare the tools and materials.
2. Pour the dragon fruit juice sample into the beaker until it reaches the 250 ml mark.
3. Attach the viscometer to the stand and calibrate the device.
4. Attach and select the appropriate spindle for measurement.
5. Place the sample precisely beneath the spindle and insert the spindle into the sample until it reaches the marked line.
6. Click "run" displayed on the viscometer screen to activate the spindle rotation.
7. Record viscosity values (CP) and % torque of the sample at each rotational speed level with speed intervals of 6, 12, 30, and 60 rpm (depending on the type of spindle used).
8. After reaching the maximum speed, reduce the spindle rotation speed and record viscosity values (CP) and % torque at each speed level until reaching the minimum speed.
9. Repeat steps 2-8 using the papaya juice sample.

3.4 Formula used

The formulas used in the Rheological Characteristic Practicum for Liquid Materials are as follows:

a. Shear Stress

$$\sigma_a = k_{a\sigma} \,(C \times \text{dial reading})$$

Explanation:

σ_a = *Average shear stress* (Pa)

$k_{\alpha\sigma}$ = Shear stress conversion factor (Pa)

C = *Dimensionless number* (RV model = 1)

dial reading = % *torque*

b. Shear Rate

$$\dot{y}_a = k_{N\gamma}\,(N)$$

Explanation:

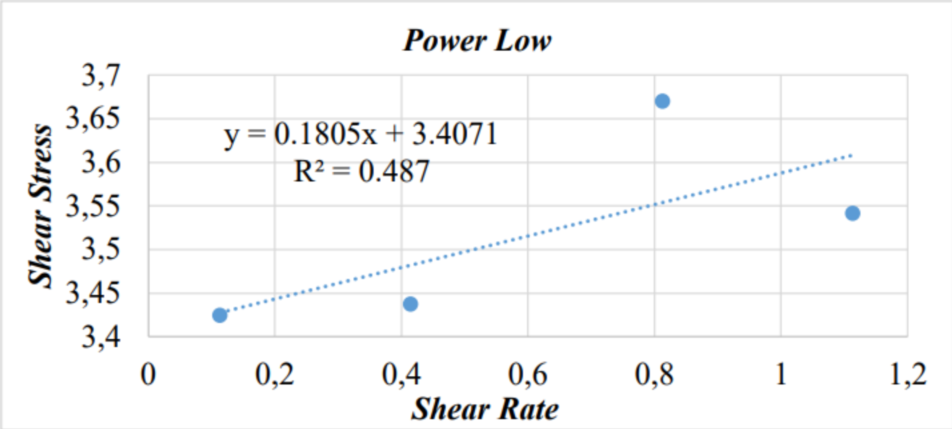
γ_a = *Average shear rate* (s^{-1})

$k_{N\gamma}$ = Shear rate conversion factor (s^{-1})

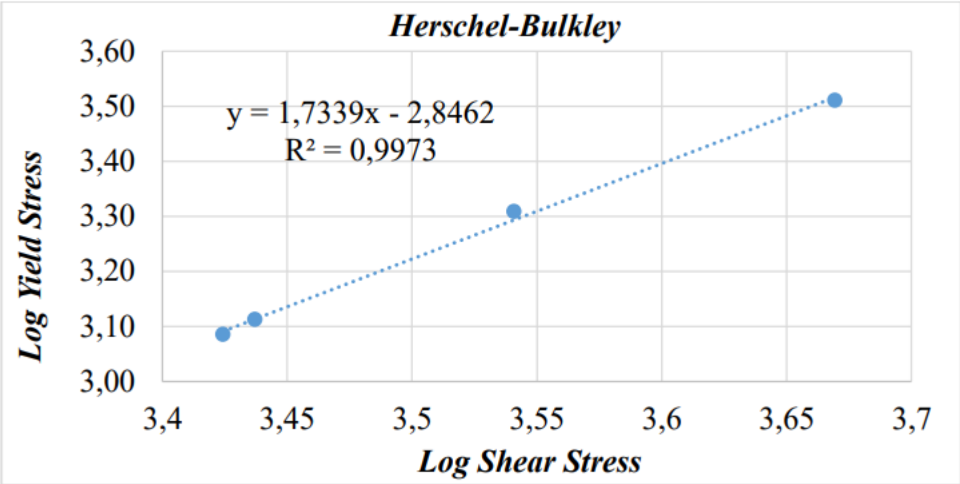
N = Rotational speed (rpm)

4. RESULT AND DISCUSSION

4.1 Result



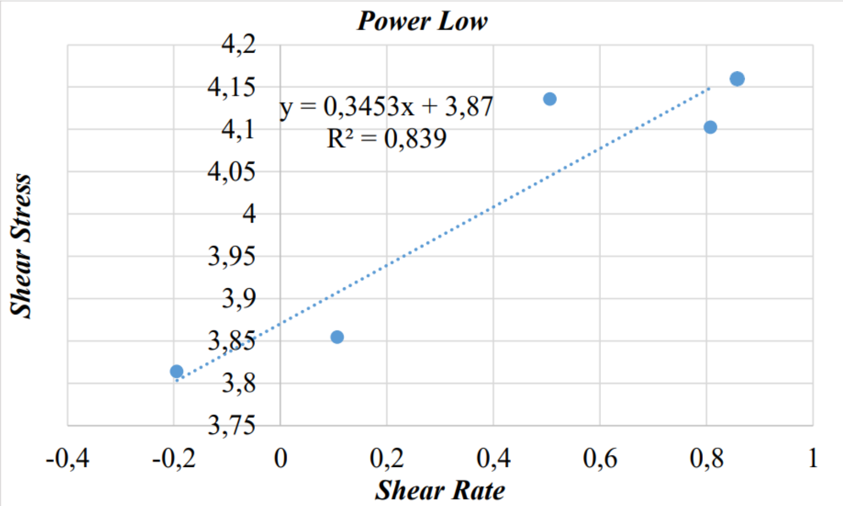
Picture 17. Power Law Graph of Dragon Fruit Juice



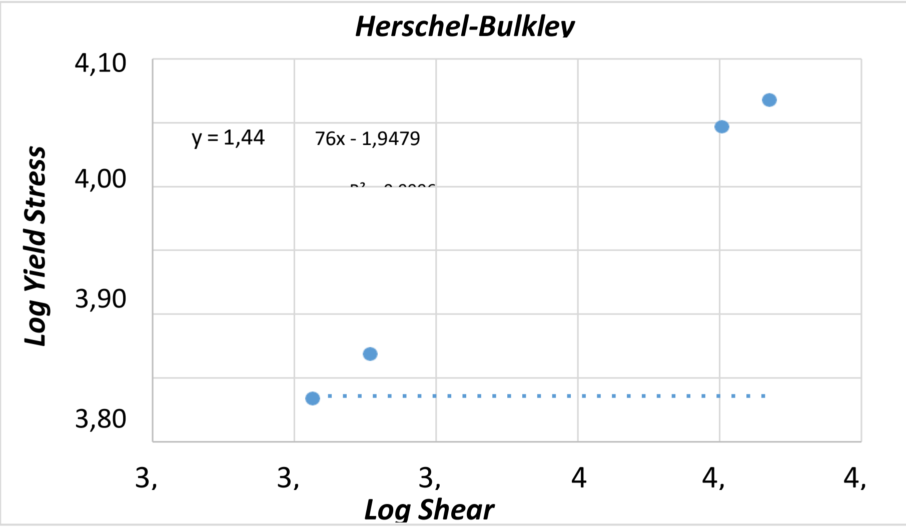
Picture 18. Power Law Graph of Dragon Fruit Juice.

Based on the graph results, there is a power law graph observed in dragon fruit juice. This graph illustrates the relationship between shear stress and shear rate with respect to "n" in the dragon fruit juice sample using spindle L2. The equation for this relationship is y = 0.1805x + 3.4071, and from this equation, it's known that the value of "n" is 0.1805. If the value of "n" is less than 1, then the dragon fruit juice sample falls under pseudoplastic or shear thinning behavior, classifying it as a non-Newtonian fluid.

Furthermore, the Herschel-Bulkley graph for the dragon fruit juice sample displays the relationship between the log shear stress and log yield stress with respect to "n" using spindle L2. The equation for this relationship is y = 1.7339x - 2.8462, and from this equation, it's determined that the value of "n" is 1.7339. If the value of "n" is greater than one, the dragon fruit juice sample is categorized as having dilatant flow behavior. This corresponds to Mujiman's statement (2018), which indicates that pseudoplastic behavior occurs when the viscosity of a material or food product decreases as the force needed to flow it increases. The greater the applied force, the smoother or more fluid the flow becomes. Flowing into a fluid stream, it dilates. This is in accordance with Mujiman's statement (2018), which states that pseudoplastic is where the viscosity of a material or food product decreases and if the force to flow it increases. The greater the force applied, the smoother or more watery the fluid flow becomes.



Picture 19. Power Law Graph of Papaya Fruit Juice.



Picture 20. Herschel-Bulkley Graph of Papaya Fruit Juice.

Based on the results of the power-law graph of papaya fruit juice, which shows the relationship between shear stress and shear rate with respect to 'n' in the papaya fruit juice sample using spindle L4, where the equation value is y = 0.3453x + 3.87, it is known that the value of 'n' is 0.3453.

If the value of 'n' is less than 1, then the papaya fruit juice sample falls into the category of pseudoplastic or shear thinning fluids and is considered a non-Newtonian fluid. The fourth graph presents a Herschel-Bulkley graph of the papaya fruit juice sample, illustrating the relationship between the log shear stress and log yield stress with respect to 'n' using spindle L4. The equation for this relationship is $y = 1.4476x - 1.9479$, indicating that the value of 'n' is 1.4476. If the value of 'n' is greater than one, then the papaya fruit juice sample falls into the category of dilatant flow. This aligns with Yohana's statement (2020), which suggests that dilatant flow is associated with an increase in volume. Dilatant flow is characteristic of suspensions with a high concentration of 50% deflocculated particles, exhibiting an increase in viscosity with an increase in the rate of shear..

5. Closure

Based on the conducted Rheological Characteristics of Liquid Materials practicum, it can be concluded that rheology is utilized for product development by studying rheological properties, enabling the understanding of the structure of each product. This can be correlated with technical processes typically involving mass transfer, heat, and momentum exchange. The spindles used were spindles L2 and L4. If the value of n is less than one, then the sample is categorized as pseudoplastic; if the value of n is equal to 1, then it falls under Newtonian fluid; if the value of n is greater than one, then the sample belongs to dilatant flow.

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ATTACHMENT

Attachment 9. Table of Rheological Characteristics of Fluid Materials.

Table 21. Measurement Results of Dragon Fruit Juice Sample.

Rotor	**RPM**	***Shear Rate***	***Shearing Stress***	***Log Shear Rate***	***Log Shearing Stress***	***Log Yield Stress***
L2	6.0	1.30	2656.7	0.11	3.42	3.08
L2	12.0	2.60	2736.1	0.41	3.44	3.11
L2	30.0	6.51	4672.2	0.81	3.67	3.51
L2	60.0	13.02	3475.5	1.11	3.54	3.31

Table 22. Measurement Results of Papaya Fruit Juice Sample.

Rotor	**RPM**	***Shear Rate***	***Shearing Stress***	***Log Shear Rate***	***Log Shearing Stress***	***Log Yield Stress***
L4	6.0	0.64	6503.4	-0.19	3.81	3.81
L4	12.0	1.28	7143.0	0.11	3.85	3.85
L4	30.0	3.21	13652.1	0.51	4.14	4.14
L4	60.0	6.42	12639.6	0.81	4.10	4.10

Attachment 10. Documentation of Rheological Characteristics of Fluid Material Experiment.

Picture 21. Documentation of Installing Spindle L2.

1. INTRODUCTION

1.1 Background

Processing raw products into processed food or ready-to-consume products requires special techniques and processing methods while considering the properties and characteristics of the raw materials. The characteristics of the raw materials determine the processing methods that can be applied to them, so that the resulting products can be sold and desired by consumers. The characteristics of the raw materials that are of concern in the processing process include the rheological characteristics of the raw materials, the level of maturity, color, texture, and physical geometry of the raw materials, as well as the density and weight of the solid materials.

Rheological characteristics refer to the properties of fluid materials to resist deformation caused by forces acting on the fluid. The rheological characteristics of fluid materials are closely related to viscosity, where viscosity is the ability of a fluid material to resist friction as a result of forces acting on it, such as stirring. The viscosity of each raw material varies depending on the amount of water content and solid content in the raw material. The viscosity of fluid materials can be measured using a viscosity measuring device called a viscometer, which works by calculating the shear rate and shear stress generated from the friction between the rotating spindle and the solution or fluid used in the measurement.

The rheological characteristics of fluid materials are widely utilized in agriculture, particularly in the processing of raw agricultural food materials into products or food. Rheological characteristics can be used as reference data in determining preservation methods, drying, packaging, and heating of raw materials to obtain processed products ready for consumption.

Based on the above description, the Rheological Characteristics of Fluid Materials practicum is essential to understand the determination of rheological characteristics of materials, grasp the basic principles of fluid material viscosity, learn how to determine properties and characteristics based on obtained parameters, become familiar with different types of fluid flow, and apply methods to determine the properties and characteristics of fluid materials in the field of agriculture.

1.2 Objectives and Purpose of Practicum

The purpose of conducting the Rheological Characteristics of Fluid Materials practicum is to determine rheological parameters of materials based on the power law model and understand the rheological properties of materials based on the obtained rheological parameters.

The benefits of conducting the Rheological Characteristics of Fluid Materials practicum are that it can be used in developing food products, evaluating the characteristics of liquid food products, and applied in daily life, especially in the field of agriculture

2. LITERATURE REVIEW

2.1 Rheology

Rheological characteristics are related to the deformation or changes in shape and propagation properties of a material due to the influence of applied forces. In everyday life, various food products in liquid form can be found, such as ice cream, tomato sauce, sweet soy sauce, honey, condensed milk, and baby food. Rheological properties can be observed subjectively through organoleptic tests using the senses, as well as objectively using testing equipment available in laboratories, such as a viscometer (Megavitry et al., 2022).

Rheology studies the relationship between shear stress and shear rate in liquid or semi-liquid products, or the relationship between strain and stress in solid objects. The viscosity value is inversely proportional to the shear rate, meaning that the higher the viscosity, the lower the shear rate. Non-Newtonian fluids will experience changes in viscosity when subjected to a force that moves the fluid. The difference in viscosity values obtained in an experiment is influenced by the rotating speed of the spindle in the equipment; the faster the spindle rotates, the lower the viscosity value produced in each sample. The viscosity value produced is inversely proportional to the rotational speed of the spindle but directly proportional to the shear rate value produced by the sample (Suhriani et al., 2017).

2.2 Fluid Flow

Fluid is a substance that can flow and adapt to the shape of the container it occupies. Fluids are divided into two types: liquids and gases. The specific term for fluid in the form of a liquid is called "liquid," which includes water, oil, gel, and other liquids with viscosity. In physics, there are various methods to measure the properties of a fluid. The viscosity of a fluid can be measured to determine the resistance it offers during stirring. In this case, the fluids being measured are dragon fruit and papaya juices, and their viscosity values will be determined using a viscometer and experimental methods (Kristina and Panuluh, 2021).

Fluids with a linear relationship between shear stress and shear rate or constant viscosity are called Newtonian fluids. Fluids where shear stress is not linearly related to shear strain are called non-Newtonian fluids. Fluids that exhibit time-dependent behavior are called thixotropic fluids, for example, ink. Fluids whose viscosity decreases over time even though the shear rate remains constant are called rheopectic fluids, for example, plaster in the medical field (Laksono, 2021).

2.3 Viscosity

Viscosity is a measure of a fluid's resistance to shear forces or frictional forces it experiences. Viscosity is also referred to as the thickness or "stickiness" of a liquid (fluid). The higher the viscosity, the higher the density of the fluid. Water and oil have nearly the same density, but they exhibit different behaviors. The characteristics of a fluid cannot be fully described by its density alone; an additional property like viscosity is needed to describe the fluidity of a substance (Laksono, 2021).

Viscosity is the friction that occurs between adjacent layers within a fluid. Viscosity in gases is caused by collisions between gas molecules, while in liquids, it occurs due to cohesive forces between liquid molecules. Density is the measurement of mass per unit volume of an object. Total solids refer to the amount of solids in a product, whether soluble or insoluble, remaining after the water in a product is evaporated. Total solids can also be understood as the components that make up a solution, including both soluble and insoluble solids in a material or product (Muti and Purbasari, 2021).

The coefficient of fluid viscosity is denoted as ŋ. The coefficient of fluid viscosity is defined as the ratio of shear stress (F/A) to the rate of change in shear stress. The SI unit for ŋ is newton meter per second (Nms). The value of ŋ depends on the type of fluid and is influenced by temperature. Fluids that flow easily, such as kerosene or water, have relatively small shear stress for a rapid change in a certain shear strain, indicating relatively low viscosity. On the other hand, fluids like molasses or glycerin require a higher shear stress for a rapid change in the same shear strain, indicating higher viscosity. The viscosity of all fluids is greatly affected by temperature. For liquid fluids, as temperature increases, viscosity decreases due to increased molecular movement, while for gases, higher temperatures lead to an increase in viscosity (Laksono, 2021).

Viscosity is an important property in the processing of liquid food because processed products can change when heated, cooled, or thickened. Changes in viscosity can affect the pumping power required in food processing. Viscosity can also be seen as the internal resistance of a fluid to flow. Usually, the viscosity of liquid food increases with an increase in liquid concentration and the amount of solids present in the product or food (Megavitry et al., 2022).

The internal resistance that arises in a fluid to flow is also known as viscosity. In a fluid, there are layers that flow at the surface, and the uppermost layer flows the fastest and drags the subsequent layers to flow, but their speed is lower, and this continues from layer to layer until the flow stops when the layer closest to the surface stops moving (Megavitry et al., 2022).

When a shear force is applied to the surface of a fluid, a change in shape called deformation occurs. If the force continues to be applied, continuous deformation occurs, causing the fluid to keep moving, and this is known as flow. The fluid moves because of the shear force that arises, known as shear stress, and the gradient of its velocity is called shear rate (Megavitry et al., 2022).

2.4 Viscometer

A viscometer serves as a tool to analyze or measure the viscosity level of liquid materials, and it can accurately measure the viscosity of a liquid material according to its specific standard. The viscometer works by measuring the resistance (viscosity) given by the solution during the stirring process using a plate. There are several types of viscometers, but the ones commonly used are the Ostwald viscometer, the Hoppler viscometer, and the cone and plate viscometer. According to Hafuza (2021), the explanations for the three types of viscometers are as follows:

A. Ostwald viscometer

This type of viscometer measures the time required for the liquid to flow. More specifically, it measures the duration for the liquid to pass a certain mark. The calibration of this viscometer is done using water with a known viscosity level, allowing for comparison.

B. Hoppler viscometer

The Hoppler viscometer operates according to Stokes' law. This means that viscosity can be determined by dropping an object into a liquid substance. The object used for the experiment is precisely known in terms of its size. The Hoppler viscometer takes into account both gravitational and frictional forces in its calculation.

C. Cone and plate viscometer

Compared to the previous two viscometers, the cone and plate viscometer can be considered the most advanced. By using a small sample volume, this tool can precisely measure the viscosity level, making it easier to use..

2.5 Newtonian and non-Newtonian Flow

Considering the flow properties, liquid food materials are generally classified into two groups: Newtonian and non-Newtonian. Newtonian fluids have a constant viscosity that does not change with an increase in force, for example, dilute sugar solutions, salt solutions, and acidic solutions. On the other hand, non-Newtonian fluids have a viscosity that changes with a change in force. Non-Newtonian products can be broadly categorized into three types: first, plastic liquids, such as sweet soy sauce, condensed milk, bottled chili sauce, tomato sauce, and pudding; second, pseudoplastic liquids, such as coconut milk, soy sauce, fresh milk, and thin cream; and third, dilatant liquids, such as thick sugar solutions, peanut butter, and starch dispersions. These liquids at low concentrations typically exhibit Newtonian properties, but when the concentration increases, their viscosity rapidly increases, transitioning them into non-Newtonian behavior (Megavitry et al., 2022).

2.6 Dilatan Flow

Dilatant flow is a type of fluid behavior in which the resistance or viscosity increases with an increase in shearing rate or stirring speed. Dilatant flow is characterized by an increase in viscosity as the shear rate increases; hence, it is also known as "shear thickening." Suspensions that exhibit such flow behavior include starch suspensions, printing inks, and pastes. The relationship between F/A and dv/dx can be represented in an equation analogous to the equation for pseudoplastic flow, but the value of N is less than 1. This type of flow is the opposite of pseudoplastic flow. Pseudoplastic flow is often known as a "shear-thinning system" (Wijayanti, 2019).

2.7 Pseudoplastik Flow

A large number of pharmaceutical products, including natural and synthetic gums such as tragacanth, sodium alginate, methylcellulose, and carboxymethyl cellulose, exhibit pseudoplastic flow. Unlike plastic materials, there is no yield value in these substances, and the shear stress decreases with increasing shear rate. Higher shear forces cause the initially inhibited flow to transition into an ideal or nearly ideal flow. The viscosity decreases as the shear rate increases, making the system more fluid-like. The pseudoplastic behavior can change at higher temperatures or at certain concentrations, which can cause the flow to become more viscous (Wijayanti, 2019).

2.8 Plastic Flow

The plastic flow curve does not pass through the origin but rather intersects the shear stress axis at a certain point called the yield value. Bingham materials will not flow until the shear stress applied to them exceeds this yield value. Below this value, the material behaves as if it is elastic. Rheology experts classify Bingham materials as solids, while materials that start flowing at the smallest shear stress are defined as liquids. The yield value is an important property of certain dispersion systems, as it determines the nature, characteristics, and flow type of a liquid material being used (Wijayanti, 2019).

3. METHODOLOGY

3.1 Time and Place

The Practical of Rheological Characteristics of Fluid Materials will be conducted on Friday, May 19, 2023, starting from 15:00 WITA until it is finished at the Processing Laboratory, Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, Makassar.

3.2 Tools and Materials

The equipment used in the Practical of Rheological Characteristics of Fluid Materials includes a viscometer & spindle set, a 250 ml beaker glass, a digital thermometer, writing tools, and a smartphone camera.

The materials used in the Practical of Rheological Characteristics of Fluid Materials are dragon fruit juice, papaya juice, and water.

3.3 Practicum Methodology

The working procedure in the Practical of Rheological Characteristics of Fluid Materials is as follows:

1. Prepare the equipment and materials.
2. Pour the dragon fruit juice sample into the beaker up to the 250 ml mark.
3. Attach the viscometer to the stand and calibrate the equipment.
4. Install and select the appropriate spindle for the measurement.
5. Place the sample right in the center beneath the spindle and insert the spindle into the sample up to the boundary mark.
6. Click "run" on the viscometer screen to start rotating the spindle.
7. Record the viscosity values (CP) and % torque of the sample at each rotational speed level with speed intervals of 6, 12, 30, and 60 rpm (depending on the type of spindle used).
8. After reaching the maximum speed, reduce the spindle's rotational speed and record the viscosity values (CP) and % torque at each speed level until reaching the minimum speed.
9. Repeat steps 2-8 using the papaya juice sample.
10. Clean and dry the spindle, then store it in the appropriate order in the box.

3.4 Used Formulas

The formula used in the Rheological Characteristics of Fluid Materials experiment is as follows:

a. Shear Stress

$$\sigma_a = k_{\alpha\sigma} (C \times \text{dial reading})$$

Explanation:

σ_a = *average shear stress* (Pa)

$k_{\alpha\sigma}$ = Shear stress conversion factor (Pa)

C = *dimensionless number* (RV model = 1)

dial reading = % torque

b. Shear Rate

$$\dot{\gamma}_a = k_{N\gamma} (N)$$

Explanation:

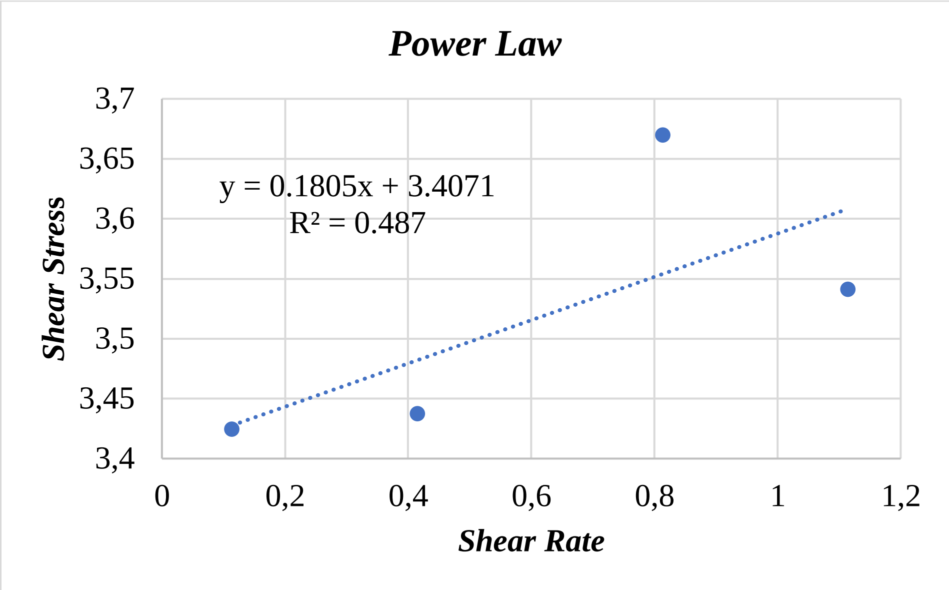
$\dot{\gamma}_a$ = *average shear rate* (s^{-1})

$k_{N\gamma}$ = Shear stress conversion factor (s^{-1})

N = Rotational speed (rpm)

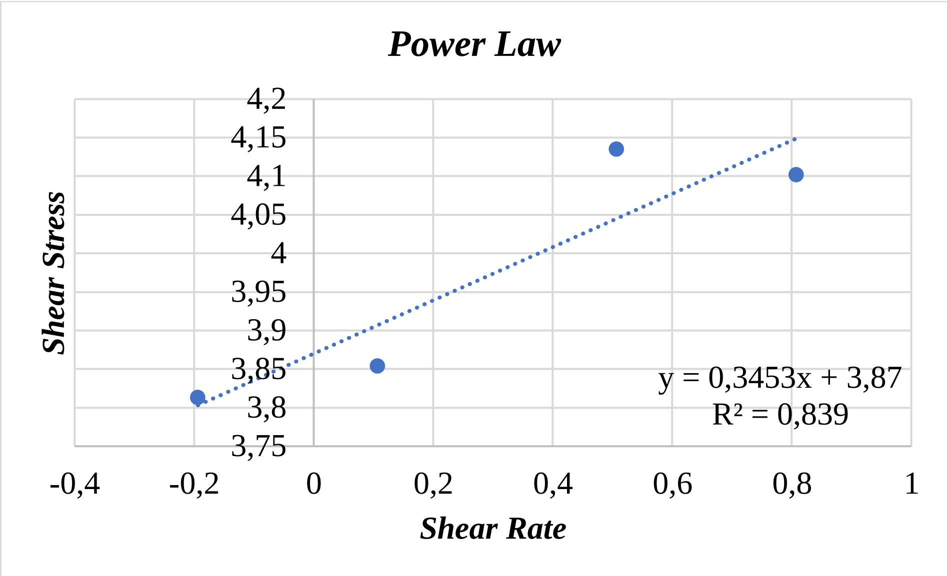
4. RESULT AND DISCUSSION

4.1 Result



Picture 22. Dragon Fruit Juice Power Law Graph

Based on Graph 1, which shows the power law values of the fruit juice, the obtained results are as follows: the value of n is 0.1805, the value of k is 2553.289152, the log k value is 3.4071, and the yield stress value is 1441.7. The shear rate (strain) and shear stress (stress) comparison shows a direct proportionality, indicating that the higher the stress applied to a flow, the greater the strain that occurs. Changes in stress and strain are closely related to the flow behavior and material deformation. The value of n = 0.1805 indicates that the dragon fruit juice solution belongs to the pseudoplastic flow, where pseudoplastic flow exhibits behavior resembling both liquid and solid materials. In a quiescent state, pseudoplastic flow behaves like a solid, but when subjected to shear forces, it behaves like a liquid by following the direction of the applied force. This is consistent with Wijayanti's statement (2019) that there is no yield value, as seen in plastic materials, where the shear stress decreases with increasing shear rate. Higher shear forces cause the initially inhibited flow to transition into an ideal or nearly ideal flow.



Picture 23. Dragon Fruit Juice Power Law Graph

Based on Graph 1, which shows the power law values of the fruit juice, the obtained results are as follows: the value of n is 0.3453, the value of k is 753545.7941, the log k value is 3.87, and the yield stress value is 2815.5. The value of n = 0.3453 indicates that the papaya juice solution belongs to the pseudoplastic flow, where pseudoplastic flow exhibits behavior resembling both liquid and solid materials. In a quiescent state, pseudoplastic flow behaves like a solid, but when subjected to shear forces, it behaves like a liquid by following the direction of the applied force. This is consistent with Wijayanti's statement (2019) that there is no yield value, as seen in plastic materials, where the shear stress decreases with increasing shear rate. Higher shear forces cause the initially inhibited flow to transition into an ideal or nearly ideal flow.

5. Closure

Based on the Practical of Rheological Characteristics of Fluid Materials, it can be concluded that rheological characteristics refer to the properties of a fluid material to resist deformation or applied forces. The rheological characteristics of solutions are related to the type of flow based on the comparison of shear rate and shear stress values. The fruit juice solutions exhibit pseudoplastic and dilatant flow behavior when subjected to deformation and pressure. The dragon fruit juice solution shows pseudoplastic and dilatant flow behavior, while the papaya juice solution also exhibits pseudoplastic and dilatant flow behavior when subjected to deformation and pressure.

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ATTACHMENT

Attachment 10. Table of Rheological Characteristics of Fluid Materials.

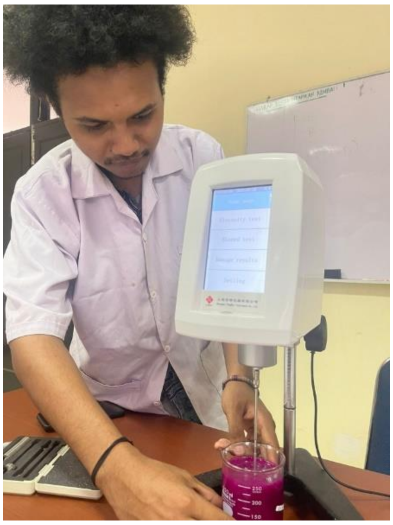
Table 21. Measurement Results of Dragon Fruit Juice Sample.

Rotor	RPM	*Shear Rate*	*Shearing Stress*	*Log Shear Rate*	*Log Shearing Stress*	*Log Yield Stress*
L2	6.0	1.30	2656.7	0.11	3.42	3.08
L2	12.0	2.60	2736.1	0.41	3.44	3.11
L2	30.0	6.51	4672.2	0.81	3.67	3.51
L2	60.0	13.02	3475.5	1.11	3.54	3.31

Table 22. Measurement Results of Papaya Fruit Juice Sample.

Rotor	RPM	*Shear Rate*	*Shearing Stress*	*Log Shear Rate*	*Log Shearing Stress*	*Log Yield Stress*
L4	6.0	0.64	6503.4	-0.19	3.81	3.81
L4	12.0	1.28	7143.0	0.11	3.85	3.85
L4	30.0	3.21	13652.1	0.51	4.14	4.14
L4	60.0	6.42	12639.6	0.81	4.10	4.10

Attachment 11. Documentation of Rheological Characteristics of Fluid Material Experiment.



Picture 24. Documentation of Installing Spindle L2.

9. INTRODUCTION

1.1 Background

Improving the competitiveness of a food ingredient is one of the most important factors in increase quality or quality from something product food. Matter Which must Pay attention to a liquid food product, namely the nature of its flow. Flow characteristics direct testing facilities can use rheological properties a food item. The rheological properties of liquid food ingredients that can be used as parameters something measurement ie the thickness. viscosity or viscosity ie resistance measure of a substance to changes due to its presence pressure or voltage. The viscosity of a liquid can determined in a manner quantitative with quantity called the viscosity coefficient (η). The higher the viscosity of a material then it will the slower the flow and the denser the liquid. Conversely, the lower the viscosity of a liquid, the greater it will be movement from the liquid.

Rheology is a science that studies deformation or change form and flow. The flow of food is divided into two streams of them Genre Newtonians And Genre non-Newtonian. Genre newtonians own relationship between shear stress and shear rate . Genre non-Newtonian own behavior Which more complex Because exists characteristic the relationship between shear stress and shear rate is influenced by time and some are not. The nature of the fluid flow is important for applications in processing of agricultural products, such as dragon fruit juice and fruit juice pawpaw. The nature of the fluid can help in determining the application of viscosity the right fit on the material, so it is necessary to measure the viscosity to study the rheological properties of materials. There are two models commonly used for determine properties liquid, ie model power law and Herschel models Bulkley. Measurement of viscosity (viscosity) in liquid materials can use tools that called by viscometer.

Based on the description above, it is necessary to do the Characteristics practicum Liquid Material Rheology to determine and determine the rheological properties of materials liquid based model power law .

1.2 Objectives and Benefits

The purpose of conducting the Rheological Characteristics of Liquid Materials practicum is to determine rheological parameters of materials based on the power law model and to understand the rheological properties of materials based on the obtained rheological parameters.

The significance of conducting the Rheological Characteristics of Liquid Materials practicum lies in its ability to aid in the development of food products, evaluating the characteristics of liquid food products, and its practical applications in everyday life, particularly in the field of agriculture.

2. LITERATURE REVIEW

2.1 Rheology

Rheology can be interpreted as one of the things that is very important because it is very affect almost all areas of life. Rheology is a study of behavior Genre rheology as something knowledge Which learn about existschange form And Genre from something fluid as well as How response fluid to the reception of pressure and stress. The industrial world in rheology can be used for product development. Rheology is very important because it can ease in investigation the viscosity of a true liquid, solutions and also colloidal systems, both dilute and thick, are much practical rather than theoretical. Rheology is usually applied to fluid materials (or a material that exhibits a time-dependent response to *stress*). Genreusually measured using shear and shear parameters of stress. Rheology is closely related to viscosity. Viscosity can be defined as A size rejection A fluid to change form in lowerpressure from *shear* (Zamaluddien *et al.,* 2019).

Rheology learn about connection between pressure swipe (*shearing _ stress*) with shear speed (*shearing rate*) on liquid or semi-liquid products or the relationship between *strain* and *stress* in a solid. Rheology is needed to calculate the viscosity of a liquid that does not flow under gravity. rheology can also be said as a study of the flow of matter, especially when in the liquid state but also in solids and semi-solids when responding shown to be plastic flow and not due to elastic deformation when force is applied. Rheology can be defined as constitutive laws Which explain behavior from something Genre (Suhriani *et al.,* 2017)

2.2 Viscosity

Viscosity can defined as something viscosity on product food. Viscosity can describe characteristic fluid something product Which have resistance to a flow which can provide increased strength Which can withhold movement relatively. Viscosity can interpreted Also a resistance to fluid flow which is the friction between the moleculesliquid with each other. Viscosity is a measure of the thickness of a fluid which shows the size of the internal friction of the fluid. A type of liquid that easy to flow, it can be said to have a low viscosity and vice versa A material that is difficult to flow is said to have a high viscosity. Viscosity Also can said as resilience fluid If accept style from outside.The viscosity of each fluid is different and is expressed quantitatively by the viscosity coefficient (η). Tool to determine the value of the viscosity of a liquid called with a viscometer (Zulaikhah and Fitria, 2020).

Several factors can affect the viscosity of a material viz ratio water Which there is on material the. Decline viscosity consequence increase in water ratio due to the viscosity is affected by the water content in something material. The more A little rate water in material so viscosity will the more tall And on the contrary the more Lots rate water in material soviscosity will the more low. Temperature compared backwards with viscosity when the temperature rises, the viscosity will decrease and vice versa if the temperature decreases then the viscosity of a material will increase or be large. In addition to temperature and levels water, that isaffect the value of the viscosity is the flow time of a fluid. There is a relationship between the length of time flowing with the viscosity of a liquid. The bigger the time he flowed so mark viscosity from something substance liquid the the more big And conversely, the smaller the flow time, the greater the viscosity value of a liquid it will get smaller. This can be proven from the results of the calculation of timeby viscosity meter substance liquid (Rahmani *et al.,* 2022).

2.3 Viscometer

Measuring instrument used to determine the viscosity (viscosity) of a liquid the viscometer. This viscosity measuring instrument can measure the level of viscosity something substance liquid with accurate And Specific in accordance with standard Which has determined. Making tool viscometer addressed For obtain time so that can counted mark viscosity something fluid. Viscometer consists from various types of. One of the most commonly used viscometer models is the ball falling, ball rolling, capillary tube, concentric cylinder rotation and plate cone rotation. Principle Work viscometer type capillary with measure speed flow something fluid with volume certain in pipe capillary. Measurement viscosity done manually with mark time flow of solution from the mark limit beginning to the limit end something which sign has determined (Rahmani *et al* ., 2022).

2.4 Genre fluid

A fluid can be defined as a substance that changes shape continuously when exposed to shear stress. Fluids have molecules that are far apart, forces smaller intermolecular than solids and the molecules are more free moving thus the fluid is more easily deformed. Fluid flow can defined as a fluid displacement that forms a flow line with certain speed. Fluid flow can be divided into two, namely *invicidal flow* And *viscous* . Genre *invicid* is Genre Which viscosity the fluid considered zero so that it is said to be an ideal flow l.

Viscous flow is the flow that occurs in a fluid that is thick or viscous and this fluid depends by friction between particle composer fluid the. Genre *viscous* Fluids are classified into two, namely Newtonian and Non-Newtonian fluids. fluidNewtonian is a fluid that has a linear *shear stress curve.* fluid Non-newtonian is a fluid that does not follow Newton's laws of Genre. Non-Newtonian fluids are divided into *pseudoplastic* and *dilatant. Pseudoplasty* (n<1) ie something model approach fluid Which Where, the viscosity decreases but *the shear stress* increases. *Dilatant* (n>1) ie the non-newtonian fluid approach model whose viscosity and *shear stress* from fluid will tend experience enhancement (Basuki And Susanto, 2019).

2.5 Types Genre

Types of fluid flow both liquid and gas are divided into i.e. laminar, transitional and *turbulence* . Laminar flow is flow that has a *streamline* straight to direction Genre. Characteristics from Genre laminar that is own smooth streamlined and has a very regular movement. Transition flow is the boundary between changes from laminar flow to *turbulence* . The transition flow does not occur suddenly, the transition flow occurs over several area Which where there is fluctuation between laminar And *turbulence* before become *turbulence* . Genre *turbulence* is Genre Which characteristic random and have a stream that is not regular. *Turbulence* flow is flow Which has the characteristics of very irregular speed fluctuations and movements. *The Reynold* number or *Reynolds number* is a dimensionless numberused to characterize the type of flow. The *Reynolds* number is a ratio between the inertial force and the viscous force. The type of flow can be characterized with the size of the *Reynolds number* . The greater the *Reynolds number* then the flow will be increasingly turbulent whereas if the number *Reynolds* getting smaller, the flow will be more laminar. Can be seen if $Re \leq 2300$ included laminar flow, $2300 \leq Re \leq 4000$ including transition flow and if $Re \geq 4000$ including Genre *turbulence* (Fadli *et al* ., 2021) .

2.6 Method *Herschel-Bulkley*

Herschel-Bulkley fluid is a general model of non-Newtonian fluids, where the strain experienced by a fluid is related to the stress in a complicated way non-linear. Three parameters characterize this relationship including consistency (k), index Genre (n) And voltage shift melted. Consistency is constant simple proportionality whereas flow index measures the extent of fluid experience dilution shift or coagulation shift. Voltage melted quantify the amount of stress that the fluid may undergo before yielding And begins to flow (Li *et al.,* 2021).

2.7 Method *power law*

The Power Law model for non-Newtonian fluids is one of the viscosity modelsthe most common used in analysis hydraulic. Model This state that the shear stress required to move the fluid at a certain speed. The *Power Law* model defines the apparent viscosity of a fluid as n-1. Model *Power Law* values n = 1 correspond to Newtonian fluids while $0 < n < 1$ is fluid *shear thinning* (*pseudoplastic*) And $n > 1$ symbolize fluid *shear thocking* (*dilatants*). Non-Newtonian fluids are fluids that change depending on style that influences it. Non-Newtonian fluids have the property that, the thicker a material will increase the *shear rate* generated. Use model This must own mark For K And n or own datatheological test. K And n on formula *Power Law* is consistency index And index Genre Which obtained through test chart. Results mark K is the intercept and the value of n is the slope of the graph. This *Power Law* model do not have default constant. Lack of models *power Law* is this model cannot explain the limitation of low and high *shear rates* fluid data *shear thinning* (Li *et al.*, 2021).

2.8 Parameter rheology

An object can in principle behave in three ways in response the force acting on it, that is, it can be elastic, plastic or flowing. Third These rheological parameters are widely used as a basis for understanding rheology object congested along technique measurement. According to Dianingsih *et al* . (2016)rheological parameters among them ie as following:

a. Behavior Elastic

Behavior elastic something object can calculated from a number of or how much the change in length that occurs after a force is applied. elastic behavior occurs when the pressure (*stress*) on an object is directly proportional to the strain. Pressure is the force exerted (F) per unit area (A) whereas *strains* is the result of *stress* and expressed as change length (ΔL) per initial unit length (L). The expression of the relationship between the two is known with modulus young (E). Equality the only can applied Ifthing is under pressure.

b. Behavior Plastic

Objects that are plastic will experience a continuous change in shapeif imposed style. Behavior plastic ideal can explained with Imagine an object placed on a flat surface. When styleabout it, so object the No will move until something level a certain *stress* is reached or often referred to as the yield *stress* after the yield *stress* This achieved, so Genre or movement object the will going on so on.

c. Behavior Flow

Behavior characteristic flow (fluidity) Which ideal happen in object Which flow, where shape change (power flow) is directly proportional to the force which are given. The nature of flow (fluidity) is usually not owned by the object Which solid shape.

3. METHODOLOGY

3.1 Time And Place

Practice Characteristics rheology Material Liquid was held on Friday, 19 May 2023 o'clock 15.00 WITA until finished in Laboratory *processing* , Program Studies Technique Agriculture, Department Technology Agriculture, Faculty Agriculture, University Hasanuddin, Makassar.

3.2 Tool And Material

Tool used on practice Characteristics rheology Material Liquid that is *viscometer* & *spindle set* , 250 ml *beaker* , digital thermometer, stationery and camera *cellphone* . Material used on practice Characteristics rheology Liquid Material that is juice dragon fruit, juice papaya fruit and water.

3.3 Procedure Practice

As for procedure Work on practical Rheological Characteristics Material Liquid that is:

1. Prepare tool And material.
2. Enter sample juice fruit dragon to in beaker until reach linelimit 250 ml.
3. Install *viscometer* on static And do calibration tool.
4. Install And determine *spindles* Which in accordance For measurement.
5. Put sample appropriate in middle lower *spindles* And enter *spindles*

to in sample until reach line limit.

6. Clicking run Which listed on screen *viscometer* Which will rotating *spindles* .
7. Record the value of the viscosity (CP) and % torque of the sample at each level rotational speed with a range of 6, 12, 30 and 60 rpm (depending on on the *spindle type* Which used).
8. After reaching the maximum speed, reduce the rotational speed again *spindles* And note mark viscosity (CP) And % torque on every level speed until reach speed minimum.
9. Repeat steps 2-8 with use sample juice fruit pawpaw.
10. clean up And dry *the spindles* Then save on box in accordance order.

3.4 Formula Which Used

As for formula Which used on practice Characteristics rheology Material Liquidthat is:

a. Shear stress

$$\sigma_a = k_{\alpha\sigma} \ (C \times \text{dial reading})$$

Explanation:

σ_a = *average shear stress* (Pa)

$k_{\alpha\sigma}$ = Shear stress conversion factor (Pa)

C = *dimensionless number* (RV model = 1)

dial reading = % torque

c. Shear Rate

$$\dot{\gamma}_a = k_{N\gamma} \ (N)$$

Explanation:

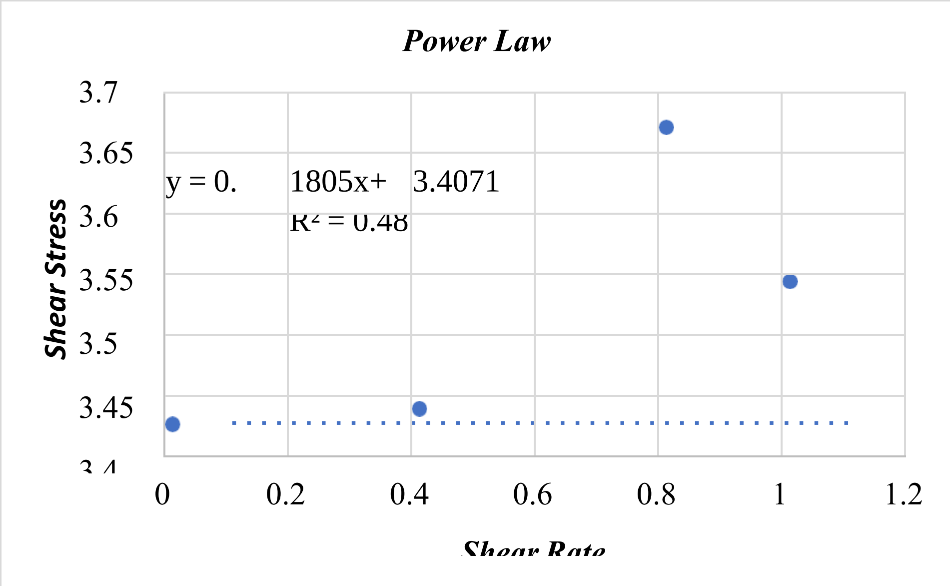
$\dot{\gamma}_a$ = *average shear rate* (s^{-1})

$k_{N\gamma}$ = Shear stress conversion factor (s^{-1})

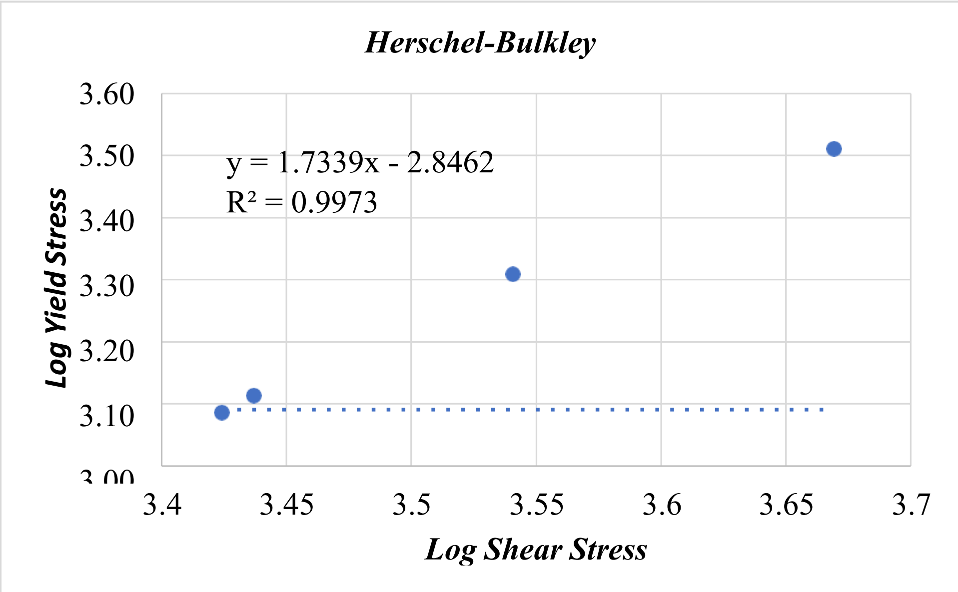
N = Rotational speed (rpm)

4. RESULTS AND DISCUSSION

4.1 Results And Discussion



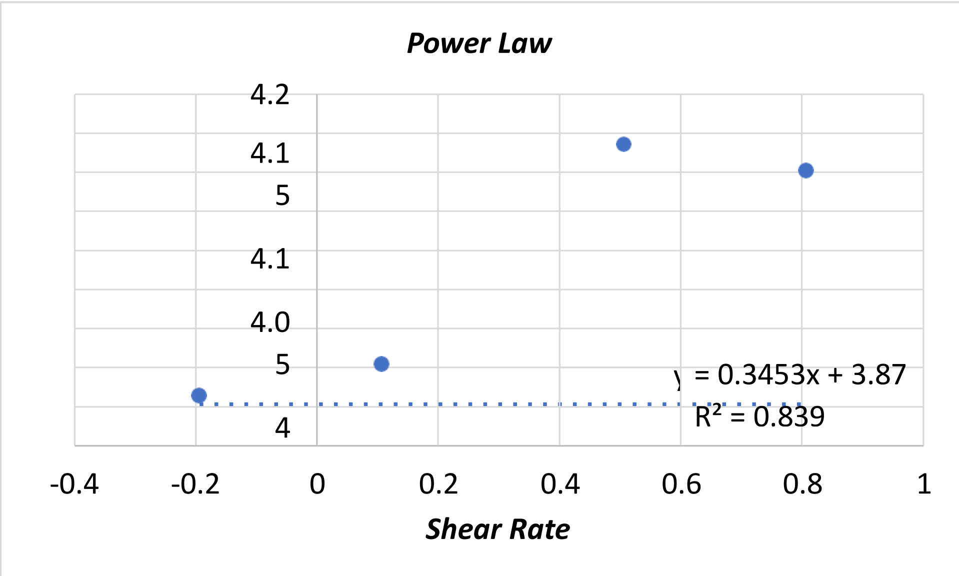
Picture 25. Chart *power law* Juice Fruit Dragon.



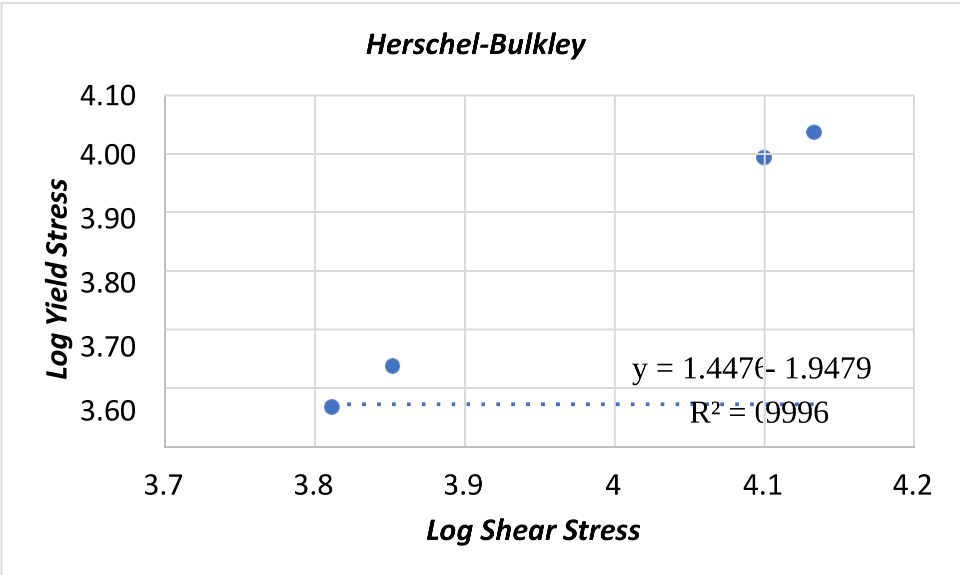
Picture 26. Graphics *Herschel-Bulkley* Juice Fruit Dragon.

The results obtained on *the power law* and *Herschel Bulkley graphs* on juice Dragon fruit can be seen that the highest R2 value is in the *Herschel Bulkley model* which is worth 0.9973 while the value of R^2 in the *power law model* is worth 0.487. Based on results comparison Which obtained between model *power law* And*herschel bulkley* can said, that model Which appropriate used in

determine parameter rheology something material liquid ie with use the *Herschel Bulkley* model because the resulting R2 value is greater than R^2 on models *power law* . Mark R^2 on model *herschel bulkley* showR^2 = 0.9973 Which where means show that sample juice fruit dragon including non-Newtonian fluids of *pseudoplastic* type . That too strengthened with *shear stress* which is increasing as it increases rotational speed (RPM). This is in accordance with the statements of Basuki and Susanto (2019), that *pseudoplastic* (n <1) is a fluid approach model Where, the viscosity decreases but *shear the stress* is increasing.



Picture 27. *Power* chart *law* Juice Fruit Pawpaw.



Picture 28. Chart *Herschel-Bulkley* Juice Fruit Pawpaw.

The results obtained on *the power law* and *Herschel Bulkley graphs* on juice papaya fruit can be seen, that the highest R2 value is at model *herschel bulkley* which is worth 0.9996 while the value of R^2 in *the power law model* is worth 0839. Based on the comparison results obtained there is a difference mark R2 in the papaya fruit juice sample which can be said to be a parameter Which suitable used For determine characteristic Genre ie model *herschel bulkley* because of value R2 models - This bigger in comparison model *power law*. The fluid in papaya fruit juice is a non-newtonian *pseudoplastic fluid* because mark rheology (n<1). fluid non-Newtonian Wrong One type fluid Which No follow the rules of viscosity, can change according to the force that affects it and has fluid properties if a material has a high viscosity value so *share rate* also increased . This is in accordance with the statement Li *et al.* (2021), that fluid non-Newtonian own characteristic Which Where, the more thick something material will the more increase *shear* that *rate* generated.

5. CLOSURE

The conclusion from the practical rheological characteristics of liquid liquids is deep determine parameter rheology can use model *power law*. Model *power law* Wrong One model viscosity Which most general used in hydraulic analysis. This model states that shear stress is required to move the fluid at a certain speed. Determine the properties of the rheology material can use parameter from viscosity substance liquid (viscosity). Viscosity is size viscosity something fluid Which show big the small internal friction of the fluid which, if the viscosity of a material is high then the type of fluid is Newtonian whereas if the viscosity of a material is low then type the fluid non-Newtonian.

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ATTACHMENT

Attachment 15. Table of Rheological Characteristics of Fluid Materials.

Table 21. Measurement Results of Dragon Fruit Juice Sample.

Rotor	RPM	*Shear Rate*	*Shearing Stress*	*Log Shear Rate*	*Log Shearing Stress*	*Log Yield Stress*
L2	6.0	1.30	2656.7	0.11	3.42	3.08
L2	12.0	2.60	2736.1	0.41	3.44	3.11
L2	30.0	6.51	4672.2	0.81	3.67	3.51
L2	60.0	13.02	3475.5	1.11	3.54	3.31

Table 22. Measurement Results of Papaya Fruit Juice Sample.

Rotor	RPM	*Shear Rate*	*Shearing Stress*	*Log Shear Rate*	*Log Shearing Stress*	*Log Yield Stress*
L4	6.0	0.64	6503.4	-0.19	3.81	3.81
L4	12.0	1.28	7143.0	0.11	3.85	3.85
L4	30.0	3.21	13652.1	0.51	4.14	4.14
L4	60.0	6.42	12639.6	0.81	4.10	4.10

Attachment 16. Documentation Practice Rheological Characteristics Material Liquid.

Picture 29. Documentation Practice Characteristics rheology Material Liquid.

1. INTRODUCTION

1.1 Background

The concept of rheology has a wide range of applications in everyday life, ranging from food and beverages to cosmetics, paints, and building materials. Understanding rheology can help optimize the texture, viscosity, or flow behavior of food materials. Understanding the rheological properties can be leveraged to enhance the quality and performance of products in various aspects of daily life.

In the field of agriculture, rheology plays a significant role in materials derived from agriculture that undergo rheological changes, such as milk, vegetable oils, dough, and sauces. The application of rheology in agriculture involves measuring and characterizing the rheological properties of agricultural materials, developing rheological models to predict flow and deformation behavior, and utilizing technology. Agriculture faces various rheology-related challenges, especially in the processing of agricultural materials such as oil refining. Understanding rheology is essential to ensure operational efficiency and that the quality of agricultural products meets standards and market demands.

Understanding rheology in agriculture is also crucial in the processing of vegetable oils, where the viscosity and flow properties of oils can influence extraction and purification processes. Rheology of fluids studies the flow and deformation behavior of liquids, such as suspensions, solutions, or emulsions. Fluids exhibit different flow properties depending on their composition and structure. For example, flowability, viscosity, thixotropy (viscosity recovery after applying stress), and rheological waves (fluid response to pressure) are some relevant parameters in fluid rheology. Understanding the rheological behavior of fluids aids in the development of agricultural products like pesticides, liquid fertilizers, and chemicals used in agricultural processing.

Based on the above description, it is essential to conduct a Rheological Characteristics of Fluid Materials experiment to understand the fluid characteristics of agricultural materials and determine the viscosity of agricultural fluid materials. Based on the description above, it is necessary to conduct a Rheological Characteristics of Fluid Materials experiment to understand the fluid characteristics of agricultural materials and determine the viscosity of agricultural fluid materials.

1.2 Objectives and Benefits

The purpose of conducting the Rheological Characteristics of Liquid Materials practicum is to determine rheological parameters of materials based on the power law model and to understand the rheological properties of materials based on the obtained rheological parameters.

The significance of conducting the Rheological Characteristics of Liquid Materials practicum lies in its ability to aid in the development of food products, evaluating the characteristics of liquid food products, and its practical applications in everyday life, particularly in the field of agriculture.

2. LITERATURE REVIEW

2.1 Papaya Fruit

Papaya fruit (Carica papaya L.) is a popular agricultural commodity enjoyed by the people of Indonesia. Papaya fruit contains various vitamins such as vitamin A, vitamin B, vitamin C, minerals, and energy, and it is rich in antioxidants. The thickness of papaya fruit can vary depending on the level of ripeness. Ripe papaya is usually thicker than unripe papaya. Papaya has a soft texture and a denser consistency. The higher fiber content in papaya, especially in the central part known as the seed, provides additional thickness. Papaya fruit can be consumed fresh and can also be processed into various products, including papaya jam. Due to its high water content, papaya fruit is prone to spoilage, leading to a short shelf life. One way to extend the shelf life of papaya fruit is by processing it into various products (Lumula et al., 2021).

2.2 Dragon Fruit

Dragon fruit, also known as pitaya, contains bioactive compounds beneficial for the body, such as antioxidants, dietary fiber in the form of pectin, several minerals including calcium, phosphorus, iron, and vitamins such as vitamin C, vitamin B1 (thiamin), vitamin B2 (riboflavin), and vitamin B3 (niacin). Vitamin C enhances the immune system, while B-complex vitamins play a role in energy metabolism and nerve function. Dragon fruit has a relatively low viscosity or thickness. It has a soft texture, crispy flesh, and is water-rich. This is due to its high water content and relatively low fiber content. Dragon fruit cannot be stored for long due to its high water content of around 90%, with a shelf life of 7-10 days at 14°C. Therefore, further processing is necessary to preserve its nutritional content and extend its shelf life (Widowati et al., 2020).

2.3 Rheology

Rheology refers to the study of flow and deformation of materials, both fluids and solids. It investigates how materials respond and change shape under different load conditions, such as stress, deformation, flow rate, viscosity, and thickness. Rheology also examines the relationship between shear stress and shear rate in fluids and the relationship between strain and stress in solid materials. Fluid systems are classified into two types: Newtonian and non-Newtonian. Newtonian fluids adhere to Newton's law of viscosity, where the shear rate is directly proportional to the shear stress. Non-Newtonian fluids do not follow this law, and their viscosity can change with applied stress. Non-Newtonian behavior occurs in heterogeneous dispersions like colloids, emulsions, and suspensions (Adi and Zulkarnain, 2020).

The behavior of fluids is influenced by factors such as intermolecular forces and solute interactions, which restrict particle movement at the molecular level. Changes in temperature and concentration can impact these interactions and, consequently, the rheological behavior of fluids. Higher temperatures increase kinetic energy of molecules, making particles more active and reducing intermolecular forces, leading to a decrease in viscosity with rising temperature. Conversely, lower temperatures restrict molecular movement, resulting in increased viscosity. Additionally, solute concentration can influence fluid behavior by affecting intermolecular forces. Both temperature and concentration variations play roles in determining the rheological properties of fluids (Habibi et al., 2019).

2.4 Fluid Characteristics

Fluids are substances that can flow when subjected to external forces. They can change shape and are not permanently fixed. Fluids take the shape of the containers they pass through. Fluid characteristics encompass static pressure, dynamic pressure, total pressure, fluid velocity, and shear stress. In regions where wall friction effects are negligible, shear stress can be disregarded, and fluid behavior approaches that of an ideal fluid. An ideal fluid exhibits incompressibility and has a viscosity of zero. Potential flow describes such behavior and adheres to Newton's mechanics and the law of mass conservation (Jalaluddin et al., 2019).

Viscous fluids are influenced by intermolecular cohesive forces. For gases, viscosity arises from molecular collisions. Different fluids possess varying viscosities. High viscosity inhibits fluid movement, making it difficult for objects to move through it. Viscosity in liquids arises from cohesive forces between their molecules. It determines how easily molecules move due to friction between layers of material. Viscosity indicates a fluid's resistance to flow. Factors like temperature, intermolecular forces, molecule size, and the number of dissolved molecules influence viscosity. Viscosity can be considered as the internal movement within a fluid (Regina et al., 2018).

2.5 Viscometer

A viscometer is a measuring instrument used to determine the viscosity of liquids accurately and according to predefined standards. It measures the degree of viscosity of a liquid, providing specific measurements based on standard methods. Various types of viscometers are available, including falling ball viscometers, tube viscometers, capillary viscometers, Ostwald viscometers, and rotational systems. An alternative viscometer type is the Ostwald viscometer. It requires a smaller sample size compared to other viscometers. Alternative viscometers determine viscosity by measuring the time a certain solution takes to flow through a burette due to gravity. The principle behind viscometer operation involves measuring the time taken by a fluid to pass through two predetermined points in a vertical capillary tube (Regina et al., 2018).

2.6 Time-Independent Fluid Modeling

According to Rao (2014), time-independent fluid modeling is divided into three main types:

a. The power law model describes the relationship between shear thinning and shear thickening using the information of constants K and n. This model is suitable for food characteristics based on liquid bases. K and n in the power law formula represent the consistency index and flow index, respectively. These values are obtained through graphical experiments by plotting log σ against log $\dot{\gamma}$. K is the y-intercept, and n is the slope of the graph. Fluids with n greater than 1 fall under shear thickening, while those with n less than 1 fall under shear thinning. The power law model is widely used because it can be applied within shear rate limits ranging from 101-104 s-1, which various viscometers can accommodate. A drawback of the power law model is its inability to explain low and high shear rate limitations in shear thinning fluids.

b. The Herschel-Bulkley model combines the yield stress value, which is determined by a power law model, and can also be classified under the Herschel-Bulkley model. In this model, σ represents shear stress (Pa), $\dot{\gamma}$ is shear rate (s-1), nH is the flow index, and σH is the yield stress. Pseudoplastic fluids typically have n values less than 1, indicating decreasing viscosity as shear rate increases. This means that higher shear rates result in lower fluid viscosity.

3. METHODOLOGY

3.1 Time And Place

Practice Characteristics rheology Material Liquid was held on Friday, 19 May 2023 o'clock 15.00 WITA until finished in Laboratory *processing* , Program Studies Technique Agriculture, Department Technology Agriculture, Faculty Agriculture, University Hasanuddin, Makassar.

3.2 Tool And Material

Tool used on practice Characteristics rheology Material Liquid that is *viscometer* & *spindle set* , 250 ml *beaker* , digital thermometer, stationery and camera *cellphone* .
Material used on practice Characteristics rheology Liquid Material that is juice dragon fruit, juice papaya fruit and water.

3.3 Procedure Practice

As for procedure Work on practical Rheological Characteristics Material Liquid that is:

1. Prepare tool And material.
2. Enter sample juice fruit dragon to in beaker until reach linelimit 250 ml.
3. Install *viscometer* on static And do calibration tool.
4. Install And determine *spindles* Which in accordance For measurement.
5. Put sample appropriate in middle lower *spindles* And enter *spindles* to in sample until reach line limit.
6. Clicking run Which listed on screen *viscometer* Which will rotating *spindles* .
7. Record the value of the viscosity (CP) and % torque of the sample at each level rotational speed with a range of 6, 12, 30 and 60 rpm (depending on on the *spindle type* Which used).
8. After reaching the maximum speed, reduce the rotational speed again *spindles* And note mark viscosity (CP) And % torque on every level speed until reach speed minimum.
9. Repeat steps 2-8 with use sample juice fruit pawpaw.
10. clean up And dry *the spindles* Then save on box in accordance order.

3.4 Formula Which Used

As for formula Which used on practice Characteristics rheology Material Liquidthat is:

a. *Shear stress*

$$\sigma_a = k_{\alpha\sigma} \, (C \times \text{dial reading})$$

Explanation:

σ_a = *average shear stress* (Pa)

$k_{\alpha\sigma}$ = Shear stress conversion factor (Pa)

C = *dimensionless number* (RV model = 1)

dial reading = % torque

b. *Shear Rate*

$$\dot{\gamma}_a = k_{N\gamma} \, (N)$$

Explanation:

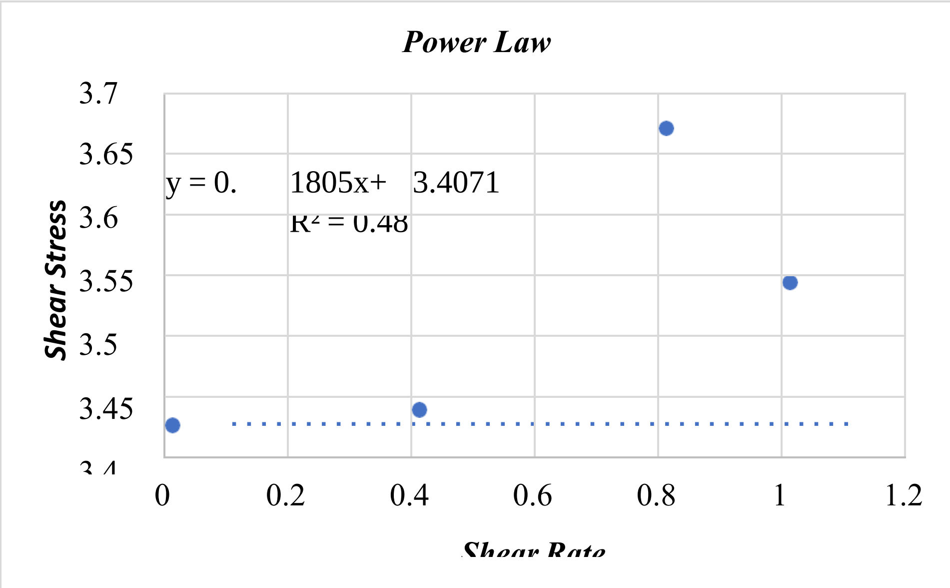
$\dot{\gamma}_a$ = *average shear rate* (s^{-1})

$k_{N\gamma}$ = Shear stress conversion factor (s^{-1})

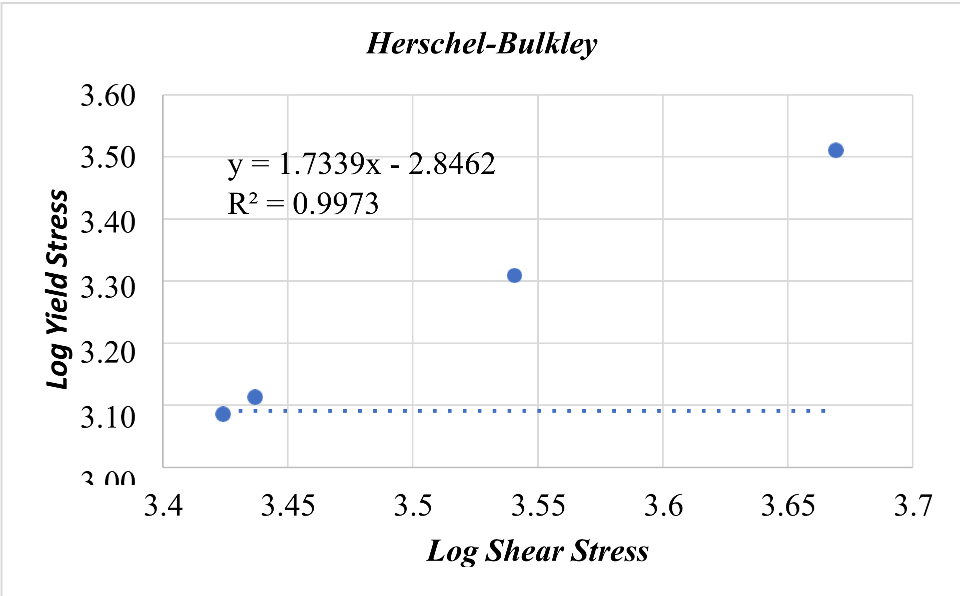
N = Rotational speed (rpm)

4. RESULTS AND DISCUSSION

4.1 Results And Discussion

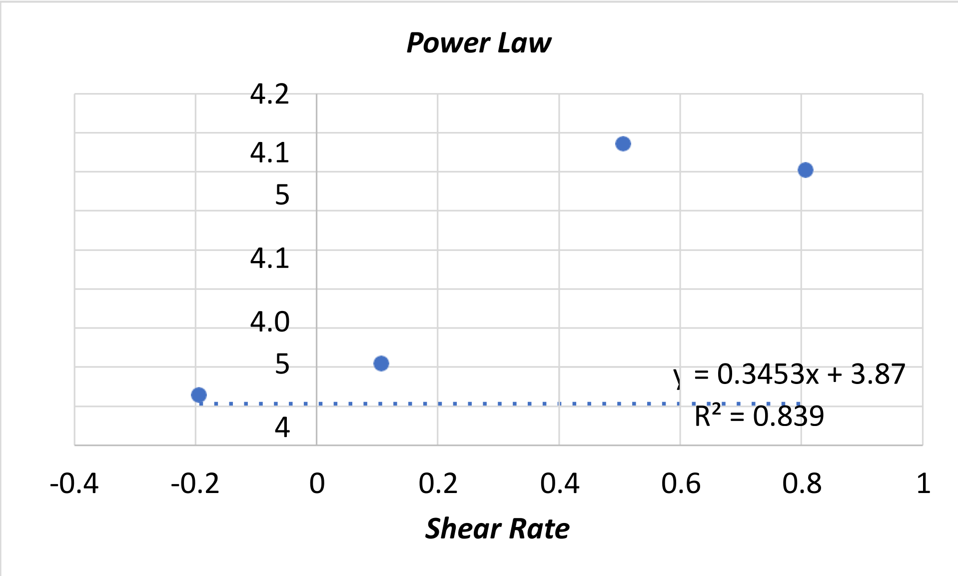


Picture 30. Chart *power law* Juice Fruit Dragon.

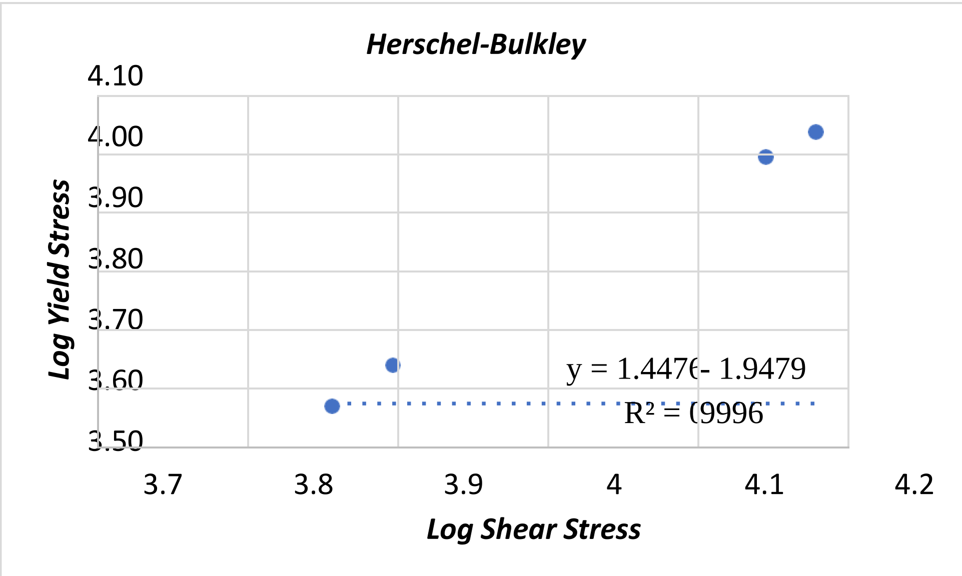


Picture 31. Graphics *Herschel-Bulkley* Juice Fruit Dragon.

Based on the power law graph of dragon fruit juice and the Herschel-Bulkley graph of dragon fruit juice, the highest R2 value was obtained using the Herschel-Bulkley method, which was 0.9973, while the R2 value using the power law method was 0.487. This indicates that the R2 value obtained using the Herschel-Bulkley method is significantly higher, indicating a closer fit. Therefore, it can be concluded that the Herschel-Bulkley method is more appropriate. According to Rao (2014), this aligns with the statement that pseudoplastic fluids typically have an index value (n) less than 1, indicating a decrease in viscosity as shear rate increases. In other words, higher shear rates result in lower fluid viscosity.



Picture 32. *Power* chart *law* Juice Fruit Pawpaw.



Picture 33. Chart *Herschel-Bulkley* Juice Fruit Pawpaw.

Based on the power law graph and the Herschel-Bulkley graph of papaya fruit juice, the obtained R2 value using the Herschel-Bulkley method was 0.9996, whereas the R2 value generated using the power law method was 0.839. This suggests that papaya fruit juice exhibits pseudoplastic behavior. Pseudoplastic behavior refers to non-Newtonian fluids where viscosity decreases with increasing shear rate. The value of n less than 1 in the power law method also supports this assumption, as in the power law model, n represents the power index that describes the change in viscosity with shear rate. This aligns with the statement by Mayagrafinda and Widodo (2020), which states that non-Newtonian fluids are a type of fluid that does not adhere to Newton's Law of viscosity. In other words, their viscosity is not constant and the rate of deformation does not always vary proportionally with the applied shear stress.

5. Conclusion

Based on the conducted Rheological Characteristics of Fluid Materials laboratory experiment, it can be concluded that determining the rheological parameters of liquid materials can be accomplished using the power law model and the Herschel-Bulkley model. The appropriate model for characterizing the rheological properties of liquid materials is the Herschel-Bulkley model, as it can depict the behavior of non-Newtonian fluid flow, including pseudoplastic fluids. The Herschel-Bulkley method enables the determination of important parameters such as yield stress, flow consistency, and power index, which characterize the flow properties of the fluid.

ATTACHMENT

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L2	12.0	2.60	2736.1	0.41	3.44	3.11
L2	30.0	6.51	4672.2	0.81	3.67	3.51
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Table 22. Measurement Results of Papaya Fruit Juice Sample.

Rotor	RPM	*Shear Rate*	*Shearing Stress*	*Log Shear Rate*	*Log Shearing Stress*	*Log Yield Stress*
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L4	12.0	1.28	7143.0	0.11	3.85	3.85
L4	30.0	3.21	13652.1	0.51	4.14	4.14
L4	60.0	6.42	12639.6	0.81	4.10	4.10

Attachment 16. Documentation Practice Rheological Characteristics Material Liquid.

Picture 34. Documentation Practice Characteristics rheology Material Liquid.

1. PENDAHULUAN

1.1 Background

The post-harvest field is one of the sectors that engages in activities to process and produce high-quality agricultural materials. The processes commonly employed aim to yield agricultural products of high quality and value, as well as long-lasting products. One of the frequently used methods in enhancing the quality of agricultural materials is subjecting them to certain conditions such as freezing, blanching, and others. The purpose of applying these conditions is to deactivate microorganisms and extend the shelf life of the agricultural materials.

Blanching is typically carried out on agricultural commodities like vegetables and fruits. This is because vegetables and fruits naturally contain active enzymes that can cause changes in color, texture, and flavor when exposed to heat or air. By blanching vegetables and fruits, the activity of these enzymes can be temporarily halted. This helps maintain the quality of the products, including vibrant color, good texture, and optimal taste and nutrition. Some examples of vegetables often subjected to blanching treatment are green beans, broccoli, carrots, sweet corn, cabbage, and cauliflower.

Freezing is another process used to improve the quality or shelf life of agricultural materials. Freezing slows down the respiratory process, allowing agricultural products to remain viable for a relatively long time. The freezing process usually involves lowering the temperature below the freezing point to slow down the decomposition process. This is because temperatures below freezing point inhibit water activity and biochemical changes.

Based on the above description, a practical activity on the Processing of Agricultural Commodity (Frozen Vegetables) is conducted to understand the processes involved in processing agricultural products, specifically through techniques like blanching and freezing.

1.2 Objectives and Benefits

The purpose of conducting the Agricultural Commodity Processing (Frozen Vegetables) practical activity is to understand the process of frozen vegetable product processing, comprehend the basic principles of blanching as a pre-treatment method, grasp the fundamental principles of freezing storage, and evaluate changes in the physical characteristics of materials during storage through blanching treatment.

The significance of the Agricultural Commodity Processing (Frozen Vegetables) practical activity lies in its applicability to enhancing the quality of agricultural products through the freezing process, which can be implemented using agricultural machinery.

2. LITERATURE REVIEW

2.1 Carrot

Carrot is a seasonal vegetable plant that grows in a bush-like form. Carrot roots contain essential nutrients, especially vitamins and minerals, which are beneficial for the body. Therefore, this vegetable is highly recommended for consumption in daily menus to fulfill the body's essential vitamin and mineral needs. Carrot production fluctuates throughout the year, sometimes experiencing abundant harvests while at other times facing shortages. This can affect the balance between demand and supply, resulting in price fluctuations. During times of abundance, prices may decrease due to excess supply, whereas during times of scarcity, prices may rise due to insufficient supply. On the other hand, consumer demand remains consistent throughout the year.

Another challenge is that vegetables are perishable food items. This is due to their high water content, which ranges from 85-95%, making them ideal for microbial growth and accelerating metabolic reactions. As a result, carrots are prone to spoilage at a faster rate (Wulansari, 2017).

Consumer pREFERENCES for instant products present a market opportunity for vegetable business operators. Dried vegetable products offer an alternative to meet this demand. Apart from catering to consumer needs, dried vegetables also hold market potential, especially in certain regions of Indonesia that are far from vegetable production centers. Dried vegetables have advantages such as reduced transportation risks, longer shelf life (up to 4 months with polyethylene plastic packaging), and lower transportation costs. As a result, dried vegetables have promising prospects both for domestic consumption and export purposes (Radiyati, 2019).

2.2. Blanching

The agricultural processing process involves a common preliminary step that is widely used in various processes such as freezing, canning, and drying of vegetables and fruits. This process is known as blanching. Blanching is a heating process applied to a material with the aim of inactivating enzymes, softening tissues, and reducing harmful microorganism contamination. This ensures that the dried, canned, or frozen products maintain good quality. The duration of blanching depends on the characteristics of the material. For example, blanching for 3 minutes yields better French fries color. Generally, optimal blanching temperatures range from around 70-95°C for 1-10 minutes. The most commonly used blanching methods are steam blanching and hot water blanching. The blanching process can affect nutritional values; some nutritional loss occurs during blanching. Boiling methods can result in a loss of 40% minerals and vitamins, 35% sugars, and 20% protein (Pujimulyani, 2020).

Blanching management for preservation is more intensive compared to regular cooking, thus minimizing nutrient loss, texture changes, and color alterations. Applying heat at a specific temperature (blanching) can be an alternative treatment to reduce nutritional decline. Physical and sensory properties of dried vegetable products are improved through Low Temperature Long Time (LTLT) blanching at 60-65°C for 30 minutes or blanching with water at 70-90°C for 10 minutes, which enhances color brightness, nutrition, and texture of the carrots. However, the yield and rehydration speed remain low. Therefore, an optimization study on blanching methods, temperatures, and durations is necessary to obtain high-quality dried agricultural materials (Gogus, 2018).

Enzymatic browning is generally an issue during vegetable preparation for further processing. Once cut or peeled, vegetables left exposed for a period will exhibit browning in their tissues. This phenomenon is caused by the formation of dark brown polymers as a reaction between polyphenol compounds and oxygen, catalyzed by the enzyme polyphenol oxidase. The prevention of enzymatic browning is based on efforts to inactivate polyphenol and oxidase enzymes, as well as to reduce contact with oxygen or air. Blanching, as a heating process, serves multiple purposes, including (Gogus, 2018).

According to Kusdibyo (2019), there are several main objectives of blanching, including:

a. Inactivating enzymes that can cause harmful reactions in the material.
b. Cleaning the product from adhering particles or contaminants.
c. Reducing the number of microorganisms.
d. Removing air from the intercellular spaces within the material's tissue to soften it for easier packaging.

2.3 Freezing

Freezing or frozen storage is a process of rapidly reducing the temperature of food materials and preventing the growth of microorganisms as well as food spoilage by maintaining a very low temperature. This is done with the aim of extending the shelf life of food materials and preserving their quality. The freezing process involves lowering the temperature of food materials below the freezing point of water, typically ranging from -18°C to -30°C.

Rapid freezing is crucial to prevent the formation of large ice crystals and cell damage in the food material. Quick freezing methods, such as forced air freezing or specialized freezing equipment capable of rapidly achieving low temperatures, are commonly used.

It is important to note that not all types of food materials are suitable for freezing. Some food materials may undergo changes in texture or quality after freezing. Therefore, it is important to follow proper storage guidelines and recommendations for each type of food that will be frozen. Freezing is a common method in food processing and can also be performed at home using a freezer or appropriate freezing equipment (Setyawan, 2017).

Freezing is a preservation method where food materials are frozen below the freezing point of the food, partially reducing the water content or forming ice crystals, thus reducing water availability. This inhibits the activities of enzymes and microorganisms, maintaining the quality of the food material. The quality of frozen produce remains close to that of fresh fruits, although it cannot be directly compared to the quality achieved through refrigeration. Freezing can preserve taste and nutritional value better than other methods, as low-temperature freezing can inhibit microbial activity and prevent chemical reactions and enzyme activity that could degrade the nutritional content of the food. While freezing significantly reduces the microbial count, it does not sterilize the food (Tambunan, 2019).

Freezing involves heat transfer in conjunction with a phase change from liquid to solid and is one of the common preservation methods used for food materials. Decreasing the temperature reduces the activity of microorganisms and enzyme systems, preventing food spoilage. Additionally, the crystallization of water due to freezing reduces the water content in the liquid phase within the food material, thereby inhibiting microbial growth and secondary enzymatic activity. The freezing process occurs gradually from the surface to the core of the material. During the initial stages of freezing, a precooling phase takes place, during which the material's temperature is lowered from its initial temperature to its freezing point. During this stage, all the water content remains in the liquid state. Following the precooling phase, a phase change occurs, leading to the formation of ice crystals (Setyawan, 2017).

One of the considerations in selecting a freezing process in the frozen food industry is freezing rate. The freezing rate not only determines the final structure of the frozen product but also affects the overall time required. The freezing rate of a food mass is the ratio between the minimal distance between the surface and the thermal center compared to the time required for the food product to reach a temperature of 0°C on the surface and -5°C at the thermal center. An alternative definition is the thermal arrest time (TAR), which measures the time required for the slowest freezing point of the product to decrease from 0°C to -5°C. The freezing rate, in this case, measures the time needed for the product's temperature at the slowest point to become cold or frozen, calculated from the point at which the initial freezing point is reached until the desired temperature below the freezing point is achieved for that product (Setyawan, 2017).

The freezing rate can be adjusted and significantly influences the properties and quality of the resulting frozen product. The characteristics of a product resulting from rapid freezing are markedly different from those resulting from slow freezing. Rapid freezing results in small, evenly distributed ice crystals within the tissue, whereas slow freezing leads to the formation of larger ice crystals distributed in the intercellular spaces with larger pore sizes. Rapid freezing is generally considered advantageous in terms of production speed, as long as the resulting product quality is not compromised. Freezing rates can be categorized as slow freezing, with freezing times of 30 minutes or more for a 1 cm-thick material, medium freezing with freezing times of 20-30 minutes or more for a 1 cm-thick material, and fast freezing, where freezing times are less than 20 minutes for a 1 cm-thick material (Setyawan, 2017).

Freezing treatments can be applied to mixed products made from various vegetables, ready to be used for producing frozen vegetables. Proper storage and freezing are essential to preserving the freshness of vegetables at harvest and maintaining their nutritional content and flavor as much as possible. Frozen food technology can offer a solution for extending the shelf life and durability of a product (Arif, 2023).

2.4 Color

Color is highly significant in the quality of food materials. The color or visual appearance is linked to the quality of the food. Testing and measurement of color aim to determine the influence of spices or other additive ingredients on color and to maintain the color of the material during its processing. Color determination in the food industry serves not only economic purposes but also brand quality and standardization. When a material deviates during processing, whether through heating or other processes, physical changes occur including alterations in color. In addition to being a quality-determining factor, color can also serve as an indicator of freshness or ripeness. It also plays a role in determining the efficacy of mixing (Rustam et al., 2018).

A colorimeter, or color reader, is used to measure color. This instrument is sensitive to the measured light and the amount of color absorbed by an object or substance. The colorimeter operates by determining color based on the blue, red, and green components of the light absorbed by the object or sample, which is then reflected by the medium, leading to a reduction in the amount of light. This color measurement device works based on the Beer-Lambert law, which states that the light absorption transmitted through a medium is directly proportional to the concentration of the medium. The color standards used are based on the hunter L, a, and b scales, where L represents lightness (range 0-100; larger values indicate greater lightness), the letter a represents red or green color (range (-128)-127; + denotes more red; - denotes more green), and the letter b represents yellow or blue color (range (-128)-127; + denotes more yellow; - denotes more blue) (Rustam et al., 2018).

3. METHODOLOGY

3.1 Time and Location

Laboratory Experiment on Agricultural Commodity Processing (Frozen Vegetables) was conducted on Friday, June 9th, 2023, at 3:00 PM WITA, located in the Processing Laboratory, Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, Makassar.

3.2 Tools and Materials

The equipment used in the Laboratory Experiment on Agricultural Commodity Processing (Frozen Vegetables) included a water bath, beaker glass, knife, ruler, colorimeter, penetrometer, and a mobile phone camera.

The materials used in the Laboratory Experiment on Agricultural Commodity Processing (Frozen Vegetables) consisted of carrots, tissues, and zip lock plastic bags.

3.3 Working Procedure

The procedure for this laboratory work is as follows:

a. Day 0

1. Prepare the equipment and materials.
2. Cut the carrots into dice shapes with dimensions of 1 x 1 x 1 cm.
3. Weigh a sample of 5 grams.
4. Fill a beaker with distilled water up to the same level as the water in the water bath.
5. Measure the temperature of the water in the beaker until it reaches 70°C.
6. Place the weighed sample into the water bath for 30 seconds.
7. Remove the sample and allow it to drain until all the surface water is dried.
8. Cool the sample to room temperature.
9. Measure the Lab color and texture before any storage is conducted.
10. Place the sample into a plastic zip lock bag and store it at freezing temperature (-18°C) for 3 days.
11. Repeat steps 1–10 with a blanching temperature of 90°C.
12. Prepare a batch of control samples (without blanching) stored at room temperature for 3 days.

b. Day 3

1. Retrieve the samples stored at freezing temperature and the samples stored at room temperature.
2. Prepare the colorimeter and penetrometer.
3. Measure the color and texture of each sample.
4. Record the color and texture results for each sample.

3.4. Formula used

The formulas used in the Agricultural Commodity Processing Laboratory (Frozen Vegetables) are as follows:

$$\Delta E = \sqrt{(L_0\text{-}L)^2 + (a_0\text{-}a))^2 + (b_0\text{-}b)^2}$$

Description:

ΔE : total color difference,

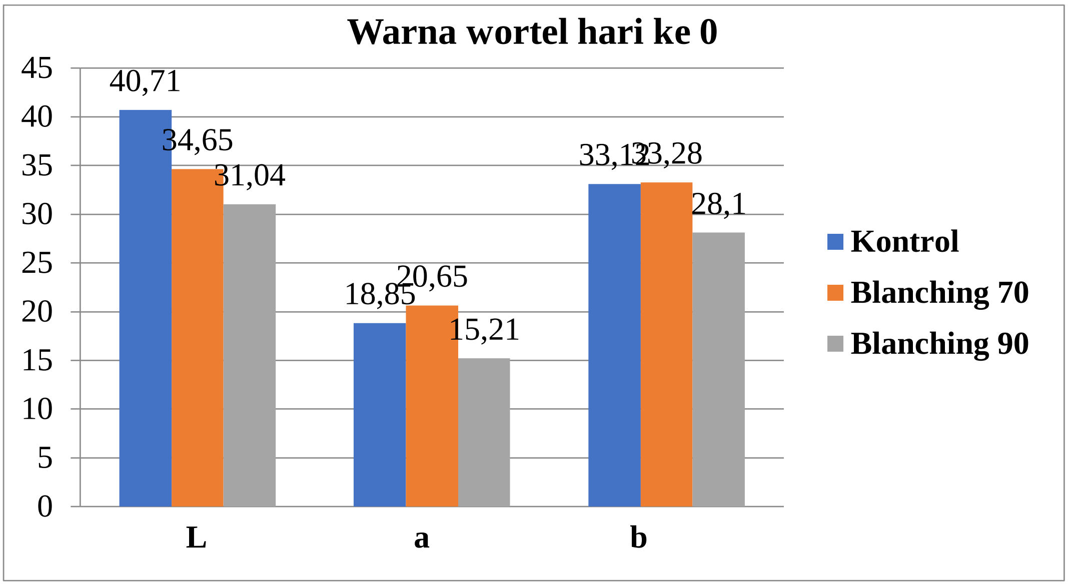
L* : *lightness components,*

a*, b* : *chromatics components*

4. RESULT AND DISCUSSION

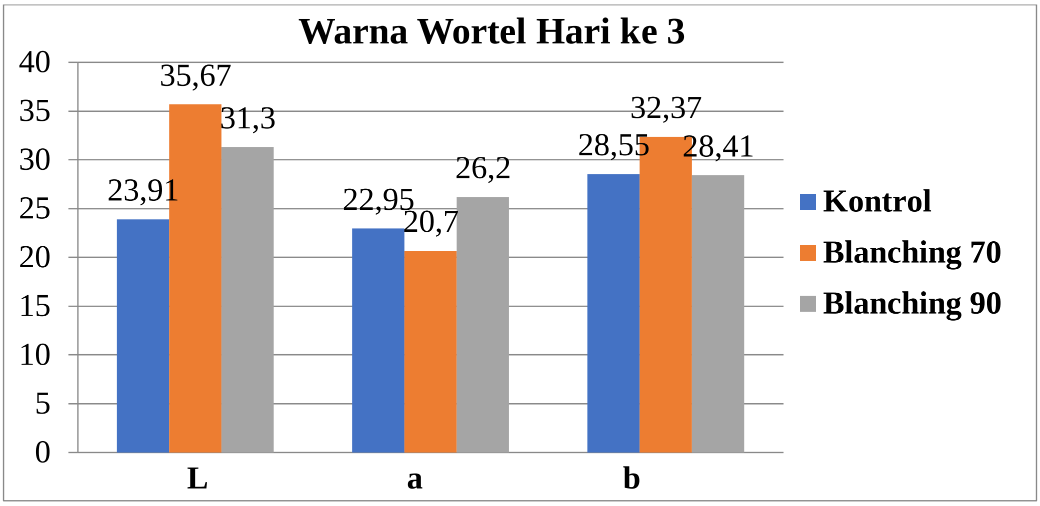
4.1 Result

4.1.1 Color of Sample on Day 0 and Day 3



Picture 35. Color Diagram of Carrots on Day 0.

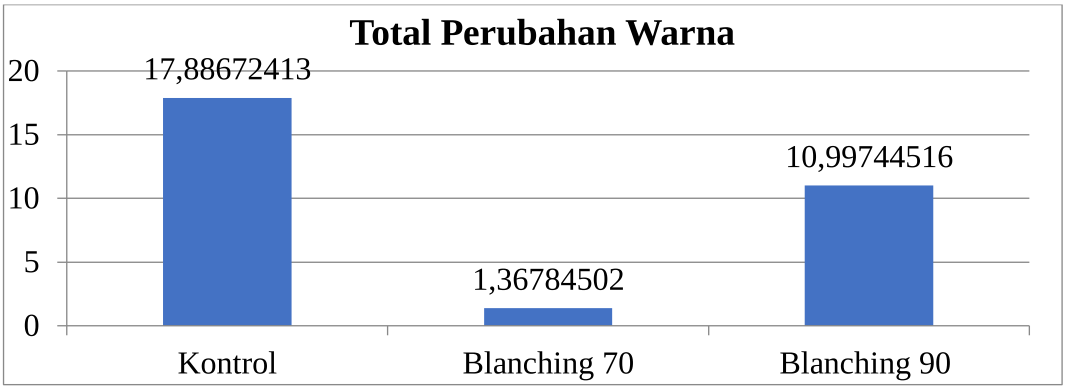
Based on the Agricultural Product Processing (Frozen Vegetables) practicum, it can be observed that there is a significant color change in the carrot samples undergoing blanching at 70°C and 90°C, due to the influence of temperature. The color of the control sample had the highest color level at 40.71 on L, then gradually decreased in the blanching treatment at 70°C to 18.85, and then increased in the blanching treatment at 90°C to 33.13. The color of the blanching samples at 70°C and 90°C also experienced similar fluctuations in color levels on day 0. Additionally, the color levels of the samples after treatment did not decrease significantly, so they remained within reasonable limits. This is in line with the statement by Kamsiati et al. (2020) that the purpose of the blanching process in vegetable processing is to maintain the brightness of color, preserve the texture, clean the vegetables, and inhibit enzymatic damage.



Picture 36. Color of Sample on Day 3

Based on the results obtained in the above diagram, it can be seen that blanching treatment preserves the color of carrots after day 3. The color of the control carrots experienced a decrease in L, which was 23.91, while it increased in the blanching treatment at 70 degrees to 22.95 and at 90 degrees to 28.55. The color of carrots in the blanching treatment at 70 degrees showed a significant increase of 35.67 in L, followed by 20.7 in a, and 32.37 in b. Similarly, the color of carrots in the blanching treatment at 90 degrees also experienced an increase of 31.3 in L, 26.2 in a, and 28.41 in b. The blanching treatments applied helped maintain the color of the carrots and preserve their quality until day 3. This finding aligns with Kamsiati et al.'s statement (2020) that vegetable processing using blanching as a pre-preservation step before the freezing process helps retain the quality of frozen vegetables by inhibiting enzyme activity and preserving their color and texture.

4.1.2 Total Color Change

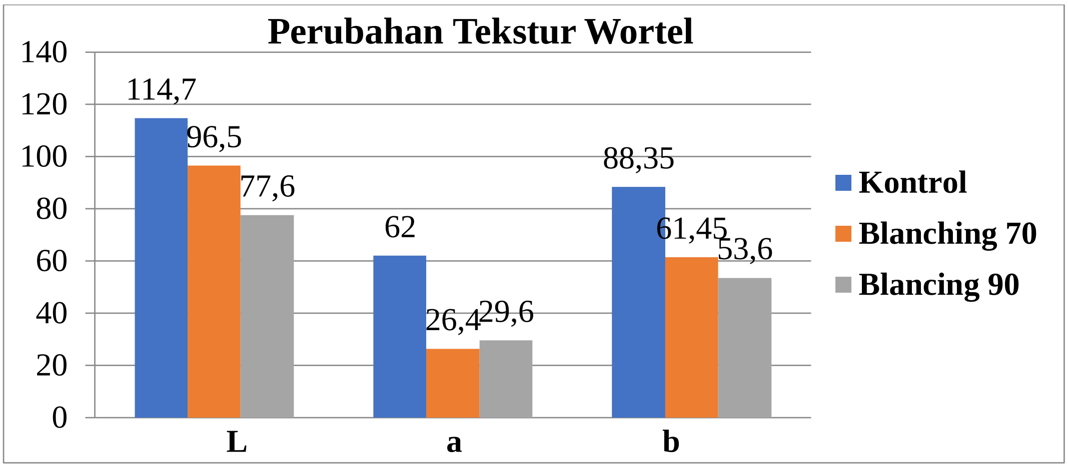


Picture 37. Total Color Change in Carrot Samples

Based on the Agricultural Commodity Processing practicum (Frozen Vegetables), it can be observed that carrot samples subjected to blanching treatment experienced the smallest color changes. The color of the control carrots underwent a significant change, specifically 17.88, as they did not undergo blanching treatment, leading to contamination from the environment, which caused substantial color changes in the carrots. The color of carrots treated with blanching at 70 degrees experienced the smallest color change, which was 1.36, whereas the color of carrots treated with blanching at 90 degrees experienced a relatively significant color change of 10.99. These color changes are influenced by several environmental factors, such as microorganisms, environmental temperature, and oxygen exposure intensity in the food material.

Blanching treatment at 70 degrees can be considered highly suitable and efficient for carrots as it resulted in minimal color changes. This finding is in line with Kamsiati et al.'s statement (2020) that vegetable processing using blanching as a pre-preservation step before the freezing process helps maintain the quality of frozen vegetables by inhibiting enzyme activity and preserving their color and texture.

4.2 Texsture



Picture 38. Texture Changes in Carrot Samples.

Based on the results obtained regarding the texture changes in carrot samples, it is evident that the control sample experienced significant texture changes in L, which were 114.7, followed by 62 in a, and 88.35 in b. The texture of carrot samples treated with blanching at 70 degrees underwent minor changes, with values of 77.6 in L, 26.4 in a, and 53.6 in b. On the other hand, the texture of carrot samples treated with blanching at 90 degrees experienced relatively more significant changes, with values of 77.6 in L, 29.6 in a, and 53.6 in b. These texture changes indicate that the blanching treatment at 70 degrees resulted in the least texture changes, as it underwent the blanching process to reduce color and texture changes, as well as preserve its nutritional content and enzymes. This demonstrates that the blanching treatment at 70 degrees is the most suitable and efficient treatment to be applied to carrot samples since it resulted in the least texture changes. This finding aligns with Kamsiati et al.'s statement (2020) that heat exposure can damage the cytoplasmic and other membranes, causing the easy movement of materials inside and outside the cell and leading to a loss of turgor properties. The texture of dried food products is significantly influenced by their components, physical-chemical characteristics, and microstructure. Generally, heat treatment can reduce the texture value of fruit cell walls, making them smoother.

4.3 Sample Photos During Storage

Picture 39. Carrot Control Treatment Photos on Day 0 and Day 3.

Picture 40. Carrot Blanching Treatment at 70°C Photos on Day 0 and Day 3.

Picture 41. Carrot Blanching Treatment at 90°C Photos on Day 0 and Day 3

Based on the results obtained from frozen and non-frozen carrot samples, it was observed that the samples subjected to the freezing process appeared fresher compared to the samples that did not undergo freezing. The control sample, as well as the samples treated with blanching at 70°C and 90°C, appeared fresher than the samples after day 3. The control sample experienced a significant color change by day three, appearing drier compared to day 1. However, the carrot samples treated with blanching at 70°C and 90°C appeared relatively fresh on day 3, as the blanching treatment preserved their texture and color.

The level of freshness in the three different treatments is influenced by several factors such as microorganism presence, environmental temperature, and storage duration. This finding aligns with Rozana and Sunardi's statement (2021) that freezing is recognized as one of the best methods for preserving the quality of fruits and vegetables. The freezing process for fresh-cut fruits can reduce the level of spoilage that typically occurs in such products. During freezing, most of the water in the food material turns into ice, reducing water activity and slowing down physical and biochemical changes that could damage the product.

5. CONCLUTION

Based on the Agricultural Commodity Processing (Frozen Vegetables) practicum that has been conducted, it can be concluded that blanching is one of the steps in the freezing method. This method involves the process of boiling and immersing the material in ice water or cold water. During the storage phase, low temperatures below -2°C are used to prevent damage to the texture, color, and other characteristics of the material. On the other hand, in the blanching process, the food material is boiled at high temperatures for the purpose of preservation.

The blanching method can be divided into two types: thermal and non-thermal. In the thermal process, the material is sterilized using hot steam, while in the non-thermal process, other techniques, such as the use of specific chemicals, are employed to expedite the process.

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ATTACHMENT

Attachment 1-5. Table of Results of Agricultural Commodity Processing Practicum (Frozen Vegetables).

Tabel 1-5. Warna Wortel Hari Ke-0 dan 3.

Jenis Sampel	Warna Hari 0			Warna Hari 3			Total Perubahan Warna
	L	a	b	L	a	b	
Kontrol	40,71	18,85	33,12	23,91	22,95	28,55	17,88672413
Blanching 70	34,65	20,65	33,28	35,67	20,7	32,37	1,36784502
Blanching 90	31,04	15,21	28,1	31,3	26,2	28,41	10,99744516

Tabel 1-5. Tekstur Wortel Hari Ke-0 dan 3.

Jenis Sampel	Tekstur hari 0	Tekstur hari 7	Rata-rata
	Kekerasan	Kekerasan	
Kontrol	114,7	62	88,35
Blanching 70	96,5	26,4	61,45
Blancing 90	77,6	29,6	53,6

Attachment 2-5. Dokumentation of Agricultural Commodity Processing Practicum (Frozen Vegetables).

Picture 42. Documentation of Cutting Carrots.

1. INTRODUCTION

1.1 Background

The post-harvest field is one of the sectors that engages in activities to process and produce high-quality agricultural materials. The processes commonly employed aim to yield agricultural products of high quality and value, as well as long-lasting products. One of the frequently used methods in enhancing the quality of agricultural materials is subjecting them to certain conditions such as freezing, blanching, and others. The purpose of applying these conditions is to deactivate microorganisms and extend the shelf life of the agricultural materials.

Blanching is typically carried out on agricultural commodities like vegetables and fruits. This is because vegetables and fruits naturally contain active enzymes that can cause changes in color, texture, and flavor when exposed to heat or air. By blanching vegetables and fruits, the activity of these enzymes can be temporarily halted. This helps maintain the quality of the products, including vibrant color, good texture, and optimal taste and nutrition. Some examples of vegetables often subjected to blanching treatment are green beans, broccoli, carrots, sweet corn, cabbage, and cauliflower.

Freezing is another process used to improve the quality or shelf life of agricultural materials. Freezing slows down the respiratory process, allowing agricultural products to remain viable for a relatively long time. The freezing process usually involves lowering the temperature below the freezing point to slow down the decomposition process. This is because temperatures below freezing point inhibit water activity and biochemical changes.

Based on the above description, a practical activity on the Processing of Agricultural Commodity (Frozen Vegetables) is conducted to understand the processes involved in processing agricultural products, specifically through techniques like blanching and freezing.

1.2 Objectives and Benefits

The purpose of conducting the Agricultural Commodity Processing (Frozen Vegetables) practical activity is to understand the process of frozen vegetable product processing, comprehend the basic principles of blanching as a pre-treatment method, grasp the fundamental principles of freezing storage, and evaluate changes in the physical characteristics of materials during storage through blanching treatment.

The significance of the Agricultural Commodity Processing (Frozen Vegetables) practical activity lies in its applicability to enhancing the quality of agricultural products through the freezing process, which can be implemented using agricultural machinery.

2. LITERATURE REVIEW

2.1 Carrot

Carrot is a seasonal vegetable plant that grows in a bush-like form. Carrot roots contain essential nutrients, especially vitamins and minerals, which are beneficial for the body. Therefore, this vegetable is highly recommended for consumption in daily menus to fulfill the body's essential vitamin and mineral needs. Carrot production fluctuates throughout the year, sometimes experiencing abundant harvests while at other times facing shortages. This can affect the balance between demand and supply, resulting in price fluctuations. During times of abundance, prices may decrease due to excess supply, whereas during times of scarcity, prices may rise due to insufficient supply. On the other hand, consumer demand remains consistent throughout the year.

Another challenge is that vegetables are perishable food items. This is due to their high water content, which ranges from 85-95%, making them ideal for microbial growth and accelerating metabolic reactions. As a result, carrots are prone to spoilage at a faster rate (Wulansari, 2017).

Consumer pREFERENCES for instant products present a market opportunity for vegetable business operators. Dried vegetable products offer an alternative to meet this demand. Apart from catering to consumer needs, dried vegetables also hold market potential, especially in certain regions of Indonesia that are far from vegetable production centers. Dried vegetables have advantages such as reduced transportation risks, longer shelf life (up to 4 months with polyethylene plastic packaging), and lower transportation costs. As a result, dried vegetables have promising prospects both for domestic consumption and export purposes (Radiyati, 2019).

2.2. *Blanching*

The agricultural processing process involves a common preliminary step that is widely used in various processes such as freezing, canning, and drying of vegetables and fruits. This process is known as blanching. Blanching is a heating process applied to a material with the aim of inactivating enzymes, softening tissues, and reducing harmful microorganism contamination. This ensures that the dried, canned, or frozen products maintain good quality. The duration of blanching depends on the characteristics of the material. For example, blanching for 3 minutes yields better French fries color. Generally, optimal blanching temperatures range from around 70-95°C for 1-10 minutes. The most commonly used blanching methods are steam blanching and hot water blanching. The blanching process can affect nutritional values; some nutritional loss occurs during blanching. Boiling methods can result in a loss of 40% minerals and vitamins, 35% sugars, and 20% protein (Pujimulyani, 2020).

Blanching management for preservation is more intensive compared to regular cooking, thus minimizing nutrient loss, texture changes, and color alterations. Applying heat at a specific temperature (blanching) can be an alternative treatment to reduce nutritional decline. Physical and sensory properties of dried vegetable products are improved through Low Temperature Long Time (LTLT) blanching at 60-65°C for 30 minutes or blanching with water at 70-90°C for 10 minutes, which enhances color brightness, nutrition, and texture of the carrots. However, the yield and rehydration speed remain low. Therefore, an optimization study on blanching methods, temperatures, and durations is necessary to obtain high-quality dried agricultural materials (Gogus, 2018).

Enzymatic browning is generally an issue during vegetable preparation for further processing. Once cut or peeled, vegetables left exposed for a period will exhibit browning in their tissues. This phenomenon is caused by the formation of dark brown polymers as a reaction between polyphenol compounds and oxygen, catalyzed by the enzyme polyphenol oxidase. The prevention of enzymatic browning is based on efforts to inactivate polyphenol and oxidase enzymes, as well as to reduce contact with oxygen or air. Blanching, as a heating process, serves multiple purposes, including (Gogus, 2018).

According to Kusdibyo (2019), there are several main objectives of blanching, including:

a. Inactivating enzymes that can cause harmful reactions in the material.
b. Cleaning the product from adhering particles or contaminants.
c. Reducing the number of microorganisms.
d. Removing air from the intercellular spaces within the material's tissue to soften it for easier packaging.

2.3 Freezing

Freezing or frozen storage is a process of rapidly reducing the temperature of food materials and preventing the growth of microorganisms as well as food spoilage by maintaining a very low temperature. This is done with the aim of extending the shelf life of food materials and preserving their quality. The freezing process involves lowering the temperature of food materials below the freezing point of water, typically ranging from -18°C to -30°C. Rapid freezing is crucial to prevent the formation of large ice crystals and cell damage in the food material. Quick freezing methods, such as forced air freezing or specialized freezing equipment capable of rapidly achieving low temperatures, are commonly used.

It is important to note that not all types of food materials are suitable for freezing. Some food materials may undergo changes in texture or quality after freezing. Therefore, it is important to follow proper storage guidelines and recommendations for each type of food that will be frozen. Freezing is a common method in food processing and can also be performed at home using a freezer or appropriate freezing equipment (Setyawan, 2017).

Freezing is a preservation method where food materials are frozen below the freezing point of the food, partially reducing the water content or forming ice crystals, thus reducing water availability. This inhibits the activities of enzymes and microorganisms, maintaining the quality of the food material. The quality of frozen produce remains close to that of fresh fruits, although it cannot be directly compared to the quality achieved through refrigeration. Freezing can preserve taste and nutritional value better than other methods, as low-temperature freezing can inhibit microbial activity and prevent chemical reactions and enzyme activity that could degrade the nutritional content of the food. While freezing significantly reduces the microbial count, it does not sterilize the food (Tambunan, 2019).

Freezing involves heat transfer in conjunction with a phase change from liquid to solid and is one of the common preservation methods used for food materials. Decreasing the temperature reduces the activity of microorganisms and enzyme systems, preventing food spoilage. Additionally, the crystallization of water due to freezing reduces the water content in the liquid phase within the food material, thereby inhibiting microbial growth and secondary enzymatic activity. The freezing process occurs gradually from the surface to the core of the material. During the initial stages of freezing, a precooling phase takes place, during which the material's temperature is lowered from its initial temperature to its freezing point. During this stage, all the water content remains in the liquid state. Following the precooling phase, a phase change occurs, leading to the formation of ice crystals (Setyawan, 2017).

One of the considerations in selecting a freezing process in the frozen food industry is freezing rate. The freezing rate not only determines the final structure of the frozen product but also affects the overall time required. The freezing rate of a food mass is the ratio between the minimal distance between the surface and the thermal center compared to the time required for the food product to reach a temperature of 0°C on the surface and -5°C at the thermal center. An alternative definition is the thermal arrest time (TAR), which measures the time required for the slowest freezing point of the product to decrease from 0°C to -5°C. The freezing rate, in this case, measures the time needed for the product's temperature at the slowest point to become cold or frozen, calculated from the point at which the initial freezing point is reached until the desired temperature below the freezing point is achieved for that product (Setyawan, 2017).

The freezing rate can be adjusted and significantly influences the properties and quality of the resulting frozen product. The characteristics of a product resulting from rapid freezing are markedly different from those resulting from slow freezing. Rapid freezing results in small, evenly distributed ice crystals within the tissue, whereas slow freezing leads to the formation of larger ice crystals distributed in the intercellular spaces with larger pore sizes. Rapid freezing is generally considered advantageous in terms of production speed, as long as the resulting product quality is not compromised. Freezing rates can be categorized as slow freezing, with freezing times of 30 minutes or more for a 1 cm-thick material, medium freezing with freezing times of 20-30 minutes or more for a 1 cm-thick material, and fast freezing, where freezing times are less than 20 minutes for a 1 cm-thick material (Setyawan, 2017).

Freezing treatments can be applied to mixed products made from various vegetables, ready to be used for producing frozen vegetables. Proper storage and freezing are essential to preserving the freshness of vegetables at harvest and maintaining their nutritional content and flavor as much as possible. Frozen food technology can offer a solution for extending the shelf life and durability of a product (Arif, 2023).

2.4 Color

Color is highly significant in the quality of food materials. The color or visual appearance is linked to the quality of the food. Testing and measurement of color aim to determine the influence of spices or other additive ingredients on color and to maintain the color of the material during its processing. Color determination in the food industry serves not only economic purposes but also brand quality and standardization. When a material deviates during processing, whether through heating or other processes, physical changes occur including alterations in color. In addition to being a quality-determining factor, color can also serve as an indicator of freshness or ripeness. It also plays a role in determining the efficacy of mixing (Rustam et al., 2018).

A colorimeter, or color reader, is used to measure color. This instrument is sensitive to the measured light and the amount of color absorbed by an object or substance. The colorimeter operates by determining color based on the blue, red, and green components of the light absorbed by the object or sample, which is then reflected by the medium, leading to a reduction in the amount of light. This color measurement device works based on the Beer-Lambert law, which states that the light absorption transmitted through a medium is directly proportional to the concentration of the medium. The color standards used are based on the hunter L, a, and b scales, where L represents lightness (range 0-100; larger values indicate greater lightness), the letter a represents red or green color (range (-128)-127; + denotes more red; - denotes more green), and the letter b represents yellow or blue color (range (-128)-127; + denotes more yellow; - denotes more blue) (Rustam et al., 2018).

3. METHODOLOGY

3.1 Time and Location

Laboratory Experiment on Agricultural Commodity Processing (Frozen Vegetables) was conducted on Friday, June 9th, 2023, at 3:00 PM WITA, located in the Processing Laboratory, Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, Makassar.

3.4 Tools and Materials

The equipment used in the Laboratory Experiment on Agricultural Commodity Processing (Frozen Vegetables) included a water bath, beaker glass, knife, ruler, colorimeter, penetrometer, and a mobile phone camera.

The materials used in the Laboratory Experiment on Agricultural Commodity Processing (Frozen Vegetables) consisted of carrots, tissues, and zip lock plastic bags.

3.5 Working Procedure

The procedure for this laboratory work is as follows:

a. Day 0

1. Prepare the equipment and materials.
2. Cut the carrots into dice shapes with dimensions of 1 x 1 x 1 cm.
3. Weigh a sample of 5 grams.
4. Fill a beaker with distilled water up to the same level as the water in the water bath.
5. Measure the temperature of the water in the beaker until it reaches 70°C.
6. Place the weighed sample into the water bath for 30 seconds.
7. Remove the sample and allow it to drain until all the surface water is dried.
8. Cool the sample to room temperature.
9. Measure the Lab color and texture before any storage is conducted.
10. Place the sample into a plastic zip lock bag and store it at freezing temperature (-18°C) for 3 days.
11. Repeat steps 1–10 with a blanching temperature of 90°C.
12. Prepare a batch of control samples (without blanching) stored at room temperature for 3 days.

b. Day 3

1. Retrieve the samples stored at freezing temperature and the samples stored at room temperature.
2. Prepare the colorimeter and penetrometer.
3. Measure the color and texture of each sample.
4. Record the color and texture results for each sample.

3.5. Formula used

The formulas used in the Agricultural Commodity Processing Laboratory (Frozen Vegetables) are as follows:

$$\Delta E = \sqrt{(L_0\text{-}L)^2+(a_0\text{-}a))^2+(b_0\text{-}b)^2}$$

Description:

ΔE : total color difference,

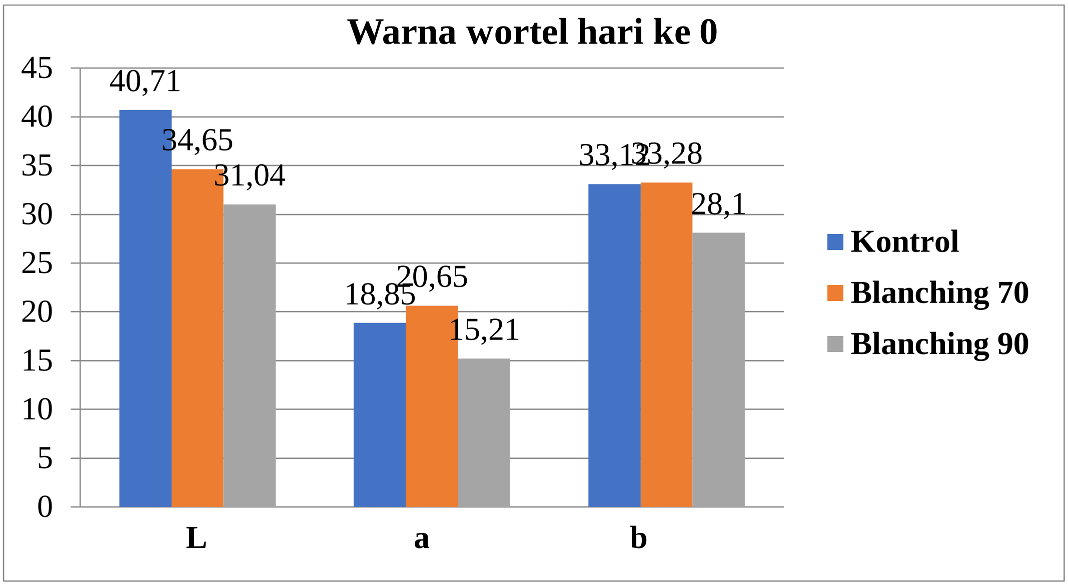
L* : *lightness components,*

a*, b* : *chromatics components*

4. RESULT AND DISCUSSION

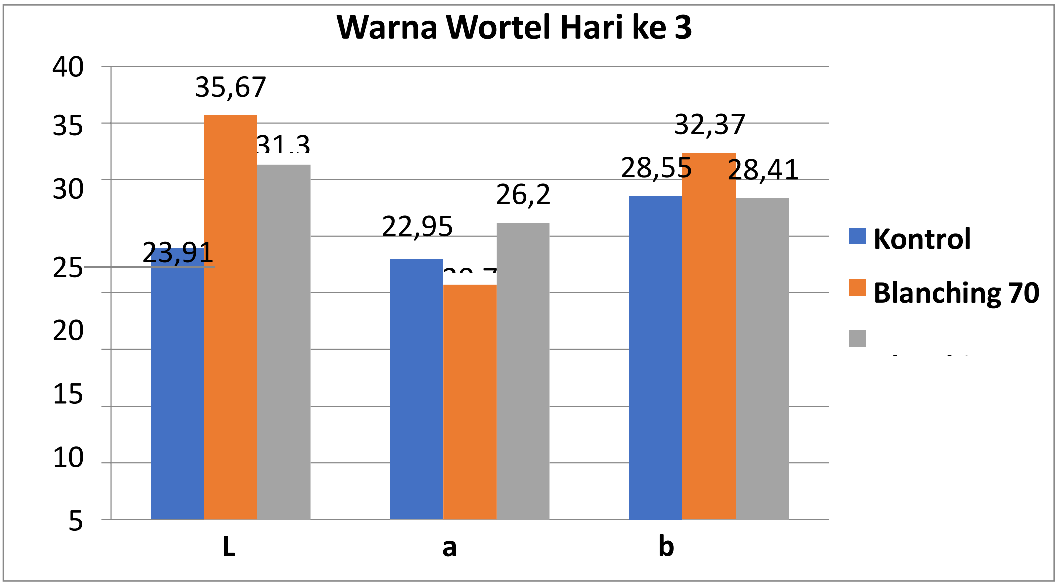
4.1 Result

4.1.1 Color of Sample on Day 0 and Day 3



Picture 43. Color Diagram of Carrots on Day 0.

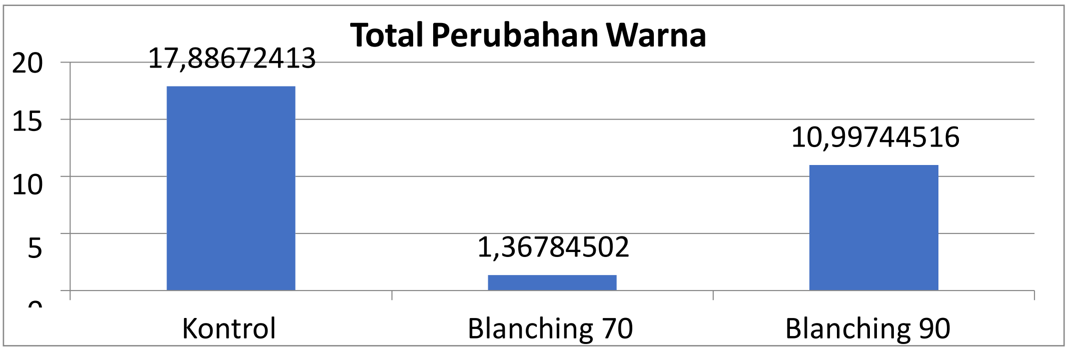
Based on the Agricultural Product Processing (Frozen Vegetables) lab experiment, it can be observed that there are color changes in the carrot samples on day 0, both with blanching processes at 70°C and 90°C, as well as without blanching. The most prominent result seen in the carrot samples is the color change, and among the three processes applied to the samples, the blanching process at 70°C on the carrot samples exhibited the most notable color improvement. This is due to the blanching process enhancing color, texture, taste, and other attributes. The L value in the carrot samples on day 0, where the concentration level increases, indicates that the unblanched carrot samples have a high brightness level of up to 100%. This aligns with the statement by Pujimulyani (2020), stating that an effective blanching temperature typically ranges from around 70°C to 95°C for 1 to 10 minutes.



Gambar 44. Diagram Warna Wortel Hari ke 3.

Based on the results obtained from the above diagram, color changes can be observed over time. The outcomes of the color change process with different treatments on the carrot samples indicate that the color of the samples before and after blanching has evolved with time. The results reveal that the color intensifies as time progresses, particularly in the process prior to blanching. Among the carrot samples, the ones subjected to blanching at 70°C exhibit the most favorable color. This can be attributed to various factors influencing the color enhancement process, including the condition imposed on the samples, such as blanching. The blanching process has been shown to enhance or improve the color of the samples compared to those without blanching, which may exhibit a slightly reddish hue. The L value of the carrot samples on day 3 has decreased, indicating a decline in concentration level, resulting in a pale orange color. As the intensity of dark color increases in a sample, the L value of the carrot samples decreases. This aligns with the statement by Rustam et al. (2018), which explains that the color standards are based on the hunter L, a, and b scales. In this scale, L represents lightness (range 0-100: higher values indicate greater lightness), the letter a represents red or green color (range (-128)-127; + denotes more red; - denotes more green), and the letter b represents yellow or blue color (range (-128)-127; + denotes more yellow; - denotes more blue).

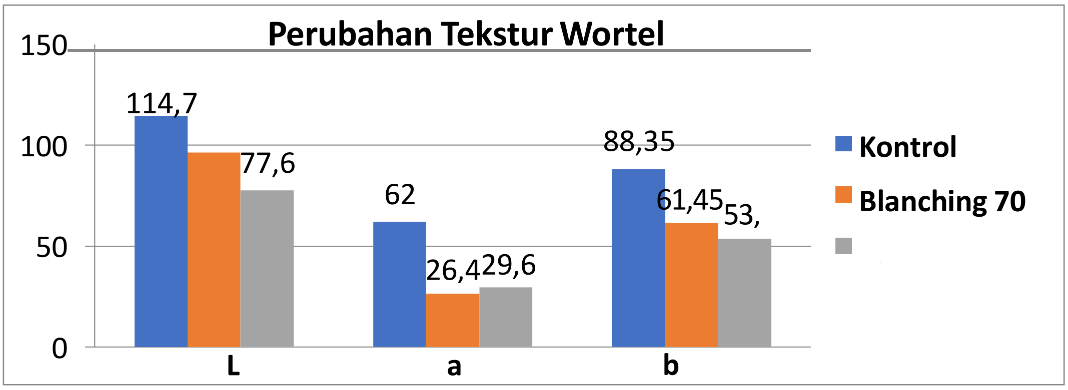
4.1.1 Total Perubahan Warna



Picture 45. Total Perubahan Warna pada Sampel Wortel.

Based on the Agricultural Product Processing (Frozen Vegetables) lab experiment, the total color changes that occur in carrot samples under different treatments can be determined. The results obtained from the overall color change process in carrot samples reveal that the highest or maximum color enhancement occurs in the samples without blanching or freezing. This indicates that the process of not blanching the carrots will preserve the color of the carrots, but they will be more prone to damage without blanching and freezing, leading to factors such as nutrient loss or accelerated respiration. This is in line with the statement by Arif (2023), highlighting that a key advantage of food freezing techniques is the preservation of food quality, including nutritional value and organoleptic properties.

4.2 Tekstur



Picture 46. Perubahan Tekstur pada Sampel Wortel.

Based on the results obtained from the texture change process in carrot samples, as depicted in the bar chart above, the most significant decrease in texture is observed in the third sample, which underwent blanching at 90°C. The carrot became more tender due to the blanching process carried out before freezing. This indicates that in order to achieve a soft and durable texture, it is advisable to perform blanching before the freezing process. This aligns with the statement by Gogus (2018), which suggests that blanching management for preservation is more intensive compared to regular cooking, resulting in nutrient loss, texture alteration, and color change.

4.3 Foto Sampel Selama Penyimpanan

Picture 47. Foto Wortel Perlakuan Kontrol Hari ke 0 dan ke 3.

Picture 48. Foto Wortel Perlakuan *Blanching* 70 ^{o}C Hari ke 0 dan ke 3.

Picture 49. Foto Wortel Perlakuan *Blanching* 90 ^{o}C Hari ke 0 dan ke 3.

Based on the obtained results, it is evident in the carrot samples with and without freezing processes. The outcomes indicate that the samples subjected to freezing appear fresher compared to those without undergoing the freezing process. For instance, in the carrot samples without additional treatments like blanching and freezing, the color slightly turns reddish or pale orange. This is due to the presence of microorganisms that lead to a decline in the sample's quality, including color, freshness, and other aspects. Freezing serves as an alternative used to inhibit or suppress metabolic processes in agricultural products, resulting in extended shelf life, improved quality, and other benefits. This aligns with the statement by Arif (2023), which highlights that frozen food technology can serve as a solution to prolong the shelf life and durability of a product. Frozen food technology involves preserving food by lowering its temperature below the freezing point of water.

5. CLOSURE

Based on the conducted Agricultural Product Processing (Frozen Vegetables) laboratory experiment, it is evident that blanching is a food processing technique involving a preliminary heating treatment. Blanching is utilized in various processes such as freezing, drying, and canning. Water, steam, or hot air is commonly used as the blanching medium, with temperatures adjusted accordingly. The appropriate temperature and duration of heating depend on the material and the blanching objective. An optimal blanching temperature is 70°C. In the case of carrot samples, it is observed that no blanching is suitable to achieve a vibrant color; however, this can lead to rapid spoilage of the food material. Conversely, blanching treatment extends the shelf life of the food material, albeit resulting in a less vibrant color. As for texture, not blanching can cause the carrot samples to become dry.

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ATTACHMENT

Attachment 1-5. Table of Results of Agricultural Commodity Processing Practicum (Frozen Vegetables).

Tabel 1-5. Warna Wortel Hari Ke-0 dan 3.

Jenis Sampel	Warna Hari 0			Warna Hari 3			Total Perubahan Warna
	L	a	b	L	a	b	
Kontrol	40,71	18,85	33,12	23,91	22,95	28,55	17,88672413
Blanching 70	34,65	20,65	33,28	35,67	20,7	32,37	1,36784502
Blanching 90	31,04	15,21	28,1	31,3	26,2	28,41	10,99744516

Tabel 1-5. Tekstur Wortel Hari Ke-0 dan 3.

Jenis Sampel	Tekstur hari 0	Tekstur hari 7	Rata-rata
	Kekerasan	Kekerasan	
Kontrol	114,7	62	88,35
Blanching 70	96,5	26,4	61,45
Blancing 90	77,6	29,6	53,6

Attachment 2-5. Dokumentation of Agricultural Commodity Processing Practicum (Frozen Vegetables).

Figure 50. Documentation of Cutting Carrots.

1. INTRODUCTION

1.1 Background

The development of food and nutrition science shows that vegetables other than contain component substance nutrition Also contain substance non nutrition Which very useful for health in the form of dietary fiber. Vegetables are a source of fiber main And source antioxidants experience as well as Lots contain vitamin And mineral. There is a tendency for consumers to like food products that are practical, natural, cheap. has a high organoleptic quality and has characteristic functional. Product frozen Ready serve Which bragged in study This intended to meet consumer demands. Cooling technique and freezing is one of the oldest methods of preservation on which it is based on the removal of heat from the material. Cooling technique (refrigeration) refers on reduction process temperature product who does not reach point its frozen Which it means during process cooling.

In principle, freezing food is to reduce the temperature of the product to in lower point frozen, Which aim For hinder growth microorganisms and slow down the activity of enzymes and chemical reactions in food consequence temperature Which very low. Technology freezing moment This Keep going expand which allows the product to freeze rapidly. Besides it is with fast freezing, prevention of microbial growth is also faster and the activity of the enzyme is quickly stopped which is thus, damage toproduct can minimized. Freezing on material food Also will provide various benefits in the storage of food products, especially for industry food, for example For hinder decline rate nutrition, hinder growth microorganisms destroyer food And even on some food products.

Based on description in on so need done practice Processing Agricultural Commodities (*Frozen Vegetables*) to understand which method used in processing product vegetable And fruit, understand principle basefrom method *blanching* And freezing material food as well as change characteristics material after treatment *blanching* .

1.2 Objective And Utility

The purpose of doing practicum processing of Agricultural Commodities (*Frozen vegetables*) understand process processing product vegetables frozen, understand principle base *blanching* as *pre-treatment,* understand principle base from freezing storage and evaluating changes in the physical characteristics of materials during storage with treatment *blanching.*

As for the usefulness of the practice of Processing Agricultural Commodities (*Frozen Vegetables*) which can be applied to the quality improvement process results agriculture with process freezing Which applied on the machine agriculture.

LITERATURE REVIEW

2.1 Carrot

Carrots come from temperate climates, namely subtropics. Carrots are Vegetables are a source of vitamins A, B and C which are easy to find. Lots of carrots contains high vitamin A. Vitamin A in carrots is very easily oxidized by air and destroyed when heated to high temperatures by air and ray. The carotenoid pigments in carrots are highly unsaturated, easy natural compounds unraveled by oxidation And warmup. Vegetable And fruit Which colored yellowReddish contains a lot of β-carotene, one of which is in vegetables carrot (*Daucus carota* , L). Carrots include root vegetables which are known as sources vitamins and antioxidants, where carrots are one type of vegetable own color orange (Effendi et al., 2022).

2.2 Blanching

Blanching can interpreted as Wrong One technique Which often used For keep something material food on period time Which long. Method *blanching*the will guard quality from material agar food still fresh, yet notdamage substance enzyme Which contained in material food. *Blanching* caninterpreted as something process boiling vegetables in a manner short Which WhereFor maintain texture And the color. Generally, process boiling*blanching* done around two until three minute. After boiled, vegetablessoaked in water ice For stop process ripening. *Blanching*can applied in process storage vegetables home nor industry.Application technique This can stop activity enzymatic Which Can makerotten vegetables, even though they have been frozen (Khaerunnisya and Rahmawati, 2019) . *Blanching* is treatment warmup introduction on fruit And vegetables before done processing. Temperature And time that is 82-93 ^{O}C during 3 until5 minute. Objective *blanching* is maintain color, inactivate enzymereason change color And smell. There is two method *blanching* that is blanchingsteam And *blanching* boiled. Method b *lanching* boiled that is material entered toin water Which has boiling. Method This Enough efficient, However ownThe disadvantage is the loss of food components that are easily soluble in waterand heat-resistant materials. *Blanching* can also remove air fromfruit tissue, reducing the number of microbes and facilitating filling because the material becomes soft (Susan And Mohammed, 2019).

Blanching is a heating process that is given to something material Which aim For inactivate enzyme, soften network And reduce contamination microorganisms detrimental, so that obtained the quality of dried, canned and frozen products is of good quality. Long *blanching* depend on characteristic material, blanching 3 minute produce a better color *french fries* . Generally, the process of boiling *blanching* done around two until three minute. After boiled, vegetables soaked in ice water to stop the cooking process. *Blanching* It can be applied in both home and industrial vegetable storage processes. Application of this technique can stop the enzymatic activity that could make vegetables rotten, though already frozen (Widyasanti, 2019).

2.3 *Blanching* Thermal

Some food products require thermal processing at moderate temperatures For eliminate microorganisms pathogen And components other reason damage so that extend age save And security product. *Blanching* with a thermal process is used to inactivate the enzyme in food And For prevent reaction damage product. Process thermal is process preservation material food by using energy hot. Thermal processing is used to remove or reduce the amount microbes and decomposing enzymes. Thermal processing will be able to increase the shelf life a product. Thermal processes, known to several levels of heat or process thermal Which general used, among them that is *blanching* . There is a number of method Which used For do *blanching* that is with using hot water, steam, *microwave* and individual *quick blanching* . This matter This is done because heat can eliminate biological and microbiological activity unwanted food ingredients so that it can extend age save And can maintain quality material food (Lizio *et al* ., 2021).

2.4 *Blanching Non-* Thermal

Non-thermal blanching can be interpreted as a process of boiling vegetables by short For maintain texture And the color. Generally, processBlanching is done for about two to three minutes. After boiling, vegetables soaked in water ice For stop process ripening. The *blanching* method can be applied in the storage process home and industrial vegetables. Food preservation *non-* thermal is alternatives processing food traditional Which interesting For produce minimally processed food products. Non -thermal *blanching* methodis a method that uses a variety of *non* -thermal food preservation, processing pressure tall is preservation nonthermal Which has applied commercial. High pressure curing have weaknesses, i.e. limitations in inactivating bacterial spores, especially endospores under conditionsacidity low. Preservation thermal is Wrong One method For increase storability like canning (Ribak *et al* ., 2022).

2.5 Freezing

Technology freezing food or known with designation *frozen food technology* is one way to extend the shelf life and durability of something product with method lower temperature until in lower point frozen water. Decreasing temperatures and disappearance of water availability will hinder Microorganism growth and enzyme activity in food products can cause food to be more durable and not easy to rot. This freezing technique can maintain the taste and nutritional value of an ingredient food. The advantage of the *frozen food technology technique* is the quality of the food like nutritional value (Arif and Nur'aini, 2023).

Freezing is a way of preserving food by means of Freeze ingredients at temperatures below the freezing point of the food. Freezing occurs during the process or state in which a liquid or gas changes into object congested consequence decline temperature. Freezing happen when temperature object reaches or falls below the freezing or solidification point, that is, the temperature at which substance the experience change phase become congested. Freezing can maintain flavor And mark nutrition material food Which more Good than method other, Because preservation with temperature low (freezing) can hinder activity microbe, prevent happening reactions chemistry And activity enzymes that can damage material food (Bimantara, 2018).

2.6 Rate Water And Color Material Food

Moisture content can be interpreted as the amount of water contained in the material expressed in percent form. Moisture content is one of the characteristics very important on material food. Rate water Also can influence appearance, texture and taste of food. Water content in the material Food also determines the freshness and durability of the food. Fruits and vegetables have a high water content, making them vulnerable against damage due to enzymatic and chemical reactions and microbial action, damage mechanical, influencing quality product fresh, resulted lost 40-50%. Problems the become problem Which must in finish in storage food. Color product food is component Which very important For determine quality or degrees reception something material food or product food. Besides That color can used as instruction about change chemistry on material food such as browning and caramelization reactions. The color on the fruit is usually measured in units L, a And b as standard international measurement color, by *Commission Internationale d'Eclairage* (CIE) (Nadhifah 2020).

Factor time have meaning important in *blanching* , It means with using the right time is expected to get good results. *Blanching* time that is too long will damage the material so it doesn't feasible to be processed whereas if it is too short the destructive enzymes that exist in material is not completely dead. The *blanching* process must match the characteristicsAnd considering the material (Nadhifah 2020).

2.7 Mark LaB

The color of a food during storage will change Which can influenced by condition storage. System color hunter lab own three attribute among them, that is mark L, a, And b. Mark L show the brightness of a sample (chromatic color, 0 = faint to 100 = bright). Red to green chromatic colors are indicated by a values (a = 0 to 100 for red, a = 0 to -80 for green). Blue chromatic color to yellow is indicated by the value of b (b= 0 to 70 for yellow, b= 0until -70 for blue) (Mirontoneng And Lenkey, 2020).

2.8 Colorimeter

Colorimeter can interpreted as tool Which used in colorimetry. Field science, say This generally refers on device Which measure absorbance at a certain wavelength of light by a specific solution. This device is commonly used to determine the concentration of a dissolved solution known in a given solution. *Colorimeter* serves to measure how much color is absorbed by an object based on on blue, red, and green. *Colorimeter* works with absorbs the light that passes through the medium and measures how much light which is reflected by mediums. *Colorimeter* will changed so that the user can analyze the concentration of a particular substance in the medium the. This device works on the basis of the Beer-Lambert law, which states that the absorption of light transmitted through the medium is directly proportional with medium concentration (Revelation *et al* ., 2018).

2.9 Penetrometer

Penetrometer can be interpreted as a hardness measuring tool used For detect level maturity on fruit fruit based on level violence, fruit Which Already ripe Of course just will own level violence more low compared to with fruit Which Still raw. In addition to ripeness, we can also measure the sweetness of the fruit with a measuring instrument fruit sweetness level. The maturity level of the fruit actually can known by looking at the color display, but please note that not all fruits can be known from their visual level of ripeness just, myself inside determine maturity fruit (Muhtaram and Charity, 2021).

3. METHODOLOGY

3.1 Time And Place

Practice Processing Commodity Results Agriculture (*Frozen vegetables*)held on Friday, 9 June 2023 o'clock 15.00 WITA take place in Laboratory *processing*, Program Studies Technique Agriculture, Department Technology Agriculture, Faculty Agriculture, Hasanuddin University, Macassar.

3.2 Tool And Material

Tool Which used on practice Processing Commodity Results Agriculture (*Frozen Vegetables*) namely *waterbath* , glass *breaker* , knife, ruler, *colorimeter* ,*penetrometer* and camera *handphone*

Material Which used on practice Processing Commodity ResultsAgriculture (*Frozen vegetables*) that is carrots, wipes And plastic *zip lock* .

3.3 Procedure Practice

As for procedure Work practice This is as following:

a. Day to 0

1. Prepare tool And material.
2. Cut carrot shape dice shape with size 1x 1x 1cm.
3. Weigh sample weighing 5 grams.
4. Enter *breaker* containing water *aquades* until threshold limit Which The same with water Which There is on *waterbath* .
5. Measure temperature water in in breaker until it reaches temperature 70 ℃
6. Enter sample Which has weighed to in *waterbath* during 30second
7. Lift sample And drain sample until whole water onsurface dry sample
8. Lower temperature sample until reach temperature room.
9. Measure color LaB And texture before done something storage
10. Enter sample to in plastic *zip lock* And keep sample ontemperature frozen (-18℃) during 3 day
11. Repeat step 1 – 10 with *blanching* temperature 90 ℃
12. Prepare *batch* sample control (without *blanching*) Which saved onroom temperature during 3 day.

b. Day to 3

1. Take sample Which has saved into the temperature frozen And samplein room.
2. Prepare tool *colorimeter* And *penetrometer.*
3. Measure color And texture on each sample.
4. Noted results color And texture on each sample.

3.4. Formula Which Used

As for formula Which used on practice Processing Commodity ResultsAgriculture (*Frozen Vegetables*) that is:

$$\Delta E = \sqrt{(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2}$$

information

ΔE : Total color difference

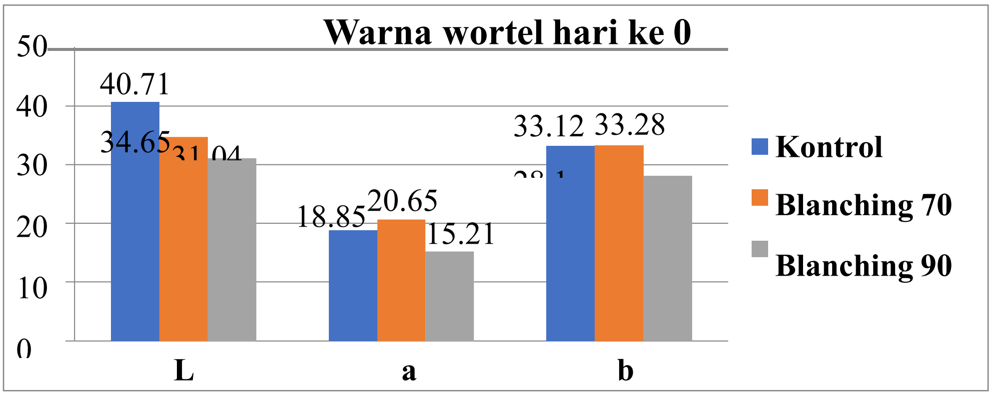
L* : *Lightness components*

a*, b* : *Chromatics components*

4. RESULTS AND DISCUSSIO

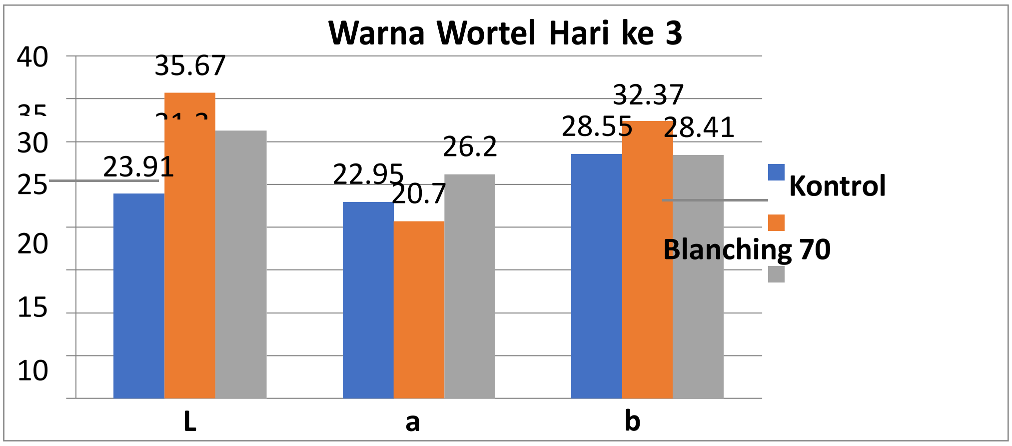
4.1 Results

4.1.1 Color Sample Day 0th and the 3rd



Picture 51. Diagram Color Carrot Day 0th.

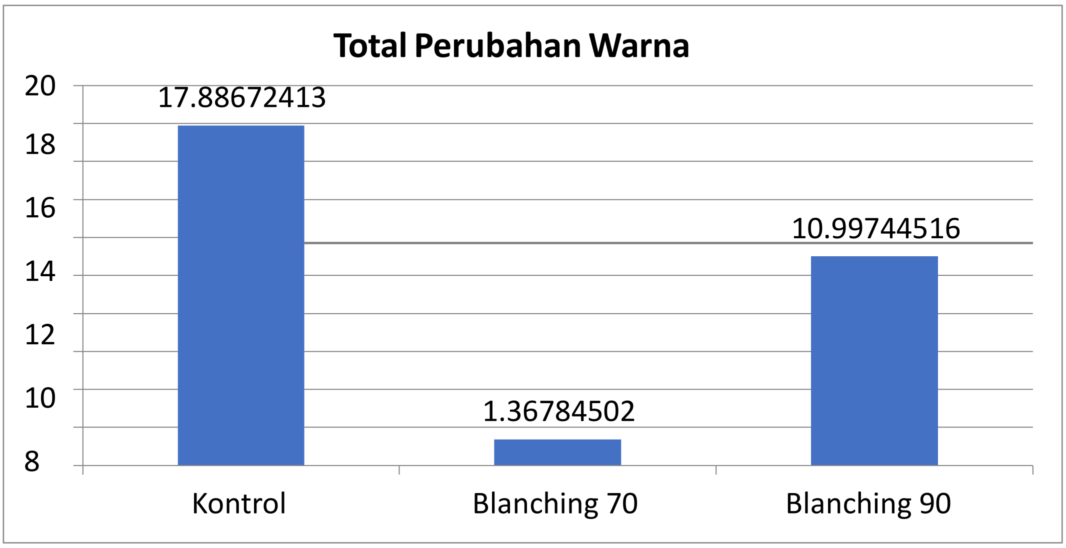
Based on practice Processing Commodity Results Agriculture (*Frozen Vegetables*) can be seen in the form of color changes in the carrot samples 0 in the *blanching process* with a temperature of 70 ^{o}C and 90 ^{o}C and without processing *blanching.* It can be seen that the color of the carrot sample is the brightest from the 3 processes the treatment given to the sample is in the *blanching process* with temperature 70 ^{o}C. This is because of the *blanching method* can maintain texture and the color of the forages. One of the factors that influence changes in material food the ie condition storage. Matter This in accordance with statement Mirontoneng and Lenkey (2020), that color from something material Food during storage will experience changes that can be affected by storage conditions.



Picture 52. Diagram Color Carrot Day to

Based on practice Processing Commodity Results Agriculture (*Frozen Vegetables*) can be seen as a result of a color change in the carrot sample on the 3rd day either with a *blanching process* with a temperature of 70 ^{o}C and 90 ^{o}C as well process without he did *blanching.* Results Which seen most go on in a manner significant in the sample with process *blanching* at 70 ^{o}C. This matter because by doing the *blanching process* will maintain the color and texture. This is in accordance with the statement of Khaerunnisya and Rahmawati (2019) , that *blanching can be interpreted as a process of* boiling vegetables by short Which Where For maintain texture And the color.

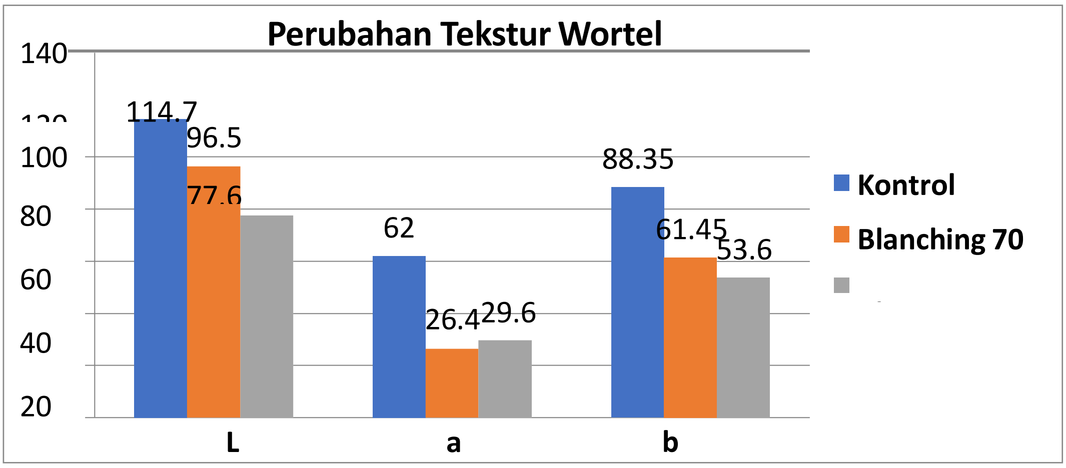
4.1.2 Total Change Color



Picture 53. Total Change Color on Sample Carrot.

Based on practice Processing Commodity Results Agriculture (*Frozen Vegetables*) can be known the total color change in the carrot sample with different treatment. The results obtained can be seen an increase color Which most tall There is on process without method *blanching* . Matter This because time has an important meaning in *blanching* . *Blanching* time too long will damage the material so that it is not feasible to be processed whereas if too short the destructive enzymes in the material have not died. This is appropriate with the statement, that the *blanching process* must be in accordance with the characteristics andconsider from material it (Nadhifah 2020).

4.2 Texture



Picture 54. Change Texture on Sample Carrot.

Based on practice Processing Commodity Results Agriculture (*Frozen Vegetables*) results obtained due to the process of changing the texture of the sample which shows a decrease in the third sample in the *blanching process*with a temperature of 90 ^{o} C. The texture of the *blanching sample* is lower than the sample control Because sample carrot experience soften moment treatment method *blanching* in which the sample is placed in a heated *beaker* use *waterbath* so that lost happen change texture on the sample. In contrast to the control treatment which was not carried out heating the sample before finally freezing it. This is in accordance with the statementsoft Susana and Muhamad (2019), that *blanching* can also eliminate air from the fruit tissue, reduce the number of microbes and facilitate charging Because the material becomes soft.

4.3 Photo Sample During Storage

Picture 55. Photo Carrot Treatment Day Control to 0 And the 3rd.

Picture 56. Photo Carrot Treatment *Blanching* 70 ^{o}C Day to 0 And the 3rd.

Picture 57. Photo of Carrots *Blanching Treatment* 90 ^{o}C Days 0 and 3.

Based on practice Processing Commodity Results Agriculture (*Frozenvegetables*) results Which obtained look on sample carrot with processfreezing And without freezing. Results Which obtained sample Which using the freezing process is better than the sample without freezing process. Freezing technique can maintain the taste and nutritional value something material food. Superiority from technique freezing is quality fromfood such as nutritional value such as food ingredients are more durable and fresh. The carrot samples that used the *blanching treatment* did not rot either moldy Because material Which use technique This will spared from decay and can also reduce the water content of the material so that it is more durable. Matter This in accordance with statement Wise And Nur'aini (2023), that decreasing temperature and disappearance of water availability will hamper Microorganism growth and enzyme activity in food products can cause food become more durable And No easy rot.

5. CLOSURE

Conclusion from practice Processing Commodity Results Agriculture (*Frozen vegetables*) Which has done can is known, that *blanching* can interpreted as a process of boiling vegetables in brief wich one For maintain texture And the color. Generally, process boiling *blanching* done around two until three minute. Process ripening requires a temperature range of 70-90 °C for a few minutes. Both treatments on carrot samples with the *blanching method* or without *blanching* the results best For color And texture ie with treatment *blanching* Because *blanching* can inactivate enzyme, soften network And reduce contamination of harmful microorganisms, so that product quality is obtained with good quality. *Blanching* too Can remove air from network fruits, reduce microbial count and make it easy charging due material to be soft

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ATTACHMENT

ATTACHMENT 22. Table of Results of Calculation Processing Practicum Commodity Results Agriculture (*Frozen Vegetables*).

Table 35. Carrot Color of the Day 0th And 3.

Type Sample	Color Day 0			Day Color 3			Total ChangeColor
	L	a	b	L	a	b	
Control	40,71	18.85	33,12	23.91	22.95	28.55	17.88672413
Blanching 70	34.65	20.65	33,28	35,67	20,7	32,37	1.36784502
Blanching 90	31.04	15,21	28,1	31,3	26,2	28,41	10.99744516

Table 36. Texture Carrot Day 0 and 3.

Type Sample	Texture day 0th	Texture day the 3rd	Average
	Violence	Violence	
Control	114.7	62	88.35
Blanching 70	96.5	26,4	61.45
Blanching 90	77,6	29,6	53,6

Attachment 23. Documentation Practice Processing Commodity Results Agriculture (*Frozen Vegetables*).

Picture 58. Documentation Processing Practicum Commodity Results Agriculture (*Frozen Vegetables*).

1. INTRODUCTION

1.1 Background

Processing of agricultural commodities, such as *frozen vegetables* as part integral from agricultural sector. this commodity involves a series of activities to maintain the quality, shelf-life and nutritional value of agricultural raw materials by processing them into frozen products. Processing *frozen vegetables* starting from the selection of fresh and high-quality raw materials, such as green vegetables, beans, corn and also carrots. After harvesting, vegetablesare quickly processed to maintain their quality, by cutting, wash, blanching, And freeze it with fast in temperature low. The process aims to maintain the nutritional content, taste, color and texture optimum vegetables.

Processing commodity *frozen vegetables* give Lots benefit in field agriculture. First, with process vegetables become product frozen, farmers can overcome the problem of limited harvest season. They got save the rest of the crop for use in another season, so it doesn't There is excess supply Which wasted. Besides That, processing frozen Also enabling farmers to expand their market. Frozen products have age save Which more long than vegetables fresh, so that can distributed to more remote location.

Linkage of processing of agricultural commodities (*frozen vegetables*) with Agriculture also involves the management and utilization of natural resources in a manner sustainable. *frozen vegetables* in process processing commodity important For minimize waste And waste as well as optimizing use of water, energy and raw materials. In addition, commodity processing results agriculture like *frozen vegetables* also can provide value-added on product agriculture as well as increase power hold the product agriculture

Based on the description above, it is necessary to do processing practicum Agricultural Product Commodities (*Frozen Vegetables*) in order to understand the method used in the processing of vegetable and fruit products or agricultural products andunderstand principle Which underlying storage product freezing agriculture.

1.2 Objective And Utility

The purpose of doing practicum processing of Agricultural Commodities (*Frozen Vegetables*) namely understanding the process of processing frozen vegetable products, understanding principle base *blanching* as *pre-treatment*, understand principle base from freezing storage and evaluating changes in the physical characteristics of materials during storage with treatment *blanching.*

As for the usefulness of the practice of Processing Agricultural Commodities (*Frozen Vegetables*) which can be applied to the quality improvement process results agriculture with process freezing Which applied on machine agriculture.

2. REVIEW REFERENCES

2. 1 Processing Results Agriculture

Processing results agriculture can form processing simple like cleaning, selection (*grading*), packing or processing Which more advanced, like milling (*milling*), siege (*powdering*), extraction And distillery (*extraction*), frying (*roasting*), spinning (*spinning*), canning (*canning*) And process manufacturing other. Processing as an operation or series of operations on a raw material for changed shape And or composition. Processing results agriculture has the characteristics of being able to increase added value, produce productsthat can be marketed or consumed, increase competitiveness and add value income and farmer profits (Purwanto, 2019).

Processing food with high temperature, namely the processing carried out by heating above normal temperature or room temperature, for example *blanching* , pasteurization and sterilization. In contrast, food processing at low temperatures, that is processing or preservation Which done on temperature in lower temperaturenormal (room temperature), for example refrigeration and freezing. Food processing which aims to change the chemical composition of raw materials into materials food Which own composition in accordance with Which desired can done with method fermentation. There is Also processing food with methodtechnological applications using both physical and chemical principles, for example extrusion, making bread (*bread vacuum fry* And *freeze dry*). Matter Which need Before carrying out the processing process, namely the chemical composition of the material food. Besides that, factor that needs attention before carrying out the process processing that is cleanliness material, condition sanitation as well as use material addition Which in accordance with regulation security food (Utami *et al* ., 2019).

2. 2 Freezing

Freezing as a process of reducing the temperature of food ingredients to a point freeze and turn some of the water into ice or steam. Freezing is also interpreted as process taking or transfer hot from something material food. Based on method freezing can shared become two method that is fast freeze and slow freeze. Freezing time must be observed in process freezing Because can affect formation crystal icewhich is large in size which when melted can make it decrease food quality. Slow freezing produces crystals of the same size the big one. Slow freezing as freezing with *thermal arrest time* more from 2 O'clock in freeze sample. Freezing fast If time freezing not enough from 20 minute For freeze 1 cm material food Fast freezing produces small crystals in the tissue. If melted again, the melted crystals are reabsorbed by the material and only a number small ones get away as *drip* (Tatontos *et al* ., 2019).

Storage product frozen as Wrong One factor Which determine frozen food quality. Frozen product storage in Europe, at -20°F(-29°C) can maintain the quality of frozen products during storage. However, Traditionally frozen storage is carried out at 14°F (-10°C) and or 0°F (-18°C). Frozen storage at ambient temperature -18°C and below may prevent microbiological damage, provided that temperature fluctuations do not occursomething too big. In addition, the relative humidity is just right too become factor important in storage material food frozen, Where Humidity that is too low can cause moisture lossproduct and result in reduced quality. Hence, surveillance humidity conditions in the storage room is a major concern in guard quality frozen product (Amiarsi & Mulyawanti, 2013).

During the freezing process, food loses water and components Which dissolved Which There is in in network And organ, so that it can affect various chemical and biochemical reactions in cells. Loss of water during the freezing process can also result in changes network structure, such as crystal formation. In addition, the freezing process as well affect the activity of enzymes and microorganisms in foodstuffs, which may affect the nutritional quality and color of frozen products. Therefore, fast and precise freezing techniques such as *flash* freezing minimize damage moment process freezing (Amiarsi & Mulyawanti, 2013).

2. 3 ***Blanching***

Blanching as a heating process given to a material Which aim For inactivate enzyme, soften network And reduce contamination microorganisms detrimental, so obtained the quality of dried, canned and frozen products is of good quality. Long *blanching* depend on characteristic material, *blanching* 3 minute produce color brown Which more Good, However generally *blanching* need temperature range 75-95 ^{o} C during 1 until 10 minute. Method The most commonly used *blanching is blanching* with hot steam (*steam blanching*) and with hot water (*hot water blanching*). *Blanching* process can affect the nutritional value of the material, damage to some nutrients occurs in the process *blanching* . The boiling method can cause up to 40% loss of minerals and vitamin, 35% sugar And 20% proteins. Process *blanching* Which involveShort heating of food can also reduce enzyme activity which can affect nutritional quality. Loss of nutrients such as minerals, vitamins, sugars and proteins during *blanching* occur due to some of these substances can late in water or unraveled consequence exposure hot. By Because That, using the right time and temperature in the process of *blanching* food very important For minimize loss nutrition And maintain quality material which food processed (Amina & Hersoelistyorini, 2019).

Thermal *blanching* as a treatment process the usual short heat used in processing material. Process This involve warmup material food in water boiling or steam hot during period time certain, Then quick steamed or dipped in water cold or ice For stop process warmup. *Blanching* thermal own a number of objective in food processing. One is to turn off the enzyme may change the taste, color or texture of food when stored or processed Furthermore. In addition, thermal *blanching* is also used to reduce the load microbe on food, maintain color experience, as well as make it easy peeling of the skin on some types of foodstuffs such as tomatoes or beans. The applied thermal *blanching* time may vary depending on the type material food Which processed. Usually, *blanching* can done during a number of second until a number of minute, depends on size, texture And need treatment thermal Which needed For material food certain. Thermal *blanching* is a common first step in the process processing food, especially before food packaged, dried, or preserved. treat *blanching* thermal on food can be prepared with Good For steps processing material food And maintain quality during storage (Wuladari & Astuti, 2022)

Process *blanching* including to in process thermal And generally requires a temperature range of 75-95 ˚C. *Blanching* aims to inactivate enzymes that allow changes in the color, texture and taste of foodstuffs. *Blanching* time affects water content, yield, total acid and vitamin C decrease However cause brightness or color increase. Dryingwith a temperature of 70 ^{o}C causes a smaller yield and water content, however causes a brighter color, total acid, and more vitamin C compared to drying at 60 ^{o}C. The duration of the *blanching process* as well influence characteristics nutrition And quality product end, Where long Longer *blanching can cause a decrease in water content*, *yield*,total acid and vitamin C, but increases the brightness or intensity of the color product. In addition, drying with a higher temperature, such as at temperature 70 ˚C, can produce products with lower yields and levels smaller water, but a brighter color and total acid content and higher vitamin C compared to drying at a lower temperature more low, for example 60 ˚C (Permana *et al* ., 2021).

Factors Which must considered in process *blanching* ona material including the properties of materials and pigments, especially conductivity thermal which can be determined by type, variety nor at the level maturity. In addition, other influencing factors are size and shape food products to be processed as well as heating methods and media temperatures for*blanching* . Based on these factors, each material has a process *blanching* as well as combination temperature And time *blanching* Which different. Because if condition *under blanching* (*blanching* Which too fast) Which can stimulate activity enzyme Which more tall compared material without process *blanching* And if condition *over blanching* (process excessive) can cause lost scent, color, vitamin And mineral from material. So that determination time, temperature And *blanching* Which appropriate need done, Because every material own characteristic Which different. Usually *blanching* done temperature 70 ^{o}C-100 ˚C And time 1-15 minute (Wuladari & Astuti, 2022).

2.4 *Colorimeter*

The colorimeter was developed under *the Commission Internationale de standardization l'Eclairage* (CIE), the international authority on light and color, as color objective tool quantification Which represent vision color man. *Colorimeter* , based on the standardization *of the Commission Internationale de l'Eclairage* (CIE), using a measurement system based on visual responsecolor man. *Colorimeter* can measure component color in formnumber Which can interpreted in a manner objective. Use *colorimeter* in analysis color very beneficial in various industry, including food, textile and cosmetic industries, where color reproduction is consistent become key in fulfil standard And preference consumer. Through *A colorimeter* can help ensure accurate and consistent measurements quality and color consistency in the resulting product. Deep *colorimeter* process control quality Also can used For compare color sample with standard Which set, so that make it easy identification difference and adjustments required (ly *et al* ., 2020).

2. 5 Penetrometer

Measurement use penetrometer started with enter needle penetrometer into the material network but does not penetrate the material, by applying pressure and a certain time interval. Depth measurement Penetrometer needle puncture done at three different points, and value The measurement results are then averaged to get the hardness value material. Measurement use penetrometer done For determine violence material based on depth puncture needle. Process measurement involve application pressure on needle penetrometer And time Whichdetermined before measurement done. Puncture on three point Which different And average it with measure depth, can obtained mark a more representative hardness of the material. In addition, measurements using a penetrometer requires the same level of consistency on pressure Which applied For get results Which consistent. Results consistent measurements at different points give an indication Which more accurate about violence the whole material (Shit *et al* ., 2023).

2.6 *Frozen Vegetables*

Frozen vegetables as a way of preserving agricultural products in the form of vegetables at low temperature. Freezing can be deadly some types of harmful microbes sometimes even up to more than 90%. Treatment freezing can done on a number of product mixture from some ready-to-use vegetables It's important to save And freezing moment produce vegetables frozen, so that freshness vegetablesat the time of harvest can be preserved as well as nutrition and taste can be maintained as much Possible. The properties possessed by these raw material vegetables, there is anticipationa very large impact on raw material suppliers to maintain quality on something product. Technology freezing food (*frozen food technology*) can extend age save And Power stand something product so that give convenience management stock And distribution (Wise & Nur'aini, 2023).

Frozen food technology as a technology to preserve food by lower the temperature until in lower point frozen water. decline temperature And disappearance availability water can hinder or slow down growth microorganisms And activity enzyme in in food products, causing food to be more durable and not easy rot. The advantage of the food freezing technique is the quality of the food like mark nutrition And characteristic organoleptic still awake. Besides That, technology Food freezing also allows food products to be stored insidelonger period of time without the need for the use of additional preservatives Which potentially damage quality food. Matter This make *frozen food technology* as an effective solution in maintaining the availability of a material food too reduce consequential loss damaged product (Wise & Nur'aini, 2023).

3. METHODOLOGY

3.1 Time And Place

Practice Processing Commodity Results Agriculture (*Frozen vegetables*) held on Friday, 9 June 2023 o'clock 15.00 WITA take place in Laboratory *processing,* Program Studies Technique Agriculture, Department Technology Agriculture, Faculty Agriculture, University Hasanuddin, Macassar.

3.2 Tool And Material

Tool Which used on practice Processing Commodity Results Agriculture (*Frozen Vegetables*) namely *waterbath* , glass *breaker* , knife, ruler, *colorimeter* ,*penetrometer* and camera *handphone.*

Material Which used on practice Processing Commodity Results Agriculture (*Frozen Vegetables*), namely carrots, tissue and plastic *zip lock* .

3.3 Procedure Practice

As for procedure Work practice This is as following:

a. Days to 0

1. Prepare tool And material.
2. Cut carrot shape dice with the size 1x1 x 1cm.
3. Weigh sample as heavy 5 grams.
4. Enter *breaker* containing water *aquades* until threshold limit Which The samewith existing water on *waterbath* .
5. Measure temperature water in in breaker until reach temperature 70 ℃
6. Enter sample Which has weighed to in *waterbath* during 30second
7. Lift sample And drain sample until whole water onsurface dry sample
8. Lower temperature sample until it reaches temperature room.
9. Measure color LaB And texture before done something storage
10. Enter sample to in plastic *zip lock* And keep sample ontemperature frozen (-18 ℃) during 3 days
11. Repeat step 1 – 10 with *blanching* temperature 90 ℃
12. Prepare *batch* sample control (without *blanching*) Which saved on temperature during space 3 days.

b. Days to 3

1. Take sample Which has saved into the temperature frozen And sample indoor.
2. Prepare tool *colorimeter* And *penetrometer.*
3. Measure color and texture on each sample.
4. noted results color And texture on each sample.

3.4. Formula Which Used

As for formula Which used on practice Processing Commodity ResultsAgriculture (*Frozen Vegetables*) namely:

$$\Delta E\_ = \sqrt{(L\,0\,\text{-}L)^2 + (\,a\,0\,\text{-}a\,)\,)^2 + (b\,0\,\text{-}b)^2}$$

information

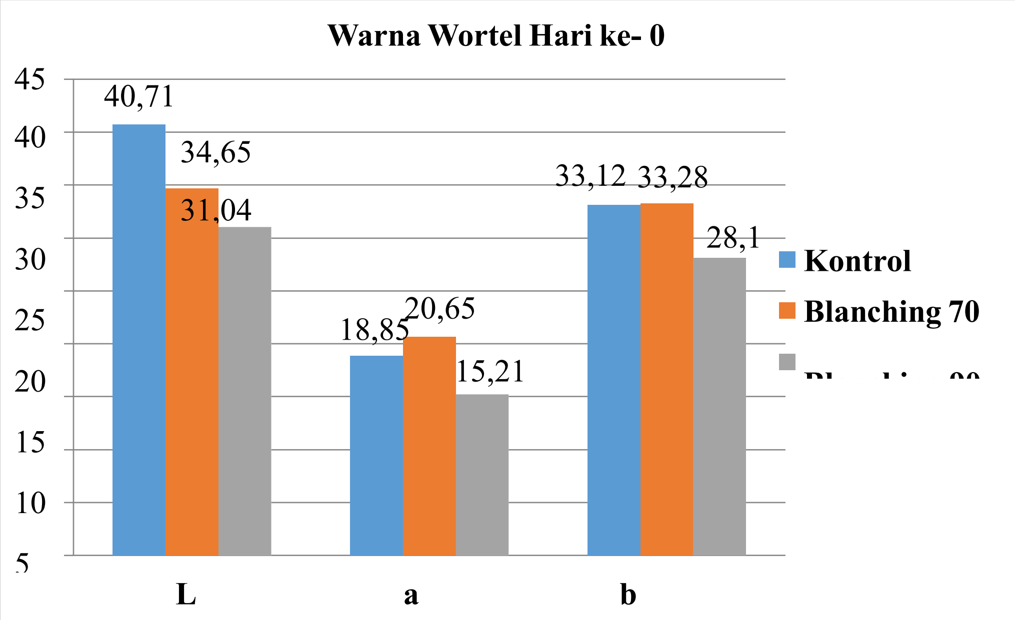
ΔE : Total color difference,

L* : *Lightness components,*

a*, b* :*Chromatics components.*

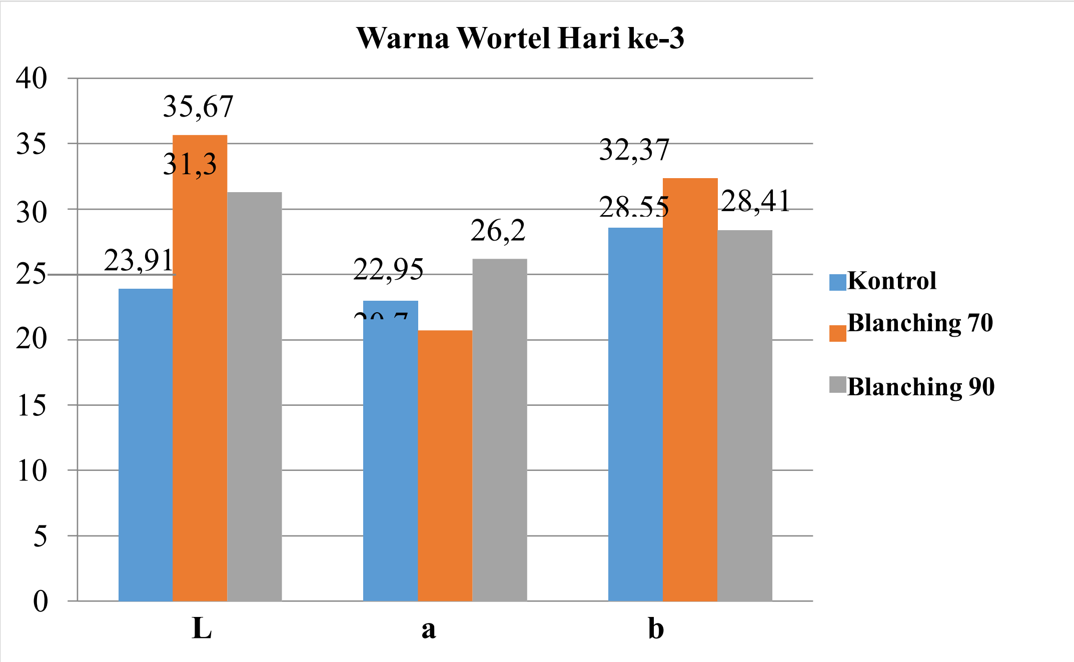
4. RESULTS AND DISCUSSION

4.1.1 Color Day Sample 0th and the 3rd



Picture 59. Diagram Carrot Color Day 0th.

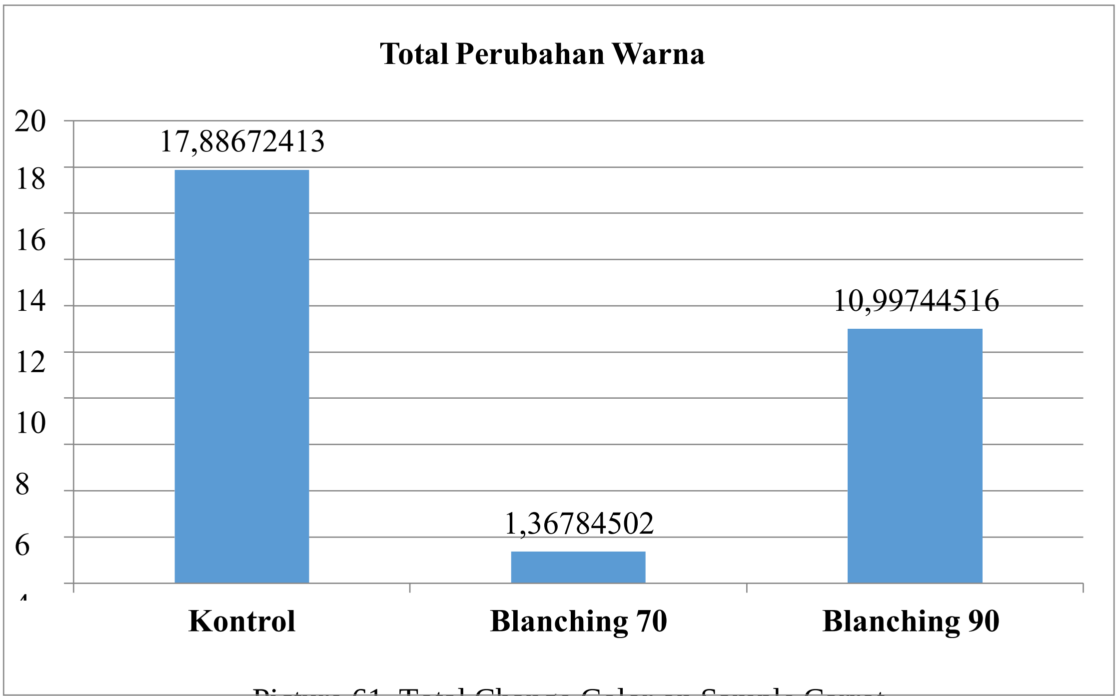
Based on Picture 1, the carrot color chart on day 0 shows the results in the form of carrot color with control (without treatment), *blanching process* with temperature of 70 ^{o}C and *blanching* at 90 ^{o}C where, the results of carrot color on day 0the one obtained with the highest score in the L diagram is the carrot that doesn't experience *blanching* with control (no treatment). It shows that color carrot on treatment control own level brightness Whichhigher than the samples that have undergone the blanching process at 70 °C and 90 °C. Increased brightness on control carrots can caused by a change in chemical composition or structure during the blanching process. Blanching processes at 70°C and 90°C are possible resulted change color Which more significant on sample carrot, causing a lower L value compared to the control. This matter according to the statement of Permana *et al* . (2021), long *blanching* causes water content, yield, total acid, and vitamin C decreased but caused brightness or color increase.



Picture 60. Diagram Color Carrot Day to 3.

Based on picture 2 of the carrot color chart on the 3rd day, the results were obtained in the form of carrot color with control (without treatment), *blanching process* with temperature of 70 ° C and *blanching* at 90 ° C where, the results of carrot color on day 0obtained with the highest value in the L diagram, namely by treatment *blanching* temperature 70 ° C. This shows that the color of the carrots in the treatment *a blanching* temperature of 70 °C has a high brightness level. Trend increase in brightness in carrots that were *blanched* at 70 °C This is due to the positive effect of the temperature on the color change on carrots. *Blanching* at 70 °C is more effective in maintaining original color of carrots and prevent unwanted changes. This is appropriate with the statement of Aminah & Hersoelistyorini (2019), which states that long *blanching* depend on characteristics material, *blanching* 3 minute produce color brown Which more Good, However generally *blanching*need temperature ranges from 75-95 ° C during 1 to 10 minute.

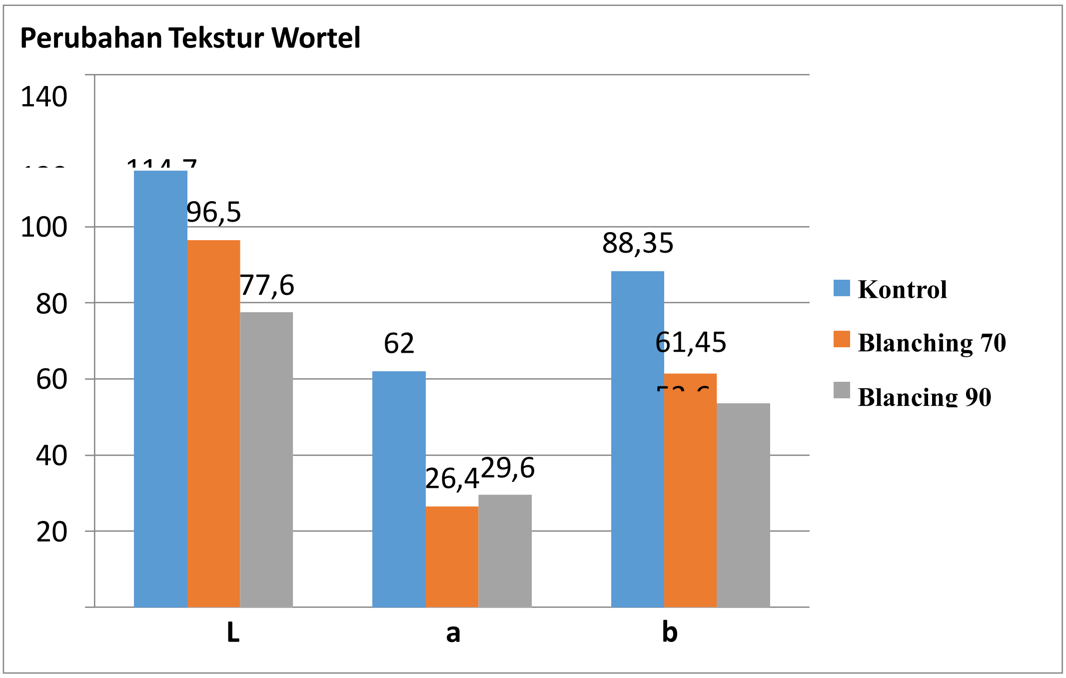
4.1.2 Total Change Color



Picture 61. Total Change Color on Sample Carrot.

Total change color Which obtained on practice Processing Commodity Results Agriculture (*Frozen vegetables*) use sample carrot i.e. the highest total color change results obtained, namely with control (without treatment). Matter the show that without exists treatment like *blanching* , the carrot samples experienced a change in color more significant. Change color Which tall on sample control can caused by factors such as enzymatic oxidation or chemical reactions happen during storage or processing. Condition This indicate exists change Which No wanted on quality color carrot. Matter Thisaccording to the statement of Amiarsi & Mulyawanti (2013), which states that during process freezing on material food happen lost water And components Which dissolved Which There is in in network And organ, so that can influence various reaction chemistry And biochemistry in in cell.

4.2 Texture



Picture 62. Change Texture on Sample Carrot.

Based on the graph of texture changes in the carrot samples obtained the results of the highest changes in carrot texture in the L diagram with control (without treatment). This shows that in the absence of such treatment blanching, carrots undergo more significant textural changes. Change high texture in the control sample could be caused by factors such as enzymatic activity or structural degradation during storage or processing. Condition This indicate exists change Which No wanted on texture quality of carrots. This is in accordance with the statement of Wulandari & Astuti (2022), Which state that usually, *blanching* can done duringa number of second until a number of minute, depends on size, texture, And need treatment thermal Which needed For material food certain.

4.3 Photo Sample During Storage

Picture 63. Photo Carrot Treatment Control Day to 0 And the 3rd.

Based on Picture 5, a photo of the control (without control) carrot day 0th And the 3rd seen that color on sample carrot Which generateddid not experience a significant change in color, where the carrot remained retains the orange color from day 0 to 3rd day, shows that the control treatment did not affect the carrot color visually range time the. Matter This show that in range time Accordingly, the control treatment did not have a significant impact on colorand the texture of carrots. However, to ensure more accurate results, analysis Furthermore, like quality testing and parameters measurement physique, can done. This is in accordance with the statement of Wulandari & Astuti (2022), which state that if condition *under blanching* (*blanching* Which too fast) which can stimulate higher enzyme activity compared to other materialswithout *blanching process* and if the condition *is over blanching* (excessive process) can cause lost scent, color, vitamin, And mineral of material.

Picture 64. Photo of Carrots *Blanching Treatment* 70 ^{o}C Days 0 and 3.

Based on picture 6 that is Photo carrot treatment *blanching* with temperature 70 ^{o}C on day 0th And the 3rd obtained results Which show change color carrot become more pale or seen A little more bright on day the 3rd compared to the initial condition (day 0). In addition, the texture of the carrots experiencing *blanching treatment* tends to be softer or slightly softer compared to carrots that were not subjected to this treatment. Change this can be due to the thermal effect produced by *blanching* , where high temperature for a certain period of time can affect the pigment and structure cell on carrot. Although thereby, change color And texture must be considered in the context of the overall quality of the carrot product after experience treatment *blanching* . Matter This in accordance with statement Permana *et al* . (2021), which states that drying with a temperature of 70 ^{o}C cause yield and rate that water more small, However cause brighter color, total acid, and more vitamin C in comparison drying with a temperature of 60 ^{o}C.

Picture 65. Photo Carrot Treatment *Blanching* 90 ^{o} C Day 0 and 3rd.

Based on Picture 7, a photo of carrots blanching *at* 90 ^{o} C on the 0th and 3rd day the carrot discoloration was obtained. On the 3rd day after *blanching* treatment , carrots tend to become paler or lighter compared to the initial condition (day 0). This is due to influence heat affects the carotenoid pigments in carrots. *Blanching* treatment on temperature 90 °C Also can influence texture carrot. Carrot Which experiencing *blanching* will become softer on the 3rd day. This matter occurs because the heat applied to carrots during *blanching* can damage themThe structure of cells and fibers in carrots reduces hardness. This is appropriate statement by Wulandari & Astuti (2021), which states that factors Which must considered in process *blanching* on something material Among them are the properties of materials and pigments, especially their thermal conductivity can determined based on type, varieties nor on level maturity.

5. CLOSURE

Based on from practice Processing Commodity Results Agriculture (*Frozen vegetables*) Which has done, so can concluded that process processing product vegetables frozen can done with method *blanching* as *pre - treatment* . *Blanching* is a short heating process for vegetables fresh before freezing. This process usually involves heating vegetables in water boiling or steam hot during a number of time certain. Principle base from storage freezing that is with lower temperature food product below the freezing point of water to slow down or stop activity of microorganisms and enzymes that can damage the product. Withlowering the temperature below the freezing point of water, microbial and enzyme activity in food products to be very limited or not active at all. After evaluate changes in the physical characteristics of materials during storage with The *blanching* treatment resulted in a significant change at both temperatures the. *Blanching* with a temperature of 70 ^{o}C, visible changes in color, texture, And relative scent smaller compared to with temperature 90 ^{o}C.

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ATTACHMENT

Attachment 21. Table of Calculation Results for Processing Practicum Agricultural Products Commodities (*Frozen Vegetables*).

Table 37. Color Carrot Day 0 And 3.

Type Sample	Color Day 0			Day Color 3			Total ChangeColor
	L	a	b	L	a	b	
Control	40,71	18.85	33,12	23.91	22.95	28.55	17.88672413
Blanching 70	34.65	20.65	33,28	35,67	20,7	32,37	1.36784502
Blanching 90	31.04	15,21	28,1	31,3	26,2	28,41	10.99744516

Table 38. Texture Carrot Day 0 and 3.

Type Sample	Texture day 0th	Texture day the 3rd	Average
	Violence	Violence	
Control	114.7	62	88.35
Blanching 70	96.5	26,4	61.45
Blanching 90	77,6	29,6	53,6

Attachment 22. Documentation of Product Commodity Processing Practicum Agriculture (*Frozen Vegetables*).

Picture 66. Documentation Measure Diameter Sample Carrots .