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Utilization of Jackfruit (*Artocarpus Heterophyllus*) Seeds as Raw Material for Vegetable Milk

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ABSTRACT: Efforts must be conducted to utilize all resources due to the rising vegetarian population, decreasing food supply, high cost of animal-based food sources, increasing lactose intolerant population, and health reasons. Therefore, this research aims to utilize jackfruit seeds as the ingredient of plant-based milk that is nutritious and liked by the panelists from its color, flavor, aroma, and mouthfeel through determining the exact temperature and pasteurization period during its making. This research uses the experimental methods with a factorial Randomized Block Design, in which the first factor is the pasteurization temperature (T1: 60°C, T2: 70°C, and T3: 80°C), and the second factor is the pasteurization period (L1: 1 minute; L2: 2 minutes, and L3: 3 minutes). Each treatment combination is repeated three times. The research shows that jackfruit seed milk using different temperature and pasteurization periods contains 2.32-3.25% protein, 1.02-1.18% fat, and 10.50-12.00°brix of total soluble solids. The overall result of the sensory test (color, flavor, aroma, mouthfeel) shows that the panelists like jackfruit seed milk. The utilization of jackfruit seeds in plant-based milk is one of the solutions to provide alternative beverages with nutrition contents similar to cow milk and reduce the dependency on soybean, whose price continues to rise.

KEYWORDS: Jackfruit Seeds, Pasteurization, Randomized Block Design, Utilize.

INTRODUCTION

By the year 2050, it is expected that most world's population will be vegetarian [1]. This prediction rises for reasons such as decreasing food supply, high resource and space requirements for the animal-based food source [2] [3], the increasing lactose tolerant people, and health reasons [4]. One of the efforts to face this circumstance is to manage and utilize affordable and accessible ingredients, such as jackfruit seeds. According to [5], every 100 grams of jackfruit seeds contains 165 calories, 4.2 grams of protein, 0.1 grams of fat, 36.7 grams of carbohydrate, 33 mg of calcium, 200 mg of iron, 1 mg of phosphorus, 0.2 mg of Vitamin B1, and 10 mg of Vitamin C.

Jackfruit is a tropical plant that is easy to grow, invulnerable to diseases and high temperature, invulnerable to drought, so it would still be available despite climate change [6], and able to produce 150 fruit from each tree [7]. Jackfruit is the favored tropical fruit due to its sweet flavor [8]. One whole jackfruit usually has 100-500 seeds, or about 8 to 15% of its edible part [9]. This large amount of seeds is usually utilized to be consumed using the process of boiling [10], roasting [11], making into chips [12], and made into flour [5] as an ingredient of various processed products. The jackfruit seed utilization that has not been produced yet is to be processed into milk.

Milk is a foodstuff needed by all people due to its benefit for growth and health [13]. The utilization of jackfruit seeds in plant-based milk is one of the efforts to complement new food sources and reduce the dependency on soy, whose price keeps increasing. This phenomenon happens because the most well-known plant-based milk by the people is soy milk. At the same time, plant-based milk could also be made from other plant-based ingredients such as mung beans, ground nut [14], adlay millet [15], Sweet Corn [16], and others, including the jackfruit seeds. Jackfruit seeds could be processed into milk due to the adequate starch content, higher calcium, and phosphorus content but lower fat content compared to soy [17].

Milk is one of the products that are nutritious and suitable growth medium for bacteria that are hazardous to humans [18]. Therefore, measures to avoid milk damage must be conducted, such as pasteurization [19] because this process is able to kill pathogen microbes and deactivate decomposing enzymes to lengthen its storage duration [20], stabilize product quality, and enhance taste and aroma [21]. Generally, pasteurization is conducted at a temperature less than 100 °C [22]. [23] stated that pasteurization could be influenced by the heating temperature and duration. According to [24], the pasteurization process on 63 °C for 30 minutes and 72 °C for 15 seconds could reduce the amount of *Brucella abortus*, *Campylobacter jejuni*, *E. coli*, *Coxiella*



¹ *burneti*, Patogenic *E. coli* (0157:H7), *L. monocytogenes*, *Mycobacterium tuberculosis*, *M. bovis*, *Salmonella enterica serotype*, *Streptococcus pyogenes*, and *Yersinia enterocolitica*. Based on those researches, this research aims to determine the suitable pasteurization temperature and duration in the making process of plant-based milk from jackfruit seeds.

METHODS

A. Ingredients and Tools

Ingredients required to make jackfruit seed milk are jackfruit seeds from one whole fruit, aquadest, and stevia sugar. Ingredients needed for physicochemical and sensory tests are liquid CuSO₄, liquid NaOH, concentrated H₂SO₄, CuSO₄ crystal, K₂SO₄ crystal, 0,1 N of HCl, 0,1 N of NaOH, NaOH 50%, 1% phenolphthalein indicator, jackfruit seed milk sample, and aquadest. Chemicals used are from Merck brand.

Tools used in the making process of jackfruit seed milk are the stirrer spoon, blender, filter, pan, stove, glass, measurement glass, bottle, basin, and stainless steel knife. Tools used for the physicochemical test are 50 ml buret (Pyrex), Soxhlet distillation and condenser flask (Pyrex), oven, 250 ml Erlenmeyer (Pyrex), measurement pipette (Pyrex) (5 ml, 10 ml, and 15 ml), 250 ml and 500 ml measurement flask (Pyrex), analytical scale, 100 ml, 250 ml, and 500 ml beaker glasses, clamp, stands, desiccator, Kjeldahl flask, destruction, and distillation tools, drop pipette, and refractometer.

B. Experiment Design

This research uses factorial Complete Randomized Design, which consisted of two factors in which each factor consisted of 3 levels, which resulted in 9 treatment combinations. Factor 1 is the pasteurization temperature (T1: 60°C, T2: 70°C, and T3: 80°C), and factor 2 is the pasteurization period (L1: 1 minute; L2: 2 minutes, and L3: 3 minutes). Each treatment is repeated three times.

C. Research Procedure

Steps in this research refer to the modified research of [15]: the jackfruit seeds are sorted and dipped in aquadest with the ratio of 1:4 between seeds and aquadest for 12 hours. The seeds were then rinsed, peeled to get their seed flesh, and washed. The skinless seed was then boiled in boiling water (100 °C) for 10 minutes before being filtered, scaled, and blended on speed 3 with water with the seed and water ratio of 1:3. Afterwards, the solution was then filtered by a cloth filter to achieve filtrate. The next step is pasteurization in accordance with the research treatment.

D. Observation Parameters

Observation conducted on each treatment is on protein content, fat content, TPT [25], and sensory test (color, flavor, aroma, and mouthfeel) using the Hedonic test [26] with a seven likeness scale (1: very dislike, 2: dislike, 3: rather dislike, 4: neutral, 5: rather like, 6: like 7: very like). There are 30 semi-trained panelists.

E. Data Analysis

Data from research and observation are subjected to analysis and test of variance (ANOVA) using the Statistic Product and Service Solution/SPSS version 26 [27]. If the analysis resulted in significant or really significant differences between treatments, the test continued to the Duncan test on the trust level of $\alpha = 95\%$. Sensor test data is analyzed based on the average value of the likeness level and continued with the Kruskal Wallis test to determine the existence of a difference between the treatment [28].

RESULT AND DISCUSSION

A. Chemical Test

1. Protein content

From the proximate analysis result, the average value of the protein content of the jackfruit seed milk ranges between 2.32-3.25% (Table 1), with the lowest value on the treatment of 80°C pasteurization temperature for 3 minutes (T3L3) and the highest value on the treatment of 60°C pasteurization temperature for 1 minute (T1L1). Based on the analysis of variance (ANOVA), treatments of temperature, pasteurization period, and inter-treatment interaction have no significant influence ($\alpha = 5\%$) on the protein content of the produced jackfruit seed milk.



Table 1 illustrates protein content of the jackfruit seed milk keeps decreasing along with the higher temperature and longer pasteurization period. At similar pasteurization temperatures with a different period, it is known that the longer pasteurization period equals lesser protein content from the milk. On similar pasteurization with a different temperature, the protein content would also be lesser. These findings are in accordance with the statement of [29] that the protein content is influenced by temperature and duration of cooking, including pasteurization. [30] added that the pasteurization's duration and temperature influence the protein denaturation level. Higher and longer pasteurization temperature and duration will lead to higher protein denaturation levels as well [31] because the heat could alter the protein structure and sever the bond between the amino acids. Generally, jackfruit seed milk, in this research, contains relatively higher protein compared to soy milk (min. 2.0%).

Table 1. The average value of protein and fat content (%) and total soluble solids/TPT (°brix) of the jackfruit seed milk at the different temperatures and duration of pasteurization

Treatment code	Treatment	Protein content (%)	Fat content (%)	TPT (°brix)
T1L1	Temperature of 60°C for 1 minute	3.25 ± 0.18	1.02 ± 0.21	10.50 ± 0.17
T1L2	Temperature of 60°C for 2 minutes	3.11 ± 0.14	1.10 ± 0.17	11.00 ± 0.20
T1L3	Temperature of 60°C for 3 minutes	2.98 ± 0.17	1.12 ± 0.12	11.50 ± 0.19
T2L1	Temperature of 70°C for 1 minute	3.02 ± 0.09	1.08 ± 0.09	11.00 ± 0.22
T2L2	Temperature of 70°C for 2 minutes	2.87 ± 0.11	1.13 ± 0.13	11.00 ± 0.17
T2L3	Temperature of 70°C for 3 minutes	2.79 ± 0.12	1.14 ± 0.24	11.50 ± 0.21
T3L1	Temperature of 80°C for 1 minute	2.81 ± 0.10	1.11 ± 0.11	11.50 ± 0.18
T3L2	Temperature of 80°C for 2 minutes	2.57 ± 0.08	1.16 ± 0.15	11.50 ± 0.25
T3L3	Temperature of 80°C for 3 minutes	2.32 ± 0.11	1.18 ± 0.12	12.00 ± 0.16

2. Fat content

The average fat content of jackfruit seed milk, as seen in Table 1, ranges around 1.02-1.18%, with the lowest value on the treatment of 60°C pasteurization temperature for 1 minute (T1L1) and the highest value on the treatment of 80°C pasteurization temperature for 3 minutes (T3L3). Generally, the higher and longer pasteurization temperature and duration, the milk's fat content tends to increase. Based on the analysis of variance (ANOVA), treatments of temperature, pasteurization period, and inter-treatment interaction have no significant influence ($\alpha= 5%$) on the fat content of the produced jackfruit seed milk.

This research result shows that the fat content of the jackfruit seed milk is a little bit higher than the fat content of the jackfruit seed as the ingredient. This finding is in accordance with the research result of [32], in which pasteurized milk has higher fat content compared to unpasteurized ones.

3. Total Soluble Solids (TPT)

The average TPT value of jackfruit seed milk, as seen in Table 1, ranges around 10.50-12.00°brix, with the lowest value on the treatment of 60°C pasteurization temperature for 1 minute (T1L1) and the highest value on the treatment of 80°C



pasteurization temperature for 3 minutes (T3L3). Generally, all TPT value results are almost similar, which is in accordance with the result of analysis of variance (ANOVA), in which treatments of temperature, pasteurization period, and inter-treatment interaction have no significant influence ($\alpha=5\%$) on the TPT of the produced jackfruit seed milk. Usually, TPT in milk is used to detect other ingredients [33], and the TPT value of jackfruit seed milk is not different from the TPT value of soy milk [34].

B. Sensory Test

1. Color

Color is the first impression that arises from the product. The judgment on color rises due to the radiation energy stimulation that falls into the eyes' retina, so food's color could increase acceptance of the consumer's likeness to a certain product [14].

The average value result of the likeness towards the color of jackfruit seed milk shows that different temperatures and duration of pasteurization on each treatment provide the likeness score between 5.41-5.78 (like), which means that the milk is liked by panelists, as shown in Table 2. This happened because the treatment provided by the jackfruit seed milk does not influence the color of the milk, so it is liked by the panelists. Based on the research of [35] on the limit of the color score of plant-based milk, this milk is heavily determined by its ingredient. Therefore, the color of the jackfruit seed milk has no different from regular milk.

Based on the analysis result of the Kruskal Wallis test, the p-value is $p = 0.01 < \alpha < 0.05$, which shows the insignificant difference in each treatment. This means different treatments of temperature and periods of pasteurization do not influence the panelists' acceptance level of the color variable of the jackfruit seed milk.

Table 2. Average scores of the sensory test of color, flavor, aroma, and mouthfeel of jackfruit seed milk

No.	Treatment code	Treatment	Color	Flavor	Aroma	Mouthfeel
1.	T1L1	Temperature of 60°C for 1 minute	5.55	4.51	5.28	5.15
2.	T1L2	Temperature of 60°C for 2 minutes	5.41	4.61	5.23	5.00
3.	T1L3	Temperature of 60°C for 3 minutes	5.65	4.85	5.35	5.12
4.	T2L1	Temperature of 70°C for 1 minute	5.55	4.68	5.13	5.56
5.	T2L2	Temperature of 70°C for 2 minutes	5.52	4.81	5.22	5.62
6.	T2L3	Temperature of 70°C for 3 minutes	5.67	5.11	5.19	5.67
7.	T3L1	Temperature of 80°C for 1 minute	5.45	5.41	5.25	5.57
8.	T3L2	Temperature of 80°C for 2 minutes	5.63	5.24	5.35	5.69
9.	T3L3	Temperature of 80°C for 3 minutes	5.78	5.62	5.42	5.71

2. Flavor

The flavor is the sensation formed by the mixture of ingredients and composition on a certain food product by the sense of taste because a product could be accepted by the consumer if it has the desired flavor. The sense of taste is sensitive to stimulating chemicals such as bitter, sour, salty, savory, and sweet [36].



The average value result of the likeness towards the flavor of jackfruit seed milk, as shown in Table 2, shows the likeness score between 4.51-5.62 (range of rather like to like). The milk's flavor is plain, just like other kinds of milk without additives. This is in accordance with the research of [36], which stated that milk's flavor is influenced by other additive ingredients.

Based on the analysis result of the Kruskal Wallis test, the p-value is $p = 0.01 < \alpha < 0.05$, which shows the insignificant difference in each treatment. This means different treatments of temperature and periods of pasteurization do not influence the panelists' acceptance level of the flavor variable of the jackfruit seed milk.

3. Aroma

Aroma is mentioned as the stimulation caused by certain foodstuff felt by the sense of smell. If the aroma is disliked, it would be rejected because aroma influences the consumer's likeness of the product so that it could be deemed as the main determiner factor [37].

The average value result of the likeness towards the aroma of jackfruit seed milk shows that different temperatures and duration of pasteurization on each treatment provide the likeness score between 5.13-5.42, which means that the milk is rather liked by panelists. The aroma produced by certain products is mainly based on their ingredients and has a stronger aroma [36]. Therefore, the milk has the aroma of jackfruit seed.

Based on the analysis result of the Kruskal Wallis test, the p-value is $p = 0.01 < \alpha < 0.05$, which shows the insignificant difference in each treatment. This means different treatments of temperature and periods of pasteurization do not influence the panelists' acceptance level of the aroma variable of the jackfruit seed milk.

4. Mouthfeel

Mouthfeel is the sensation felt by the tongue from the food product being consumed. The mouthfeel of food is heavily influenced by ingredients, processing methods, and storage conditions [38].

The average value result of the likeness towards the mouthfeel of jackfruit seed milk, as seen in Table 2, shows that different temperatures and duration of pasteurization on each treatment provide the likeness score between 5.00-5.71 (range of rather liked to liked by panelists). The most liked treatment (5.71) comes from the 80°C pasteurization temperature for 3 minutes. The difference in milk's mouthfeel is influenced by ingredients, processing method, and storage condition of the jackfruit seed milk.

Based on the analysis result of the Kruskal Wallis test, the p-value is $p = 0.01 < \alpha < 0.05$, which shows the insignificant difference in each treatment. This means different treatments of temperature and periods of pasteurization do not influence the panelists' acceptance level of the mouthfeel variable of the jackfruit seed milk.

CONCLUSION

This research proved that jackfruit seed could be utilized as the plant-based milk that contains 2.32-3.25% protein, 1.02-1.18% fat, 10.50-12.00°brix of total soluble solids (TPT), and sensory test (color, flavor, aroma, and mouthfeel) that overall liked by the panelists. The results show that jackfruit seed utilization in plant-based milk has some benefits, such as one of the solutions to increase the economic value of the jackfruit seed that has been got less attention, providing alternative products for people who do not like animal-based milk, vegetarian, and people with lactose intolerance, solution of alternative drink availability with the nutrition content similar with cow milk, and one of the solutions to decrease dependence towards the soy, whose price keeps increasing.

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