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PROCESSING JACKFRUIT SEED WASTE (Artocarpus heterophyllus lamk) INTO AN ALTERNATIVE FOOD SOURCE FOR TEMPE

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Abstract

This study aims to determine how to process jackfruit seeds (Artocarpus heterophyllus lamk) into a food source of tempeh without using soybeans, and to assess its feasibility as an alternative to soybean tempeh. The background of this study is based on Indonesia's high dependence on soybean imports, which causes the price of tempeh raw materials to increase. Jackfruit seeds were chosen because they have high nutritional content such as carbohydrates, protein, vitamins, and minerals, as well as their abundant availability. Which is suitable as a substitute or alternative to jackfruit seeds. This study used a quantitative research method with an experimental approach through the fermentation process of jackfruit seeds using Rhizopus oligosporus yeast. The results showed that jackfruit seed tempeh has good physical and organoleptic characteristics, with a solid shape, soft but compact texture, grayish white color, slightly sweet savory taste, and a distinctive aroma of tempeh. The fermentation process for two days at room temperature (28–32 °C) resulted in even mycelial growth and optimal fermentation. In terms of nutrition, jackfruit seed tempeh contains quite high protein and fiber so it has the potential to be a nutritious and affordable alternative food. Thus, jackfruit seeds have the potential to be a substitute for soybeans in the production of tempeh, while also supporting food diversification and reducing Indonesia's dependence on soybean imports.

Keywords: Jackfruit seeds; tempeh; fermentation; alternative food; soybeans

1. Introduction

Jackfruit seeds (Arthocarpus heterophyllus lamk) are the seeds found inside the jackfruit. These seeds are often considered waste, but they actually have good nutritional value and can be processed into various types of food or drinks. Jackfruit seeds are rich in carbohydrates, protein, energy, and various minerals. Jackfruit seeds are rich in nutrients, including carbohydrates (36.7g per 100g), protein (4.2g per 100g), minerals (phosphorus, calcium, iron), and vitamins (B and C). In addition to being a food ingredient, jackfruit seeds also have health benefits such as helping prevent digestive tract infections, diarrhea, and even supporting heart health. The use of jackfruit seeds can be applied to flour, chips, dodol, innovative products in the form of concrete noodles, and one of them is as an alternative ingredient for tempeh. Jackfruit seeds have the potential as an alternative ingredient for making tempeh, and can even increase protein content after the fermentation process.

Tempeh is a typical Indonesian fermented food, typically made from soybeans fermented with tempeh yeast. This fermentation process makes the soybeans easier to digest and rich in nutrients. Tempeh is a nutritious Indonesian food that serves as an important and common vegetable source for Indonesians. The nutritional content of tempeh can rival or even balance non-plant foods such as meat, fish, eggs, and milk, both in terms of protein, vitamins, minerals, and carbohydrates (Silvia, 2009). Tempeh has become popular not only for its savory taste but also for its high nutritional content. In certain circumstances, tempeh production has experienced a sharp increase in price, causing many tempeh entrepreneurs and artisans to innovate and improvise due to this problem, which has pushed the manufacturing process to save production costs. Soybeans are a crucial agricultural commodity for food security in Indonesia. They are commonly used as a raw material in the production of tempeh, tofu, soy sauce, and various other processed food products. Soybeans play a central role in the Indonesian diet, significantly impacting the stability of the country's food economy due to the substantial demand for soybeans. However, despite soybeans' strategic role

in economics, health, and consumer demand, Indonesia's soybean farming sector still faces various challenges that hamper efforts to achieve national food self-sufficiency and security.

One of the biggest challenges facing Indonesia's soybean sector is its heavy dependence on imports. According to data, nearly 80% of soybean demand is still met by imports, primarily from major soybean-producing countries such as the United States, Argentina, and Brazil. This dependence makes Indonesia highly vulnerable and resistant to international price fluctuations and unstable global market conditions. Ultimately, this reliance on imported soybeans presents challenges in maintaining stable prices for processed soybean products, such as tofu and tempeh, which significantly impacts the price of soybean raw materials.

Furthermore, the decline in agricultural land and the use of conventional cultivation methods are also significant and crucial challenges to domestic soybean production. While soybeans can be produced domestically, the decline in land area and the use of conventional cultivation methods pose challenges to domestic soybean production. The decline in soybean agricultural land, from 660,000 hectares in 2019, contributes to low productivity. In terms of productivity, soybean yields in Indonesia are only around 1-1.2 tons per hectare, indicating that soybean production in Indonesia is significantly lower than that of major soybean-producing countries.

Limited access to technology and markets is also a problem in soybean production. Soybean farmers and entrepreneurs face challenges such as limited access to modern technology and broader markets. A lack of training and government support in marketing and agricultural technology is undoubtedly hampering the development of the soybean industry in Indonesia.

2. Methodology

2.1 Types and Approaches of Research

This study employed quantitative research, an approach focused on objectively measuring the variables under study through the collection of numerical data. The data obtained were then analyzed and statistically observed to systematically and measurably examine the relationships, comparisons, and influences between variables. This approach was based on its ability to provide an accurate picture of the effectiveness of jackfruit seed tempeh as an alternative to soybean tempeh, which requires quantitative data such as nutritional data, consumer suitability, and food economics. Furthermore, this study employed an experimental approach, a component of the quantitative method, in which researchers directly perform specific actions on the research subjects under controlled conditions. In this case, the experiment was conducted using tempeh made from jackfruit seed waste as the treatment variable. This approach enabled researchers to directly observe the potential of tempeh from jackfruit seeds as a food ingredient as a substitute for soybean tempeh.

2.2 Processing Procedures

1. Tools and Materials

Tempeh made from jackfruit seeds uses jackfruit seeds as the main ingredient, tempeh yeast for fermentation, and clean water for washing, soaking, and boiling. The packaging can be banana leaves or perforated plastic to maintain air circulation during fermentation. The equipment used includes basic household items such as a boiling pot, a soaking container, a drainer, and other simple tools to support the tempeh-making process.

2. Steps for Making

The process of making tempeh from jackfruit seeds begins with preparing the ingredients and tools. The jackfruit seeds used must be selected from good quality, unrotted seeds, and of a relatively uniform size to ensure even fermentation. The steps for making tempeh from jackfruit seeds are as follows:

1) The first stage of production begins with sorting and washing the jackfruit seeds to ensure they are free of dirt and residual sap. Afterward, the seeds are soaked in clean water for approximately twenty-four hours at room temperature. This soaking process softens the seeds and aids the fermentation process in the next stage. After soaking, the seeds are boiled or steamed for thirty to sixty minutes until soft. The boiling process also kills any harmful microbes that could interfere with the growth of tempeh mold.
2) After boiling, the jackfruit seeds are drained until the water is gone and allowed to cool at room temperature. The seed coat is then peeled off, and the seeds are then chopped into small pieces to resemble soybeans in shape and texture. Once the ingredients are clean and sufficiently dry, they are then mixed with tempeh yeast. The yeast is sprinkled evenly at a ratio of approximately 0.2% of the total weight of the ingredients. The mixture is then stirred until the yeast is evenly distributed over the entire surface of the jackfruit seeds.
3) The next stage is packaging, where the fermented jackfruit seed mixture is filled into perforated plastic bags or banana leaves. The packaging is pressed until it solidifies, creating a compact, easy-to-cut tempeh

structure. The ingredients are then fermented for approximately two days at room temperature, around 28–32°C. During fermentation, the Rhizopus oligosporus mold grows, forming a white mycelium that covers the entire surface of the seeds, indicating that the fermentation process is progressing well.

Finished tempeh is characterized by an even white color, a firm texture, and a distinctive tempeh aroma. The optimal fermentation process produces jackfruit seed tempeh that not only has a distinctive flavor but is also rich in vegetable protein, making it a nutritious alternative food source and potentially replacing soy tempeh in both household and small-scale industrial markets.

3. Results and Discussion

This research produced tempeh made from jackfruit seeds (Artocarpus heterophyllus lamk) which has physical and organoleptic characteristics close to soybean tempeh. The fermentation process using Rhizopus oligosporus tempeh yeast was carried out for two days at room temperature of 28–32 °C. The results showed that the fermentation process went well with the growth of white mycelia evenly on the surface of the material, resulting in dense tempeh, a distinctive aroma, and a savory taste. After making tempeh from jackfruit seeds, the results were obtained based on the physical and food suitability with the results of fried tempeh through the table below.

Observation Aspects	Observation result	Information
Form	Solid, intact, and not easily destroyed	Fermentation was successful, mycelia grew evenly
Texture	Soft but compact (solid)	Can be cut easily without breaking
Color	Grayish white	The characteristic color of the growth of the mold Rhizopus oligosporus
Flavor	Savory, slightly sweet	Natural taste of jackfruit seeds, without sour aroma
Aroma	Typical tempeh, not rancid	Indicates perfect and hygienic fermentation

Table 1. Results of Physical and Organoleptic Observations of Jackfruit Seed Tempeh

1. Form

Based on Table 1, the resulting jackfruit seed tempeh appears dense, compact, and does not crumble easily when cut or fried. White mycelial growth from Rhizopus oligosporus can be seen covering the entire surface of the jackfruit seeds evenly. This condition indicates that the fermentation process is running optimally and the mold is able to grow well on the jackfruit seed substrate that has undergone the correct boiling and draining process. According to Asriani (2023), the dense and intact shape of the tempeh indicates the right balance of water content, aeration, and fermentation temperature to support mycelial growth. If the humidity is too high, the tempeh will be soft and easily crumbled, while if it is too dry, the mycelial growth will be uneven. Therefore, controlling the water content before fermentation is a crucial factor in producing the ideal tempeh shape.

Research by Haque et al. (2023) shows that the compact and uniform shape of tempeh is largely determined by the density of the substrate and the activity of proteolytic enzymes during fermentation. In their study of non-soybean tempeh, the dense structure of tempeh resulted from a substrate with a high starch and fiber content that supported even mycelial growth. This condition also occurs in jackfruit seeds, which have a naturally dense texture, allowing the formation of a intact tempeh network that is easy to process without breaking. Thus, the solid shape produced by jackfruit seed tempeh can be said to be an indicator of successful fermentation and demonstrates the potential of jackfruit seeds as an alternative ingredient to replace soybeans with high nutritional value.

2. Texture

The resulting jackfruit seed tempeh is soft yet dense and holds together well. This is because the high starch content of jackfruit seeds allows them to adhere to each other after fermentation, forming a compact mass similar to soybean tempeh. Boiling for approximately 60 minutes has been shown to soften the ingredients and facilitate yeast penetration into the seed tissue. According to Amalia et al. (2021), good tempeh texture is achieved by a balance between water content and mold activity, which binds the ingredients together through the formation of mycelia. The texture of jackfruit seed tempeh is also influenced by the size of the seed pieces and the fermentation time. Fermentation that is too short can result in brittle tempeh, while excessive fermentation can result in a texture that is too dry and hard.

This relates to the findings of Wulandari, Arifin, and Rahmawati (2020), who stated that the textural characteristics of tempeh made from local seeds, including jackfruit seeds, are highly dependent on the initial processing and fermentation conditions. Proper boiling and maintaining humidity encourage the formation of even mycelium, resulting in a dense, durable structure. A good texture also indicates a perfect fermentation process, as mold activity is able to form a binding network between the material particles. Therefore, regulating temperature, water content, and fermentation time are important factors that need to be considered and taken into account when producing jackfruit seed tempeh with an ideal texture: soft, compact, and resembling soybean tempeh.

3. Color

Color is an important indicator of fermentation success. The jackfruit seed tempeh produced in this study had a grayish-white color, characteristic of the growth of Rhizopus oligosporus mycelia. The white color indicates that fermentation took place under sterile conditions without contamination by other microbes such as Aspergillus or Penicillium, which can cause a greenish or blackish color. According to Nareswary & Andaka (2017), the pure white color of tempeh is the result of the dominant growth of Rhizopus mold, which completely covers the surface of the material. In addition, the grayish color difference is somewhat influenced by the natural pigment of the cream-colored jackfruit seeds. Therefore, the color of jackfruit seed tempeh can be categorized as good and in accordance with the characteristics of fermented tempeh in general.

These results are also supported by research by Widodo (2012), who found that variations in yeast content and fermentation time affect the brightness of the color of jackfruit seed tempeh. Longer fermentation with an optimal yeast dosage will result in thicker mycelial growth and a more even white color. Conversely, incomplete fermentation causes the tempeh to become unevenly colored and appear dull due to uneven mycelial growth. In addition to fermentation factors, the wrapping material also influences the final color. Banana leaf wrapping, for example, helps maintain moisture while inhibiting color oxidation. Thus, the grayish-white color produced in this study indicates that the fermentation process is ideal and meets the standards for good-quality tempeh.

4. Flavor

The taste of jackfruit seed tempeh shows good results, namely savory with a hint of natural sweetness. The savory taste arises from the fermentation process that produces free amino acid compounds, especially glutamate, which gives tempeh a distinctive umami or savory sensation. Meanwhile, the sweet taste comes from the carbohydrate and simple sugar content in jackfruit seeds, which are partially broken down by mold enzymes during fermentation. Asriani (2023) explains that tempeh fermentation increases the activity of protease and amylase enzymes that produce volatile compounds and amino acids that contribute to the savory taste. This gives jackfruit seed tempeh a more complex flavor character than soybean tempeh, with a distinctive balance between savory and natural sweetness.

The research results of Andaka, Nareswary, Budilaksana, and Trishadi (2017) also stated that the flavor of tempeh made from jackfruit seeds is greatly influenced by the composition of the raw materials and fermentation conditions. The complex carbohydrate and protein content in jackfruit seeds supports the formation of compounds that contribute to the savory taste and distinctive aroma during fermentation. The proper steaming and soaking process also helps reduce the unpleasant taste and emphasizes the natural sweetness of jackfruit seeds. Thus, the balance between enzymatic activity and nutritional content of the ingredients is a crucial factor in producing the soft, savory taste of jackfruit seed tempeh, which is easily accepted by consumers as an alternative to soy-based tempeh.

5. Aroma

The aroma of jackfruit seed tempeh resembles that of soybean tempeh, a characteristic fermentation without a sour or rancid odor. This distinctive aroma is the result of the metabolic activity of Rhizopus oligosporus, which produces alcohol, esters, and other aromatic compounds in balanced amounts. According to Amalia et al. (2021), the distinctive aroma of tempeh arises from the formation of volatile compounds such as 3-methyl-1-butanol and ethyl acetate during fermentation. The mild aroma indicates that the fermentation process took place under hygienic conditions and without contamination by spoilage microbes. Thus, the resulting aroma can be categorized as good and organoleptically acceptable.

Sari, Rahman, and Mahfud (2016) stated that fortification of tempeh based on soybeans or jackfruit seeds did not cause significant or striking changes in aroma during fermentation, even strengthening the distinctive aroma of tempeh that panelists preferred. The addition of jackfruit seeds in certain proportions increased the availability of sugars and free amino acids, which are the main precursors for the formation of aromatic volatile compounds. In addition, the proper steaming and fermentation process helped reduce the unpleasant aroma and prevented the emergence of rancid odors due to fat oxidation. Therefore, the aroma of jackfruit seed tempeh can be assessed well sensory (direct smell), indicating that fermentation was running perfectly, and supporting consumer acceptance of processed products based on local ingredients.

From a sustainability and economic perspective, utilizing jackfruit seeds as a base ingredient for tempeh has the potential to support local food diversification and reduce dependence on soybean imports. According to Wulandari, Arifin, and Rahmawati (2020), innovative use of local ingredients such as jackfruit seeds not only reduces production costs but also contributes to community food self-sufficiency. Nareswary and Andaka (2017) added that the relatively high protein content of jackfruit seeds makes them a viable alternative food source, both technologically and nutritionally. In addition to offering a taste and texture acceptable to consumers, jackfruit seed tempeh also offers added value by utilizing previously underutilized agricultural waste. Therefore, jackfruit seed tempeh is not only nutritionally superior but also holds strategic value in supporting national food security, waste management, and the development of a locally resource-based economy, which has the potential to generate export opportunities.

4. Conclusion

Based on the research results and discussion, it can be concluded that jackfruit seed tempeh (Artocarpus heterophyllus lamk) has good physical characteristics and is suitable as an alternative to soybean tempeh. In terms of shape, jackfruit seed tempeh shows a solid, compact, and not easily broken structure, indicating that the fermentation process is running optimally with the even growth of Rhizopus oligosporus mycelia. Its soft but dense texture is influenced by the high starch content and the boiling process that facilitates yeast penetration. The resulting grayish-white color indicates that fermentation is taking place under hygienic conditions without contamination from spoilage microbes. The savory and slightly sweet taste of jackfruit seed tempeh indicates a balance between proteolytic and amylolytic enzyme activity during fermentation. The distinctive aroma of fermentation is not pungent, indicating that microbial activity is taking place normally and cleanly.

Nutritionally, jackfruit seed tempeh contains adequate amounts of protein, dietary fiber, and essential minerals, and its nutritional value increases through the fermentation process. This tempeh also has high potential for further development as a local functional food because it utilizes abundant and underutilized raw materials. Therefore, making jackfruit seed tempeh not only provides a highly nutritious food alternative but also contributes to food diversification and national food security.

This study recommends optimal fermentation management, particularly in terms of duration and yeast content, to achieve the best texture and flavor. The use of natural packaging materials, such as banana leaves, is also recommended to enhance aroma and maintain moisture during fermentation. Further research can focus on more detailed nutritional analysis, particularly the levels of protein, fat, and bioactive compounds formed during fermentation, as well as product shelf life testing. Furthermore, organoleptic testing involving a broader consumer panel is needed to assess market acceptance of jackfruit seed tempeh. With further research supported by innovative processing technologies, this product has the potential to be developed into a high-value local food commodity while supporting Indonesia's independence in non-soybean raw materials.

Thank You Greeting

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