Effect of fermentation time by *Lactobacillus plantarum* FNCC 0027 on chemical, physical and physico-chemical properties of modified breadfruit flour

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**Abstract.** Breadfruit contains a high amount of carbohydrate, but it has short shelf life. Processing it into flour has the advantage of extending its shelf life and making the next process easier. The aim of this work was to study the effect of fermentation time by *Lactobacillus plantarum* FNCC 0027 on the chemical, physical and physico-chemical properties of modified breadfruit flour. The experimental design of this research was Completely Randomized Design (CRD) with variation of fermentation time (0, 12, 24, 36, 48, and 60 hours) as the factor. Reducing sugar values had a fluctuative trend. Longer fermentation time produced breadfruit flour with lower bulk density but higher whiteness index. No significant differences were found in the solubility contents. Water absorption, oil absorption, swelling power, gelatinization temperature, gelatinization time and setback viscosity of modified breadfruit flour were higher than unfermented breadfruit flour. Twenty-four hours was chosen as the optimum fermentation time to produce modified breadfruit flour.

1. **Introduction**

Breadfruit is an agricultural commodity that has the potential to be used as a raw material of carbohydrate source. In addition, breadfruit (*Artocarpus communis*) can be used as an alternative food because it contains 25% carbohydrate, 1.5% protein and 0.3% fat from its weight [13]. Nevertheless, breadfruit has a short shelf live. One alternative method to extend its shelf life is making breadfruit into breadfruit flour. Flour production has advantages such as extending the shelf life of flour and making the next processing step easier. Every 100 grams of breadfruit flour can give three times more calories than ripe breadfruit itself [10]. In addition, making breadfruit flour can increase the diversification of food products from local materials.

Breadfruit flour has been used in processed products such as breadfruit round cake, breadfruit porridge, breadfruit cake, breadfruit cookies, breadfruit cake, breadfruit pastel and fresh role cake [10]. But based on literature research, breadfruit flour as a raw material and substitution for some food products still has shortcomings. The lack of sensory value in some processed breadfruit products is thought to be due to some physical and physico-chemical characteristics of the flour that affect the sensory properties. Amilographic profile, swelling power, water absorption and oil absorption of flour have an effect on texture and general acceptance of the product. Oil absorption of flour also affects the taste of food products, while the whiteness index affects their appearance [18, 5, 20, 22].
According to Medikasari [15], breadfruit flour still has weaknesses in its functional properties, which are low volume improvement and viscosity breakdown when it is heated at 95°C and stirred mechanically. The lack of functionality of breadfruit flour has also discussed by Budiyati [7], who noted that although it has good water solubility (55.27 g/100 g), breadfruit flour has low swelling power (1.55 g/g). In addition, breadfruit flour has a susceptibility to heat, too high viscosity, low resistance to shearing and high tendency to retrogradation and sineresys.

Lactic acid bacteria can produce enzymes that hydrolyze starch into sugar and then convert it to organic acids, especially lactic acid. It will increase viscosity, gelation ability and rehydration power of produced flour. In addition, the taste will become neutral by being able to cover the taste of the original raw material up to 70%. During the fermentation process, there will be degradation of the color-forming component that can cause brown color when heating, so the brighter flour can be produced.

Fermentation time is one factor to be considered in the fermentation process. According to Nurani et al. [17], modified starch is optimally generated at the stationary phase in which secondary metabolite products are produced, such as enzymes that can hydrolyze complex compounds of flour into simpler compounds. Therefore, this research used 0, 12, 24, 36, 48 and 60 hours of fermentation time, considering that microbial growth has exceeded the stationary phase. The aim of this work was to study the effect of fermentation time by Lactobacillus plantarum FNCC 0027 on the chemical, physical and physico-chemical properties of modified breadfruit flour.

2. Materials and Methods

2.1. Making Modified Flour
The breadfruit flesh is reduced in size by slicing vertically with ± 5 mm thickness. The 300 g of breadfruit were soaked in 400 ml sterile aquades with 6% (v/v) starter Lactobacillus plantarum FNCC 0027 and then fermented for 0 hours (control), 12 hours, 24 hours, 48 hours and 60 hours at 37°C. Then it was dried in cabinet dryer (70°C for 4 hours), powdered and sieved (80 mesh).

2.2. Chemical, Physical and Physico-chemical Analysis
Several analyses were conducted on modified breadfruit flour. A chemical properties test was conducted on reducing sugar analysis using Nelson Somogyi’s method [21]. Physical properties tests were conducted on bulk density [6] and whiteness index by total colour different method [4]. Physico-chemical properties tests were conducted on gelatinization profile by Rapid Visco Analyzer method, water absorption by centrifugation method [1], solubility by centrifugation method [9] and swelling power by centrifugation method [9].

3. Results and Discussion

3.1. Chemical Characteristics

| Fermentation Length (hour) | Reducing Sugar (%) |
|---------------------------|--------------------|
| 0                         | 4.86<sup>b</sup>±0.63 |
| 12                        | 5.78<sup>c</sup>±0.61 |
| 24                        | 3.45<sup>a</sup>±0.65 |
| 36                        | 4.90<sup>bc</sup>±0.89 |
| 48                        | 4.46<sup>b</sup>±0.19 |
| 60                        | 5.08<sup>bc</sup>±0.59 |

Value in the same line followed by a different letter was significantly different (p=0.05).
Table 1 shows that the lowest reducing sugar content was found in breadfruit flour with fermentation treatment for 24 hours, while the modified breadfruit flour with the highest reducing sugar content was found in the fermentation treatment for 12 hours at 5.78%. The yield trend of reducing sugar obtained tended to fluctuate.

3.2. Physical Analysis

3.2.1. Bulk Density, Whiteness Index, Water Absorption, Oil Absorption, Swelling Power and Solubility

Table 2. Chemical, Physical and Physico-Chemical Properties of Modified Breadfruit Flour

| Fermentation Length (hour) | Bulk Density (g/ml) | Whiteness Index | Water Absorption (g/g) | Oil Absorption (g/g) | Swelling Power (g/g) | Solubility (%) |
|----------------------------|---------------------|-----------------|------------------------|---------------------|----------------------|----------------|
| 0                          | 0.62± ±0.02         | 84.59± ±0.04    | 3.09± ±0.33            | 1.13± ±0.06         | 1.99± ±0.29          | 9.93± ±0.09    |
| 12                         | 0.55± ±0.03         | 84.68± ±0.02    | 4.94± ±0.11            | 1.18± ±0.12         | 5.50± ±0.53          | 9.92± ±0.06    |
| 24                         | 0.51± ±0.03         | 85.15± ±0.33    | 4.92± ±0.34            | 1.58± ±0.17         | 5.49± ±0.52          | 9.89± ±0.06    |
| 36                         | 0.50± ±0.00         | 85.32± ±0.08    | 4.97± ±0.12            | 1.64± ±0.13         | 5.96± ±0.10          | 9.90± ±0.03    |
| 48                         | 0.51± ±0.01         | 85.47± ±0.06    | 4.91± ±0.17            | 1.39± ±0.13         | 5.98± ±0.24          | 9.88± ±0.01    |
| 60                         | 0.50± ±0.02         | 85.34± ±0.09    | 4.59± ±0.26            | 1.29± ±0.06         | 5.39± ±0.39          | 9.86± ±0.05    |

Value in the same line followed by a different letter was significantly different (p=0.05).

Table 2 shows that the longer fermentation, bulk density of breadfruit flour has a trend that tends to decrease. The decrease in bulk density during fermentation can be attributed to the increase in porosity of the flour with the longer fermentation time. According to [2], the longer the fermentation time, the greater the degradation of macromolecules into simpler molecules. The compact macromolecules become porous because they were broken into smaller molecules with small mass. Because of the stretching of the structure of the flour due to its increased porosity, the volume of flour increases, which can cause decrease of bulk density.

The result of the lowest white degree was found in the flour of breadfruit without fermentation (control) that is equal to 84.59, while the highest yield of breadfruit flour with 48 hours fermentation treatment is 85.47. According to [11], breadfruit has riboflavin (yellow pigment), so the degree of whiteness tends to increase during fermentation because the riboflavin is decreased.

The lowest water absorption result was obtained by native breadfruit flour and the highest is shown by 36 hours fermented breadfruit flour. The similar trend was shown on oil absorption result. The lowest oil absorption result was obtained by controlled breadfruit flour (without fermentation) with value of 1.13 g/g. The results obtained were not significantly different from the breadfruit flour with 12 hours of fermentation or breadfruit flour with 60 hours of fermentation. The highest absorption of oil is shown by breadfruit flour with a 36-hour-long fermentation treatment, which is equal to 1.64 g/g. According to [3], with longer fermentation in the flour, the amylose content will increase as the amylopectin content is broken down into amylose. The increased amylose content will lead to an increase in oil absorption.

Table 2 shows that fermented breadfruit flour has a higher swelling power compared to controlled breadfruit flour (without fermentation). The results are relevant to the results of [23], who found that the longer the process of corn fermentation, the greater the swelling power of modified corn flour. This is allegedly because the longer the fermentation process, the more starch is broken down. Starch is able to increase swelling power because broken starch granules bind more easily to water when heated.

Table 2 shows that the fermentation time has no significant effect (p> 0.05) on the solubility of modified breadfruit flour. Although statistically not significantly different, this decreasing trend of solubility was due to hydrolysis process during fermentation, which causes a decrease in micellar bond strength in starch granules [15].
3.2.2. Amilographic Profile

Table 3. Pasting Properties of Modified Breadfruit Flour in Various Fermentation Time

| Fermentation Length (hours) | Gelatinization Temperature (°C) | Gelatinization Time (minutes) | Peak Viscosity (cP) | Breakdown Viscosity (cP) |
|-----------------------------|--------------------------------|-------------------------------|-------------------|------------------------|
|                             | Temperature (°C)                | Time (minutes)                | Temperature (°C)  | Time (minutes)         | Viscosity (cP) |         |
| 0                           | 84.20                          | 15.00                         | -                 | -                      |                | 4815.00 |
| 12                          | 83.10                          | 15.00                         | -                 | -                      |                | 3915.00 |
| 24                          | 84.90                          | 15.00                         | -                 | -                      |                | 3630.00 |
| 36                          | 84.20                          | 15.00                         | -                 | -                      |                | 3995.00 |
| 48                          | 88.60                          | 17.00                         | -                 | -                      |                | 3240.00 |
| 60                          | 84.40                          | 15.00                         | -                 | -                      |                | 4935.00 |

As Table 3 shows, the gelatinization temperature of the breadfruit control flask was 84.20°C. After 12 hours of fermentation, it decreased to 83.10°C. The other fermentation times did not show a significant decrease or increase (ranging from 84.20°C to 84.90°C) compared to the control breadfruit flour (84.20°C). But after 48 hours of fermentation treatment, the gelatinization temperature of modified starch flour increased to 88.6°C. Because the time of gelatinization can be known, the control flour is different from breadfruit flour after fermentation for 48 hours but not different from other fermentation treatments. This suggests that the fermentation treatment has little effect on the increase or decrease in gelatinization time of modified breadfruit flour. Table 3 shows that the unfermented breadfruit flour (control) has higher breakdown viscosity than the breadfruit flour with fermentation treatment of 12 hour to 48 hours.

4. Conclusion

Reducing sugar value has a fluctuating trend with the highest value in fermentation for 12 hours. The fermentation treatment decreases the bulk density but increases whiteness index compared to native breadfruit flour. The longer the fermentation, the more water absorption, oil absorption and swelling power increase with native breadfruit flour. Fermentation did not have a real effect on the solubility value. Based on the gelatinization profile obtained because of the fermentation treatment, gelatinization temperature, gelatinization time and breakdown viscosity tended to decrease compared with unfermented breadfruit flour. Breadfruit modification by fermentation method can increase water absorption, oil absorption, swelling power and whiteness index. This result shows that flour modification by fermentation method has more effect of increasing the physico-chemical properties that the previous studies about breadfruit modification [12, 16, 19]

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