International Journal of Life Science and Agriculture Research
ISSN (Print): 2833-2091, ISSN (Online): 2833-2105
Volume 05 Issue 11 November 2026
DOI: https://doi.org/10.55677/ijlsar/V05I11Y2026-03
Impact Factor: 7.88, Page No: 807-817

The Effect of Adding Jackfruit Juice on Vitamin C, Total Phenolic, Total Dissolved Solids, and Test Organoleptics of Black Soygurt

Ulil Afidah[1], Ayesha Putriadvi[2], Anang Mohamad Legowo[3], Ratih Paramastuti[4]*
[1,2,3,4] Food Technology Department, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang, Indonesia

ABSTRACT

The development of plant-based fermented foods requires a formulation that maintains chemical characteristics while producing appropriate sensory qualities. This study aims to analyze the effect of jackfruit juice addition on vitamin C levels, total phenolics, total soluble solids, and organoleptic characteristics of black soybean-based black soygurt. The study was conducted experimentally in a laboratory using a Completely Randomized Design with five jackfruit juice concentrations, namely 0%, 5%, 10%, 15%, and 20%, with four replications, resulting in 20 experimental units. Vitamin C levels were determined by iodometric titration, total phenolics were analyzed using the Folin–Ciocalteu method, and total soluble solids were measured using a refractometer. Sensory evaluation involved 25 untrained panelists who assessed color, aroma, texture, and taste. Data on vitamin C and total soluble solids were analyzed using ANOVA, while sensory data were analyzed using the Kruskal–Wallis test. The results showed that vitamin C levels increased from 23.65 mg /100 g in the control to 55.00 mg/100 g with the addition of 20% jackfruit juice. Total soluble solids also increased from 13.85 to 15.27 °Brix. In contrast, total phenolics fluctuated and reached the highest descriptive value at a concentration of 5%, namely 115.40 mg GAE/100 g. The addition of jackfruit juice was associated with a more yellowish color, an increase in the unpleasant aroma score, and a thinner texture at concentrations of 15% and 20%. The highest sour taste intensity score was found at a concentration of 10%. The study concluded that jackfruit juice has the potential to increase vitamin C and total soluble solids levels in black soygurt, but changes in chemical and sensory characteristics were not uniform. Further formulation determination needs to consider all quality parameters and testing of consumer preferences as well as product stability and safety during storage.

KEYWORDS: Black soygurt, jackfruit juice, sensory characteristics, vitamin C.

Published online: November 06, 2026

Cite the Article: Afidah, U., Putriadvi, A., Legowo, A.M., Paramastuti, R. (2026). The Effect of Adding Jackfruit Juice on Vitamin C, Total Phenolic, Total Dissolved Solids, and Test Organoleptics of Black Soygurt. International Journal of Life Science and Agriculture Research, 5(11), 807-817. https://doi.org/10.55677/ijlsar/V05I11Y2026-03

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

Corresponding Author:
Ratih Paramastuti

1. INTRODUCTION

Functional foods are gaining increasing attention as consumers' demand for food products that not only provide nutrients but also have the potential to support digestive health, the immune system, and gut microbiota balance (Victoria et al., 2024). One food group developing in this sector is fermented products. The fermentation process can increase nutritional value, improve flavor characteristics, and help extend product shelf life naturally. In line with this development, plant-based fermented foods have become a relevant alternative, including soygurt, a yogurt-like product made from soy milk and containing vegetable protein, isoflavones, and bioactive compounds (Maulani, 2023). Developing soygurt from locally sourced ingredients has the potential to expand food diversification while providing alternative fermented products for consumers. One ingredient with the potential to be developed into soygurt is black soybeans. Black soygurt utilizes black soybeans as the main ingredient, which contain bioactive compounds, particularly anthocyanins, isoflavones, and various antioxidant components. These compounds play a role in counteracting free radicals and provide added value compared to ordinary yellow soybeans (Dewi et al., 2021). This potential is also evident in yogurt

products made from black soybeans. Research shows that approximately 80% of anthocyanins remain after fermentation, while some isoflavones are converted from glycosides to more bioactive aglycones (Esteves et al., 2025). These findings suggest that black soybean fermentation has the potential to produce products with interesting functional characteristics.

However, the nutritional potential of black soyghurt does not necessarily translate to consumer acceptance. The characteristic unpleasant aroma of soybeans and the distinct taste of cow's milk yogurt can reduce the product's acceptance (Kong et al., 2022). The unpleasant aroma is related to the activity of the lipoxygenase enzyme in soybeans, which reacts with fat and oxygen (Putra et al., 2024). Therefore, the development of black soygurt needs to pay attention not only to its bioactive content, but also to the sensory characteristics that influence consumer acceptance. One approach that can be taken is to add natural fruit-based ingredients. The addition of fruit juice is known to help mask unpleasant odors, enhance the aroma, and improve the taste and overall acceptability of yogurt without compromising its nutritional value (Marda et al., 2024). Jackfruit (Artocarpus heterophyllus Lam.) is a local ingredient with potential for this purpose. Jackfruit flesh has a strong, distinctive aroma and natural sweetness. This aroma is supported by volatile compounds, including ethyl butyrate, 3-methylbutyl acetate, and other aliphatic esters, which have the potential to function as masking agents to mask unpleasant odors (Gunawan and Basoeki, 2022). The sweetness of jackfruit comes from the sucrose, glucose, and fructose content, while malic and citric acids contribute to a mild sour taste (Syarifah et al., 2026). In addition to potentially improving aroma and taste characteristics, jackfruit contains vitamin C, vitamin A, minerals, phenolic compounds, flavonoids, carotenoids, and antioxidant components (Solichah et al., 2021). Thus, the addition of jackfruit juice has the potential to support sensory quality while enriching the nutritional and bioactive components of black soygurt.

Several previous studies have examined the potential of these two ingredients, but they tend to be separate. Faiz et al. (2022) and Jayanti and Rizkaprilisa (2024) showed that black soygurt has superior antioxidant activity and total phenolics compared to soygurt made from yellow soybeans. However, these studies have not yet formulated black soygurt with added fruit juice. On the other hand, Wardhana et al. (2022) demonstrated the potential of jackfruit extract to enhance the aroma and flavor of other products, but its application to black soygurt has not been studied. Thus, there remains a research gap regarding the use of jackfruit juice in black soygurt formulations and the effects of its addition on several quality parameters simultaneously. This gap is important to address because the addition of jackfruit juice is not only intended to help reduce unpleasant aromas but also has the potential to complement the bioactive components of black soybeans, such as anthocyanins and isoflavones, with vitamin C, carotenoids, and phenolic compounds from jackfruit.

Based on these gaps, this study aims to analyze the effect of jackfruit juice addition on vitamin C content, total phenolics, total soluble solids, and the organoleptic quality of black soygurt. This focus allows for an assessment of changes in the chemical components and sensory characteristics of the product after the addition of jackfruit juice. Specifically, this study aims to determine how the addition of jackfruit juice relates to vitamin C and total phenolics content, changes in total soluble solids, and the organoleptic quality of black soygurt. The results are expected to provide information on the potential of black soygurt formulations with jackfruit juice as an effort to develop plant-based fermented foods. This research is expected to contribute by linking the use of black soybeans and jackfruit in one formulation, which has not been the focus of previous research as summarized above. From a product development perspective, this research can serve as a basis for exploring combinations of local plant-based ingredients that consider bioactive components and sensory acceptability. From a commodity utilization perspective, the results have the potential to support the diversification of jackfruit-based products and the development of alternative plant-based yogurts. Therefore, this study focuses not only on the characteristics of black soyghurt after the addition of jackfruit extract but also on the opportunities for optimizing two local Indonesian commodities for functional food development.

2. MATERIALS AND METHODS

2.1 Research Design

This research is an experimental laboratory study aimed to analyze the effect of jackfruit juice addition on the chemical and sensory characteristics of black soybean-based black soygurt. The research was conducted from November 2025 to April 2026 at the Food and Agricultural Product Engineering Laboratory and the Food Chemistry and Nutrition Laboratory, Faculty of Animal Husbandry and Agriculture, Diponegoro University, Semarang. The study used a Completely Randomized Design (CRD) with five treatments and four replications, resulting in 20 experimental units. The treatments given were variations in jackfruit juice concentration, namely 0% (N0), 5% (N5), 10% (N10), 15% (N15), and 20% (N20). The percentage of jackfruit juice addition was calculated based on the volume of black soybean juice used as the base ingredient. Each treatment was made with the same base ingredient composition, while the concentration of jackfruit juice was the treatment factor that was differentiated. The research parameters included chemical characteristics, namely vitamin C content, total phenolics, and total soluble solids (TSS), as well as sensory characteristics including color, aroma, texture, and taste. The research hypothesis stated that variations in jackfruit juice concentration affect the chemical and sensory characteristics of black soygurt. Hypothesis testing was conducted using statistical analysis according to the characteristics of the data obtained.

2.2 Materials and Tools

The main ingredients used include black soybeans and ripe jackfruit obtained from Rasamala Market, Indoprima brand skim milk, Gulaku brand granulated sugar, and Biokul brand Greek yogurt as a source of starter culture. The starter contains Lactobacillus bulgaricus, Streptococcus thermophilus, and Lactobacillus acidophilus bacteria. Mineral water is used in the process of making black soybean juice and jackfruit juice. Chemicals for analysis include distilled water, 0.01 N iodine solution, potassium iodide (KI), 1% starch solution, 96% ethanol, Folin–Ciocalteu reagent, 10% sodium carbonate (Na_2CO_3), and gallic acid as a standard for measuring total phenolics. The equipment used includes a pan, filter cloth, stove, digital scale, blender, thermometer, measuring cup, stirrer, 500 mL glass jar, spoon, Erlenmeyer flask, beaker, dropper pipette, titration burette, magnetic stirrer, hotplate (B-ONE, Indonesia), refractometer, micropipette, analytical balance (NADEFA2104), 1 and 5 mL measuring pipettes, test tubes, and a Go Direct SpectroVis Plus Vernier spectrophotometer.

2.3 Research Procedures

a. Making Black Soybean Juice
   The production of black soybean juice refers to the method of Anjum et al. (2025) with modifications. Black soybeans are first sorted to remove impurities and unfit seeds, then soaked for 12 hours and washed with clean water. The seeds are then boiled for 15 minutes, cooled, and ground with the addition of hot water at a temperature of 80°C at a ratio of soybeans to water of 1:4. The resulting ground is filtered using a 200-mesh filter cloth to obtain black soybean juice. The resulting juice is then added with 9% skim milk and 7% sugar, each calculated based on the volume of black soybean juice, then pasteurized at 100°C for 10 minutes. After pasteurization, the juice is cooled to reach a temperature suitable for the fermentation process.
b. Making Jackfruit Juice
   The making of jackfruit juice refers to Hastuti and Junardi (2024) with modifications. Ripe jackfruit is peeled, then the flesh is separated from the unused parts. The flesh is pureed using a blender with mineral water added in a 1:3 ratio. The mixture is then filtered through a cheesecloth to separate the juice from the pulp. The resulting jackfruit juice is then blanched at 80°C for five minutes before being used as a treatment ingredient.
c. Making Black Soygurt
   The making of black soygurt refers to Cahyanti et al. (2024) with modifications. A total of 250 mL of black soybean extract was used as the formulation base for each treatment unit. 22.5 g of skim milk, 17.5 g of sugar, and 25 g of Greek yogurt starter were added in equal amounts to all treatments. The jackfruit extract variations used were 0; 12.5; 25; 37.5; and 50 mL for treatments N0, N5, N10, N15, and N20, respectively. The pasteurized black soybean extract was cooled to 40°C. The jackfruit extract was then added according to the treatment concentration and mixed until homogeneous. Greek yogurt starter was added at 10% by volume of black soybean extract, then the mixture was incubated for 24 hours at 30°C. The resulting products are then used for chemical and sensory characteristic testing.

2.4 Data Collection and Parameter Testing

Data collection was carried out through laboratory testing and sensory evaluation. Vitamin C levels were analyzed using the iodometric titration method referring to Harefa et al. (2020) with modifications. A 10 g sample was diluted using distilled water to a volume of 100 mL. A 20 g sample of the diluted result was transferred into an Erlenmeyer flask, five drops of 1% starch indicator were added, then titrated using 0.01 N iodine solution until a blue color formed as the titration end point. The vitamin C content was calculated based on the volume of iodine used, the dilution factor, and a conversion factor of 0.88, then expressed in mg/100 g of sample.

Total phenolic analysis refers to Marjoni et al. (2017) using the Folin–Ciocalteu method. A standard solution was prepared using gallic acid dissolved in 96% ethanol to obtain a stock solution with a concentration of 1,000 ppm, then diluted to several standard concentrations. A total of 0.04 mL of the standard solution was reacted with distilled water, Folin–Ciocalteu reagent, and 10% Na_2CO_3 solution. The mixture was homogenized and incubated for two hours at room temperature to produce a standard curve for gallic acid. Sample testing was carried out using a similar procedure, with absorbance measurements at a wavelength of 765 nm using a UV-Vis spectrophotometer. The total phenolic concentration was determined based on the gallic acid standard curve. Measurement of total dissolved solids refers to Permadi et al. (2021) using a refractometer. The instrument was first calibrated using distilled water until it shows a value of 0. The sample is then dropped onto the refractometer prism, leveled, and the value indicated on the reading scale is recorded in °Brix.

Sensory evaluation was conducted based on the method of Krawan et al. (2019) involving 25 untrained panelists aged 21–23 years, consisting of 17 women and eight men. Panelists assessed color, aroma, texture, and taste using a four-level scale. The color attribute is assessed based on the level of yellowish white, aroma based on the intensity of the unpleasant aroma, texture based on the level of viscosity, and taste based on the intensity of the sour taste. Prior to testing, panelists received an explanation of the assessment

procedure. Reference samples were provided for each attribute for comparison, while mineral water was used to neutralize taste buds after each sample was tasted. Assessment results were recorded using a provided form.

2.5 Data Analysis

Total phenolic data were analyzed descriptively based on the results of absorbance measurements and the gallic acid standard curve. Data on vitamin C and total soluble solids levels were analyzed using Analysis of Variance (ANOVA) at a significance level of 5% with IBM SPSS software version 26.0. If a significant treatment effect was found, the analysis was continued using Duncan's Multiple Range Test (DMRT) to identify differences between treatments. Organoleptic data were analyzed using the Kruskal–Wallis test at a significance level of 5%. If there were significant differences between treatments, the test was continued using the Mann–Whitney test. The results of the analysis were used to evaluate the effect of variations in jackfruit juice concentration on the characteristics of black soygurt based on each observed parameter.

2.6 Ethical Considerations

Sensory testing involves human panelists, so its implementation requires careful attention to providing information regarding the testing procedures and the panelists' willingness to participate. The research methods document explains the procedures and assessment methods to panelists before the testing is conducted. However, information regarding written informed consent, ethics committee or institutional review board approval, ethics approval numbers, and procedures for protecting panelist data confidentiality are not included in the source document. Therefore, the ethical approval status of the research needs to be confirmed based on the actual research documentation before the manuscript is submitted for publication.

3. RESULTS

3.1 Chemical Characteristics of Black Soygurt with Added Jackfruit Extract

Chemical characterization tests on black soygurt were conducted to determine changes in vitamin C, total soluble solids (TSS), and total phenolics levels due to the addition of jackfruit juice at concentrations of 0%, 5%, 10%, 15%, and 20%. The results showed that each parameter exhibited a distinct pattern of change. Vitamin C and TPT levels tended to increase with the addition of jackfruit juice, while total phenolics showed fluctuating changes. The results of the vitamin C level test are presented in Table 1.

Table 1Vitamin C content of black soygurt based on jackfruit juice concentration

Treatment	Jackfruit juice concentration (%)	Vitamin C (mg/100 g)
N0	0	23.65 ± 6.28^{a}
N5	5	31.90 ± 1.27^{b}
N10	10	39.05 ± 4.53^{c}
N15	15	41.80 ± 5.39^{c}
N20	20	55.00 ± 3.11^{d}

Note: Values are presented as mean ± standard deviation. Different superscript letters indicate significant differences at the 5% significance level ($p<0.05$), according to the test results in the source document.

Based on Table 1, the highest vitamin C content was found in treatment N20, which was 55.00 ± 3.11 mg/100 g, while the lowest content was found in N0 at 23.65 ± 6.28 mg/100 g. Increasing the concentration of jackfruit juice was followed by an increase in vitamin C content in all treatments. Compared to the control, treatment N20 showed an increase of 31.35 mg /100 g or approximately 132.56%. The statistical grouping results showed that N0, N5, and N10 were in different letter groups. Treatments N10 and N15 had the same superscript, so they did not show significant differences based on the grouping. Meanwhile, N20 had its own superscript. These results indicate that the addition of jackfruit juice at the highest concentration produced the highest vitamin C content among the treatments tested.

Table 2Total soluble solids of black soygurt based on jackfruit juice concentration

Treatment	Jackfruit juice concentration (%)	TPT (°Brix)
N0	0	13.85 ± 0.17^{a}
N5	5	14.70 ± 0.24^{b}
N10	10	14.90 ± 0.26^{b}
N15	15	15.12 ± 0.59^{b}
N20	20	15.27 ± 0.91^{b}

The TPT value increased from 13.85 ± 0.17 °Brix in the N0 treatment to 15.27 ± 0.91 °Brix in the N20 treatment. The difference between the two treatments reached 1.42 ° Brix or approximately 10.25%. An increase was also seen in the N5, N10, and N15 treatments, amounting to 14.70; 14.90; and 15.12 °Brix, respectively. Based on the superscripts in the table, the N0 treatment was significantly different from all treatments using jackfruit juice. In contrast, N5, N10, N15, and N20 were in the same letter group. Thus, the addition of jackfruit juice increased the TPT compared to the control, but the difference in jackfruit juice concentration between 5% and 20% did not produce a significant difference based on the reported statistical grouping.

Table 3black soygurt based on jackfruit juice concentration

Treatment	Jackfruit juice concentration (%)	Total phenolics (mg GAE/100 g)
N0	0	98.86 ± 2.07
N5	5	115.40 ± 4.62
N10	10	93.60 ± 2.58
N15	15	103.74 ± 4.22
N20	20	104.52 ± 7.33

The highest total phenolic content was found in treatment N5 at 115.40 ± 4.62 mg GAE/100 g. This value was 16.54 mg GAE/100 g higher than the control treatment. Conversely, the lowest value was found in N10 at 93.60 ± 2.58 mg GAE/100 g. At N15 and N20, total phenolic content increased again to 103.74 ± 4.22 and 104.52 ± 7.33 mg GAE/100 g, respectively. This pattern indicates that increasing jackfruit juice concentration was not followed by a linear increase in total phenolic content. The addition of 5% jackfruit juice produced the highest value, while the 10% concentration produced the lowest value among all treatments. Since the results of inferential statistical tests for this parameter are not listed in the source document, the differences in these figures are presented as descriptive trends and cannot be stated as statistically significant differences.

3.2 Sensory Characteristics of Black Soygurt with Added Jackfruit Juice

Sensory testing involved 25 untrained panelists aged 21–23 years, consisting of 17 women and eight men. Assessment includes color, aroma, texture, and taste on a four-level scale. The test results for each attribute are presented in Table 4.

Table 4Sensory test results of black soygurt with added jackfruit juice

Parameter	N0 (0%)	N5 (5%)	N10 (10%)	N15 (15%)	N20 (20%)
Color	2.44 ± 1.00	2.64 ± 1.03	2.80 ± 0.91	2.84 ± 0.94	3.12 ± 1.23
Aroma	1.36 ± 0.48^{a}	1.88 ± 0.72^{ab}	2.16 ± 1.14^{ab}	2.36 ± 1.18^{b}	2.44 ± 1.15^{b}
Texture	2.60 ± 0.81^{a}	2.84 ± 0.80^{a}	2.64 ± 0.86^{a}	1.88 ± 0.83^{b}	1.96 ± 0.84^{b}
Flavor	2.72 ± 0.89	2.88 ± 0.72	3.20 ± 0.86	3.00 ± 0.95	2.60 ± 1.04

Note: Values are presented as mean ± standard deviation. Different superscript letters on aroma and texture parameters indicate significant differences ($p<0.05$) according to the grouping in the source document. For color and taste, superscripts are not included.

The color score increased from 2 .44 ± 1.00 at N0 to 3.12 ± 1.23 at N20. Treatment N0 was categorized as slightly yellowish white, while N5 to N20 was categorized as slightly yellowish white. The highest score was found in N20, which showed a tendency for increasing yellowish color intensity along with the addition of jackfruit juice. However, the results of the color statistical tests are not presented in detail in the source table so the significance of the differences between treatments cannot be ascertained based on the mean scores alone.

The aroma score increased from 1.36 ± 0.48 at N0 to 2.44 ± 1.15 at N20. N0 was categorized as not having a strong aroma, while N5, N10, N15, and N20 were categorized as having a slightly strong aroma. Based on the superscript, N0 is significantly different from N15 and N20. Treatments N5 and N10 were in the transition group which was not significantly different from groups N0 or N15–N20. These results indicate that the addition of jackfruit juice at higher concentrations is associated with an increase in the perception of unpleasant aroma.

The highest texture score was found in N5 at 2.84 ± 0.80, followed by N10 at 2.64 ± 0.86 and N0 at 2.60 ± 0.81. All three treatments were categorized as thick. Meanwhile, N15 and N20 obtained scores of 1.88 ± 0.83 and 1.96 ± 0.84, respectively, with the slightly thick category. The results of statistical grouping showed that N0, N5, and N10 were significantly different from N15 and N20. The decrease in scores at concentrations of 15% and 20% indicated that the addition of high amounts of jackfruit juice was related to changes in texture towards a thinner consistency.

Taste scores ranged between 2.60 and 3.20. The highest value was found in N10 at 3.20 ± 0.86, while the lowest value was found in N20 at 2.60 ± 1.04. All treatments were categorized as sour based on the rating scale used. Thus, the sour taste remains the main characteristic of the product at all concentrations of jackfruit juice. The source document states that the addition of jackfruit juice did not affect the panelists' level of taste preference, but the instrument listed actually measures the intensity of the sour taste, not the level of preference directly. Therefore, conclusions regarding consumer preference or acceptance should be interpreted with caution. Overall, the results showed that the addition of jackfruit juice was associated with increased levels of vitamin C and TPT, while total phenolics exhibited a fluctuating pattern. For sensory attributes, higher concentrations of jackfruit juice resulted in a more yellowish color and increased unpleasant aroma scores, while product consistency tended to decrease at concentrations of 15% and 20%. These findings suggest that changes in chemical composition are not always accompanied by uniform sensory changes.

4. DISCUSSION

This study showed that the addition of jackfruit juice affected several chemical and sensory characteristics of black soygurt. Increasing the concentration of jackfruit juice from 0% to 20% was followed by an increase in vitamin C content from 23.65 to 55.00 mg/100 g and an increase in total soluble solids from 13.85 to 15.27 °Brix. In contrast, total phenolics reached their highest value at 5% concentration, not at the highest concentration. In terms of sensory aspects, the addition of jackfruit juice was associated with an increase in yellowish color and unpleasant aroma scores, while the texture became thinner at concentrations of 15% and 20%. These findings indicate that jackfruit juice concentration produces different responses for each parameter. Therefore, formulation determination cannot be based solely on a single indicator, such as vitamin C content, but requires simultaneous consideration of chemical and sensory characteristics.

The increase in vitamin C levels in black soybeans is consistent with the explanation of Uwanta et al. (2024), who reported that jackfruit pulp contains 122.00 mg/L of vitamin C. The addition of jackfruit juice provides an additional source of ascorbic acid that can increase the vitamin C content of the final product. The values in the control treatment also indicate that the basic ingredient components contribute to the measured vitamin C levels. Wardani and Sujana (2020) reported vitamin C levels in black soybeans from Cirebon of 24.48–25.29 mg/100 g, while this study obtained 23.65 mg/100 g in the treatment without jackfruit juice. These differences may be related to the variety, source of the ingredients, and processing conditions. Istiqomah and Ramadhani (2018) explain that geographical factors, including climate, soil, and growing environment, can influence the nutrient content of plants. In addition to the contribution of raw materials, changes in vitamin C levels can be influenced by conditions during fermentation. Engels et al. (2022) explain that the activity of hydrolytic enzymes in lactic acid bacteria can alter the food matrix and influence the release of certain components. Anwer and Wei (2024) also discussed the role of acidic conditions in the stability of ascorbic acid. However, the increase in vitamin C in this study cannot be specifically attributed to bacterial activity or protection due to the decrease in pH because pH and vitamin C changes during fermentation were not presented in detail for each stage. Thus, the contribution of jackfruit juice is the primary explanation consistent with the data pattern, while the contribution of microbial metabolism still requires further testing.

The increase in TPT is in line with the findings of Hossain et al. (2023), who explained that the addition of fruit-based food ingredients can increase total soluble solids due to the contribution of sugars and other soluble components. Suo et al. (2024) also highlighted the carbohydrate content of jackfruit, including simple sugars such as sucrose, glucose, and fructose. The addition of these components can explain the increase in TPT from 13.85 to 15.27 °Brix. Galdane et al. (2023) explained that fermentation can convert complex components into simpler compounds through enzymatic activity. Esteves et al. (2025) also discussed the transformation of soybean components during fermentation. However, the refractometer value does not only represent sugar, but rather the combined response of various solutes that affect the refractive index. Jaywant et al. (2022) discussed the principle of measuring soluble solids using refractometry, while Gaur and Gänzle (2023) explained the changes in food components during fermentation. Therefore, an increase in TPT cannot be considered direct evidence that all bioactive components or vitamins increase in the same proportion. Sitohang (2022) can be used as a supporting reference in discussing the characteristics of soluble components, but the specific relationship between vitamin C, phenolics, and TPT in this study still needs to be tested quantitatively.

Unlike vitamin C and TPT, total phenolics did not increase linearly. A 5% concentration produced the highest value of 115.40 mg GAE/100 g, while a 10% concentration produced the lowest value of 93.60 mg GAE/100 g. This pattern suggests that the amount of jackfruit juice is not the sole factor determining the measured total phenolic response. Gaur and Gänzle (2023) discussed changes in food compounds during fermentation, while Lu et al. (2025) were referenced in their thesis to explain the possible fermentation conditions that support lactic acid bacteria activity. Cirlini et al. (2020) explained that enzymes such as β-glucosidase and esterase can release phenolic compounds from bound forms. Mechanistically, this release can increase the number of reacting compounds in the total phenolic assay. However, the fermentation process can also cause transformation or degradation of phenolic compounds, so the net change depends on the balance between release and loss of compounds. Adebo and Medina-Meza (2020) emphasized that

fermentation can change the profile of bioactive compounds through biotransformation. Zhao et al. (2021) also discussed changes in phenolic compounds and their interactions with food components. In black soygurt, black soybeans and jackfruit juice are two sources of phenolic compounds that can interact with proteins and other components. Choi et al. (2020) discussed the anthocyanin content of black soybeans, which varies by variety, while jackfruit can contribute flavonoids, tannins, and phenolic acids.

It is important to note that the Folin–Ciocalteu method does not exclusively measure phenolic molecules. Pérez et al. (2023) explain that this reagent can also react with other reducing compounds, including ascorbic acid and some non-phenolic compounds. Therefore, the increase in vitamin C levels in treatments with high jackfruit juice concentrations could potentially influence the response of the total phenolic assay. The reported values should be understood as gallic acid equivalents based on the method used, rather than as a direct identification of all phenolic compounds in the product. Explanations such as osmotic pressure due to increased sugars and changes in bacterial activity, as discussed by Sionek et al. (2024), could be one hypothesis to explain these fluctuations. However, this study did not report measurements of bacterial growth or enzyme activity, so these mechanisms remain uncertain. Analysis of individual phenolic components is required to test whether the decrease in values at 10% concentration is due to degradation, changes in compound binding, or analytical response.

The color score increased from 2.44 in the control to 3.12 with the addition of 20% jackfruit juice. This change is consistent with the natural characteristics of jackfruit, which contains carotenoid pigments. Ansar et al. (2020) explain the role of carotenoids in the formation of yellow fruit flesh, while Maoka (2020) discusses the characteristics of carotenoid pigments in food. Increasing the proportion of jackfruit juice can increase the contribution of yellow color to the product. Even though it is made from black soybeans, the resulting product does not show a dominant black color. Hana and Sujono (2024) explained that black soybean anthocyanins are primarily concentrated in the seed coat. The soaking and filtering process has the potential to reduce the amount of seed coat that enters the soybean extract. Furthermore, Esteves et al. (2025) discussed the possibility of changes in color characteristics in fermented black soybean products. Kunnaryo and Wikdanari (2021) also explained that processing conditions and pH changes can affect the stability of anthocyanin pigments. While this explanation is plausible, this study did not measure anthocyanin content or instrumental color values, so the cause of the color change cannot be definitively determined. For the aroma parameter, the score increased from 1.36 in the control to 2.44 at 20% concentration. Mukarami et al. (2023), as cited in the thesis, explained that heating can cause denaturation of the lipoxygenase enzyme, which is associated with the unpleasant aroma of soybeans. However, the product manufacturing procedure involves several heating stages at different temperatures and for different purposes. The effect of each stage on the aroma-forming compounds has not been measured directly.

Suo et al. (2024) reported the presence of certain acidic compounds in jackfruit fermented using lactic acid bacteria, while Grimm and Steinhaus (2019) discussed volatile compounds that contribute to the aroma of jackfruit. Fatmala et al. (2023) explained that the interaction between volatile compounds, microbial activity, and processing conditions can influence the aroma profile. Based on these references, aroma changes in black soygurt may be the result of the interaction of raw material aromas, fermentation metabolites, and soybean characteristics. However, because volatile compound analysis was not performed, attribution to specific compounds remains conjectural. These results are also insufficient to conclude that aroma acceptance remains intact without separate liking measurement data.

The textures exhibited different patterns of chemical characteristics. Treatment N5 produced the highest score of 2.84 and was categorized as thick, while N15 and N20 obtained scores of 1.88 and 1.96, respectively, with the slightly thick category. Su'i et al. (2025) explained that acidification during fermentation triggers protein coagulation, which contributes to the formation of a gel structure. In soy-based products, gel stability is influenced by fermentation conditions and the characteristics of the protein matrix. Dimas and Desna (2021) reported that the addition of jackfruit extract can reduce the viscosity of yogurt drinks as the concentration increases. Kusnadi and Rahmawati (2017) also discussed the decrease in consistency of soy yogurt due to the addition of excessive amounts of fruit juice. These findings are consistent with the texture scores at N15 and N20. One possible explanation is that the addition of the liquid phase alters the balance between water and solids in the gel matrix. However, this mechanism cannot be confirmed without measuring the viscosity, water holding capacity, or microstructure of the product.

In the thesis, a pH value of 3.72 was reported for treatments N15 and N20. Nguyen et al. (2026) cited a reference range for the isoelectric point of soybean protein around pH 4.5–5.0, while Liu et al. (2025) discussed changes in protein interactions and gel structure due to acidification conditions. These data can be used to hypothesize that acidic conditions affect texture stability. However, a causal relationship between pH and decreased texture scores cannot be determined without more detailed gel structure data and physical characteristics. Permadi et al. (2021) also discussed the relationship between solids composition and product characteristics, but the TPT results in this study do not necessarily prove changes in viscosity. For taste, all treatments remained in the sour category, with the highest score at N10 and the lowest at N20. Emmawati et al. (2021) and Adiputra et al. (2022) explained that the formation of organic acids during fermentation is an important factor in yogurt's flavor characteristics. Gabriela et al. (2021)

discussed the potential of fruit additions in altering the balance of sweet and sour flavors, while Rahayunia and Rusmiyanto (2018) emphasized the importance of flavor balance in product acceptance. However, the taste scores in this study were based on sourness intensity, not a preference scale. Therefore, a higher score cannot be directly interpreted as a more preferred product. The discussions of Uemuramanda and Parsuhip (2025) and Margareta (2021) regarding taste complexity can be a basis for further research, but claims about clean aftertaste, decreased unpleasantness, or increased liking need to be confirmed through sensory instruments that specifically measure these attributes.

Several limitations should be considered when interpreting the study results. First, the number of treatments was limited to five jackfruit juice concentrations with four replications for experimental testing. This range is sufficient to observe initial patterns, but it does not reflect the full range of possible product responses at concentrations outside the 0–20% range. Second, the sensory testing involved 25 untrained panelists aged 21–23 years. This characteristic limits the generalizability of the results to a wider range of consumer age groups and characteristics. Third, the total phenolic content was presented descriptively without information on the results of the significance test between treatments. Fourth, the available sensory data did not include a separate measurement of overall preference. This limits conclusions about the most preferred formulation. Fifth, several mechanisms proposed in the discussion, such as changes in enzyme activity, osmotic pressure on bacteria, protein-phenolic interactions, and changes in volatile compounds, were not directly measured. Furthermore, the use of a refractometer for TPT cannot separate the contribution of sugars from other soluble components. This limitation emphasizes that the mechanistic relationships discussed are interpretations based on literature and data patterns, not mechanisms that have been directly demonstrated in this study.

Practically, the results showed that the addition of jackfruit juice can be used to increase vitamin C and TPT levels in black soygurt. A 20% concentration produced the highest vitamin C content but was also associated with a thinner texture and higher unpleasant aroma scores. Conversely, a 5% concentration produced the highest descriptive total phenolics and maintained the thick texture category. Therefore, the best formulation needs to be determined based on the product's purpose, not solely based on the highest value for a single parameter. For food product development, a concentration of 5–10% can be considered as an initial range for further research because the texture score is still in the viscous category and the total phenolic value at N5 is the highest in this test. However, this range cannot be declared the optimal formulation until it is tested with data on consumer acceptance, storage stability, and microbiological quality.

5. CONCLUSION

Based on the research results, it can be concluded that adding varying concentrations of jackfruit juice to black soygurt affected vitamin C levels, total phenolics, total soluble solids, aroma, and texture, but did not affect color or flavor. The addition of jackfruit juice also improved the sensory quality of black soygurt, particularly in aroma and texture.

REFERENCES

1. Adebo, O.A., dan Medina-Meza, I.G. Impact of fermentation on the phenolic compounds dan antioxidant activity of whole cereal grains: A mini review. Molecules. 2020; 25(4): 1-19. https://doi.org/10.3390/molecules25040927
2. Adiputra, R., Ramadiyanti, M., Ulfah, T., dan Maesaroh, D.I. Pengaruh lama waktu inkubasi, konsentrasi starter terhadap pH, viskositas dan sifat organoleptik yoghurt susu sapi. Composite: Jurnal Ilmu Pertanian. 2022; 4(2): 81-92. https://doi.org/10.37577/composite.v4i2.557
3. Anjum, N., Islam, M.N., Roy, J., dan Mahomud, M.S. Enhancing soy yogurt: The impact of mango pulp and alkali blanching on physico-chemical, nutritional dan sensory qualities. Applied Food Research. 2025; 5(2): 1-11. https://doi.org/10.1016/j.afres.2025.100983
4. Ansar, A., Sukmawaty, Putra, G.M.D., dan Najat, N.H. Application of Aloe Vera Gel as an Edible Coating at Jackfruit. Jurnal Agritechno. 2020; 13(2): 77-83.
5. Anwer, M., dan Wei, M.Q. Harnessing the power of probiotic strains in functional foods: nutritive, therapeutic, dan next-generation challenges. Food Science and Biotechnology. 2024; 33(9): 2081-2095.
6. Cahyanti, A.N., Nofiyanto, E., Sampurno, A., Sudjatinah, dan Iswoyo. Total bakteri asam laktat, pH, aktivitas antioksidan dan kesukaan soygurt nangka dengan penambahan ekstrak rempah Antonia. 2024; 12: 104-112.
7. Choi, Y.M., Yoon, H., Lee, S., Ko, H.C., Shin, M.J., Lee, M.C., Hur, O.S., Ro, N.Y., dan Desta, K.T. Isoflavones, anthocyanins, phenolic content, dan antioxidant activities of black soybeans (Glycine max (L.) Merrill) as affected by seed weight. Scientific Reports. 2020; 10(1): 19960.
8. Cirlini, M., Ricci, A., Galaverna, G., dan Lazzi, C. Application of lactic acid fermentation to elderberry juice: Changes in acidic dan glucidic fractions. Lwt. 2020; 118(1): 108779.
9. Dewi, D.C., Dewi, D.P., Laili, G.D.N., dan Hernawati, H. Kualitas susu kedelai hitam ditinjau dari kadar proksimat, aktivitas antioksidan dan kadar antosianin. Ilmu Gizi Indonesia. 2021; 4(2): 125-134. https://doi.org/10.35842/ilgi.v4i2.197

10. Dimas, F.N., dan Desna, A.W. Pengaruh penambahan sari wortel pada yoghurt ditinjau dari aw, kadar air, viskositas, total asam tertitrasi dan kadar protein. Jurnal Ilmu-Ilmu Pertanian. 2021; 5(1): 18-23 https://doi.org/10.32585/ags.v5i1.1374
11. Emmawati, A., Rizaini, R., dan Rahmadi, A. Changes the population of total bacteria, lactic acid bacteria, mold/yeast, titratable acid dan sensory response of durian yoghurt. Journal of Tropical AfriFood. 2021; 2(2): 79-89. http://dx.doi.org/10.35941/jtaf.2.2.2020.5131.79-89
12. Engels, W., Siu, J., van Schalkwijk, S., Wesselink, W., Jacobs, S., dan Bachmann, H. Metabolic conversions by lactic acid bacteria during plant protein fermentations. Foods. 2022; 11(7): 1005. https://doi.org/10.3390/foods11071005
13. Esteves, T.C.F., Felberg, I., Farah, A., Faria-Machado, A.F., Walter, E.H.M., Santiago, M.C.P.A., Pacheco, S., Antoniassi, R., Deliza, R., Carrão-Panizzi, M.C., dan Calado, V. Formulation of black soybean yogurt dan evaluation of changes in the bioactive profile dan other compositional aspects during fermentation dan storage. Beverages. 2025; 11(4): 1-22. https://doi.org/10.3390/beverages11040103
14. Faiz, S.N., Santosa, A.P., Afifah, D.N., dan Purnawanto, A.M. Karakteristik minuman sinbiotik soyghurt kedelai kuning (Glycine max) dan kedelai hitam (Glycine soja L.) dengan penambahan inulin pada konsentrasi yang berbeda. Proceedings Series on Physical & Formal Sciences. 2022; 4: 405-413. https://doi.org/10.26877/jiphp.v6i1.11822
15. Fatmala, N., Adam, K.A., dan Risna, Y.K. Karakteristik sensoris dan nilai pH yoghurt dengan variasi starter bakteri yang di inkubasi selama 8 jam. Jurnal Sains Pertanian. 2023; 7(3): 106-109. https://doi.org/10.51179/jsp.v7i3.2223
16. Gabriela, F.V., Chairunnisa, F., Raniah, N., Pratama, R., Swandi, M.K., dan Azizah, N. Uji organoleptik dan umur simpan soyghurt dengan berbagai konsentrasi gula dan waktu inkubasi. Jurnal Penelitian Biologi, Botani, Zoologi dan Mikrobiologi. 2021; 6(2): 63-69. https://doi.org/10.33019/ekotonia.v6i2.2815
17. Galdane, A.V., Pawar, C.D., dan Kakade, A.R. Physicochemical properties of jackfruit dan kokum. The Pharma Innovation. 2023; 12(12): 50-52. https://www.doi.org/10.22271/tpi.2023.v12.i12a.24471
18. Gaur, G., dan Gänzle, M.G. Conversion of (poly)phenolic compounds in food fermentations by lactic acid bacteria: Novel insights into metabolic pathways dan functional metabolites. Current Research in Food Science. 2023; 6: 1-11. https://doi.org/10.1016/j.crfs.2023.100448
19. Grimm, J. E., dan Steinhaus, M. Characterization of the Major Odor-Active Compounds in Jackfruit Pulp. Journal of Agricultural dan Food Chemistry. 2019; 67(20): 5838-5846. https://doi.org/10.1021/acs.jafc.9b01445
20. Gunawan, W.B., dan Basoeki, L.E.A.S. Incorporating watermelon rind into jackfruit seed drink: A functional drink rich in antioxidant dan phenolic compounds. Edufortech. 2022; 7(2): 112-120. https://doi.org/10.17509/edufortech.v7i2.50963
21. Hana, U.R., dan Sujono, T.A. Tinjauan literatur: Aktivitas antioksidan biji kedelai hitam. Usadha Journal of Pharmacy. 2024; 3(4): 453-464. https://doi.org/10.23917/ujp.v4i2.436
22. Harefa, N., Feronika, N., Kana, A.D., Hutagalung, R., Chaterine, D., Bela, Y. Analisis kandungan vitamin c bahan makanan dan minuman dengan metode iodimetri. Science Education dan Application Journal. 2020; 2(1): 35-42. https://doi.org/10.30736/seaj.v2i1.194
23. Hastuti, R., dan Junardi, J. Analisis kadar karbohidrat dan protein pada yoghurt biji nangka. Journal of Food Security and Agroindustry. 2024; 2(2): 54-60.
24. Hossain, A., Dewan, M.F., Billah, M.T., Ahiduzzaman, M. Jackfruit seed as a natural source for protein and mineral enrichment of yogurt. Journal of Food Processing dan Preservation. 2023; 9: 1-13. https://doi.org/10.1155/2023/9899564
25. Istiqomah, N., dan Ramadhani, A.H. Profil vitamin C mangga podang di kecamatan Mojo, Semen, Banyakan dan Tarokan kabupaten Kediri. Jurnal Biologi dan Pembelajarannya. 2018; 5(1): 24-31. https://doi.org/10.29407/jbp.v5i1.12032
26. Jayanti, J., dan Rizkaprilisa, W. Pangan fungsional dari tempe non-kedelai. Science Technology dan Management Journal. 2024; 4(2): 39-44. https://doi.org/10.53416/stmj.v4i2.242
27. Jaywant, S.A., Singh, H., dan Arif, K.M. Sensors and instruments for brix measurement : A Review. Journal Sensors. 2022; 22(6): 1-20. https://doi.org/10.3390/s22062290
28. Kong, X., Xiao, Z., Du, M., Wang, K., Yu, W., Chen, Y., Liu, Z., Cheng, Y., dan Gan, J. Physicochemical, textural, and sensorial properties of soy yogurt as affected by addition of low acyl gellan gum. Gels. 2022; 8(7): 1-11. https://doi.org/10.3390/gels8070453
29. Krawan, Y., Hervelly, H., dan Pirmansyah, W. Korelasi konsentrasi black tea powder (Camelia sinensis) terhadap mutu sensori produk dark chocolate. Pasundan Food Technology Journal (PFTJ). 2019; 6(2): 83-128. https://doi.org/10.21776/ub.jpa.2025.013.04.1
30. Kunnaryo, H.J.B., dan Wikdanari, P.R. Antosianin dalam produksi fermentasi dan perannya sebagai antioksidan. Journal of Chemistry. 2021; 10(1): 1-108. https://doi.org/10.26740/ujc.v10n1.p24-36
31. Kusnadi, J., dan Rahmawati, D. Penambahan sari buah murbei (Morus alba L) dan gelatin terhadap karakteristik fisiko-kimia dan mikrobiologi yoghurt susu kedelai. Jurnal Pangan dan Agroindustri. 2017; 5(3): 83-94.

32. Liu, Q., Xu, J., Zhou, X., Li, P., Zhang, X., Jiang, L., and Liu, Y. Studying the release of soybean taste-active peptides prepared by proteases derived from different fungi through Peptidomics. Food Chemistry. 2025; 484(35): 144443. https://doi.org/10.1016/j.foodchem.2025.144443
33. Lu, C., Zhang, J., Zhao, X., Zi, Y., and Xiao, X. Biotransformation of Phenolic Acids in Foods : Pathways, Key Enzymes, and Technological Applications. Foods. 2025; 14(13): 1-27. https://doi.org/10.3390/foods14132187
34. Maoka, T. Carotenoids as natural functional pigments. Journal of Natural Medicines. 2020; 74(1): 1-16.
35. Fauzia, A.N., dan Amir, S. The improvement of yogurt quality with the introduction of gandaria (BoueaMacrophylla Griffith). Jurnal Gizi Kerja dan Produktivitas. 2024; 5(2): 286-294. http://dx.doi.org/10.62870/jgkp.v5i2.283
36. Margareta, M. 2021. Pengaruh lama perendaman biji kedelai (Glycine max L . Merr) terhadap karakteristik organoleptik susu kedelai. Journal of Agriculture and Humavs Resource Development Studies. 2021; 2(1): 9-14. https://doi.org/10.46575/agrihumanis.v2i1.90
37. Marjoni, M.R., Afrinaldi, dan Novita, A.D. Kandungan total fenol dan aktivitas antioksidan ekstrak air daun kersen (Muntingia calabura L.). Jurnal Kedokteran YARSI. 2017; 23(3): 187-196.
38. Maulani, S.N.R. Review: Jus buah terfermentasi sebagai minuman probiotik. Jurnal Riset Teknologi Pangan dan Hasil Pertanian. 2023; 4(1): 18-28. https://doi.org/10.54367/retipa.vi.3019
39. Mukarami, K., Matsuno, M., dan Shimoyamada, M. Investigating thermal denaturation kinetics of 7S and 11S proteins and lipoxygenase in soymilk through ohmic heating. Journal of Food Process Engineering. 2023; 46(12): 1-10. https://doi.org/10.1111/jfpe.14493
40. Nguyen, T., Tuong, T., Tran, V., Huynh, Q., dan Dang, T. Accelerating the coagulation of germinated soymilk by glucono-δ-lactone using different physical treatments and quality assessment of separated soybean whey. Food Chemistry : X. 2026; 35: 1-11. https://doi.org/10.1016/j.fochx.2026.103724
41. Pérez, M., Dominguez-López, I., dan Lamuela-Raventós, R.M. The chemistry behind the folin-ciocalteu method for the estimation of (Poly)phenol content in food: Total phenolic intake in a mediterranean dietary pattern. Journal of Agricultural dan Food Chemistry. 2023; 71(7): 17543-17553. https://doi.org/10.1021/acs.jafc.3c04022
42. Permadi, E., Suciati, F., dan Lestari, R.B. Kualitas yoghurt susu kambing PE dengan suplementasi ekstrak buah lakum terhadap viskositas, total asam dan total padatan terlarut. Jurnal Sains Peternakan. 2021; 9(1): 40-47. https://doi.org/10.21067/jsp.v9i1.5668
43. Rahayunia, S., dan Rusmiyanto, E. Pengaruh penambahan sari buah lakum (Cayratia trifolia (L.) Domin) terhadap kualitas dan penerimaan organoleptic pada yoghurt. Protobiont. 2018; 7(2): 1-9 https://doi.org/10.26418/protobiont.v7i2.25291
44. Sionek, B., Szydłowska, A., Trząskowska, M., dan Kołożyn-Krajewska, D. The impact of physicochemical conditions on lactic acid bacteria survival in food products. Fermentation. 2024; 10(6): 1-17. https://doi.org/10.3390/fermentation10060298
45. Sitohang, A. Merancang minuman fungsional fruit tea nangka. Jurnal Riset Teknologi Pangan dan Hasil Pertanian. 2022; 2(2): 126-136. https://doi.org/10.54367/retipa.v2i2.1892
46. Solichah, A.I., Anwar, K., Rohman, A., dan Fakhrudin, N. Profil fitokimiadan aktivitas antioksidan beberapa tumbuhan genus artocarpus di Indonesia. Journal of Food dan Pharmaceutical Sciences. 2021; 9(2): 443-460. https://doi.org/10.22146/jfps.2026
47. Su'i, M., Cendia, M.P., dan Anggraeni, F.D. Pengembangan produk yoghurt dari santan kelapa dan susu sapi (kajian dari suhu dan lama inkubasi). Jurnal Teknologi Industri Pertanian. 2025; 19(1): 104-113. https://doi.org/10.21107/agrointek.v19i1.17429
48. Suo, H., Xiao, S., Wang, B., Cai, Y., and Wang, J. Waste to wealth : dynamics and metabolic profiles of the conversion of jackfruit flake into value-added products by different fermentation methods. Food Chemistry: X. 2024; 21(1): 1-11. https://doi.org/10.1016/j.fochx.2024.101164
49. Suo, H., Xiao, S., Wang, B., Cai, Y., dan Wang, J. Insights into physicochemical and sensory properties and metabolomics changes of antioxidant-rich jackfruit juice fermented by lactic acid bacteria. Food Bioscience. 2024; 58(7): 103815. https://doi.org/10.1016/j.fbio.2024.103815
50. Syarifah, D.L., Sachriani, dan Ngurah, I.G.A. Pengaruh penggunaan sari buah nangka (Artocarpus Heterophyllus) pada pembuatan cendol terhadap nilai Ph, daya serap dan mutu sensoris. Jurnal Ilmiah Wahana Pendidikan. 2026; 12(3.B): 71-85.
51. Uemuramanda, K.M. dan Parsuhip, A. Karakteristik fisikokimia dan sensori yoghurt sari kacang arab dengan penambahan sari bit merah. Jurnal Teknologi Pangan dan Kesehatan. 2025; 7(2): 64-72. https://doi.org/10.36441/jtepakes.v7i2.3461
52. Victoria, O., Folakemi, O.A., dan Olugbemiga, O.S. Unveiling the role of functional foods with emphasis on prebiotics and probiotics in human health: A review. Journal of Functional Foods. 2024; 119(3): 1-16. https://doi.org/10.1016/j.jff.2024.106337

53. Wardhana, M.Y., Chairuni, A.R., dan Makmur, T. Daya terima konsumen terhadap produk olahan minuman serbuk dari limbah biji nangka (Arthocarphus heterophilus). MAHATANI: Jurnal Agribisnis (Agribusiness dan Agricultural Economics Journal). 2022; 5(1): 90-97. https://doi.org/10.52434/mja.v5i1.1766
54. Zhao, Y.S., Eweys, A.S., Zhang, J.Y., Zhu, Y., Bai, J., Darwesh, O.M., Zhang, H.B., dan Xiao, X. Fermentation affects the antioxidant activity of plantbased food material through the release dan production of bioactive components. Antioxidants. 2021; 10(12): 1-15. https://doi.org/10.3390/antiox10122004