RESEARCH STUDY
English Version

OPEN ACCESS

Microbiological Properties, Dietary Fiber, and Nutritional Content of Fluidized Bed-Dried Local Legumes and Salak Yogurt Powder

Sifat Mikrobiologi, Serat Pangan, dan Kandungan Zat Gizi pada Bubuk Yogurt *dari Kacang-Kacangan dan Salak Lokal yang Diproses melalui Fluidisasi*

Irma Nuraeni[1,2], Sumarto Sumarto[1,2]*, Ani Radiati[1,2]

[1]Department of Nutrition, Poltekkes Kemenkes Tasikmalaya, Indonesia
[2]Health And Disaster Emergency (HADE) Center, Center of Excellent (CoE), Poltekkes Kemenkes Tasikmalaya, Indonesia

ARTICLE INFO

Received: *31-12-2024*
Accepted: *03-06-2025*
Published online: *12-09-2025*

Correspondent:
Sumarto Sumarto
sumarto@dosen.poltekkestasikmalaya.ac.id

DOI:
10.20473/amnt.v9i3.2025.506-513

Available online at:
https://e-journal.unair.ac.id/AMNT

Keywords:
Dietary Fiber, Fluidized Bed Dryer, Lactic Acid Bacteria, Local Legume, Nutritional Content

ABSTRACT

Background: A major challenge in producing yogurt powder (YP) is the need for drying technology that maintains probiotic viability. In Small-Medium Enterprises (SMEs), adoption of such technologies to extend shelf life remains limited. The Fluidized Bed Dryer (FBD) provides a relatively simple method for producing YP from local legumes and salak.

Objectives: To analyze the amount of Lactic Acid Bacteria (LAB), Dietary Fiber (DF), and Nutritional Content (NC) in local legumes and Salak Flour (SF) that is processed with a FBD.

Methods: An experimental design with four treatments was applied: Mungbean (MYP), Garut Redbean (RYP), Manonjaya Salak-Mungbean (MS-MYP), and Manonjaya Salak-Garut Redbean Yogurt Powder (MS-RYP). Parameters measured included microbiological properties, DF, and NC (total calories, calories from fat, ash, moisture, carbohydrate, fat, protein, sugar, cholesterol, sodium, zinc, iron, and calcium). Differences in NC were analyzed using the Kruskal-Wallis test.

Results: All YP samples contained LAB counts above the Indonesian National Standard (8×10^8 - 1×10^{10} cfu/g). DF content was higher in YP with added SF. Total ash, iron, and calcium were also higher in legume-based YP supplemented with SF, whereas sodium content was lower. Other nutrient levels were comparable between formulations with or without SF.

Conclusions: Local legume YP added with SF contains higher levels of LAB, DF, total ash, iron, and calcium than legume YP alone.

INTRODUCTION

Yogurt has gained immense popularity globally as a fermented dairy product because of its numerous health advantages. Yogurt's shelf life could be increased by freeze-drying, even if it's now quite short[1]. Yogurt is an extremely perishable fermented milk product that can easily go bad due to excess lactic acid production and other spoiling causes. Therefore, it is necessary to find ways to preserve it and give it a longer shelf life in a more stable state[2].

The increasing demand for plant-based alternatives to traditional dairy products has led to a surge in research and development efforts. Among these alternatives, legume-based yogurt has emerged as a promising option due to its nutritional value and potential health benefits. This paper will delve into the process of creating yogurt powder from legumes, its nutritional composition, and its potential applications[3-5].

Local Indonesian legumes, specifically Mung beans and Garut Red beans, are other non-milk raw materials that could be used as an alternate substrate in yogurt. Furthermore, Manonjaya salak flour, which is high in fiber and carbohydrates, can be combined with yogurt to create a synbiotic product[1]. Salak Manonjaya is one of Indonesia's native varieties whose prestige is currently declining due to its less favorable taste quality than salak on the market today. Therefore, it is necessary to revitalize the utilization of salak, one of which is through processing into flour. Salak Manonjaya flour contains nutrients that are quite good and can potentially improve the health status of those who consume it. Manonjaya salak flour can be accepted as a semi-finished food product and as a raw material for a very varied processed product. Salak Manonjaya flour has a fairly high nutrient content, especially dietary fiber was 32%. In addition, Manonjaya Salak flour has a fairly low moisture

How to cite: *Nuraeni, I., Sumarto, S., & Radiati, A. (2025) Microbiological Properties, Dietary Fiber, and Nutritional Content of Fluidized Bed-Dried Local Legumes and Salak Yogurt Powder: Sifat Mikrobiologi, Serat Pangan, dan Kandungan Zat Gizi pada Bubuk Yoghurt dari Kacang-Kacangan dan Salak Lokal yang Diproses melalui Fluidisasi. Amerta Nutrition, 9(3), 506–513.*

content was 7%, so it has the potential to extend its shelf life[6].

The challenge in making yogurt powder is that a drying technology is needed to maintain the probiotics in the product. One of the drying technologies of yogurt powder to extend shelf life was a freeze-drying technology[1]. However, the technology is still difficult to adopt in SME because it is costly. A simple technology, a FDB, could be introduced to make yogurt powder from local beans and salak. The use of FDB in the food industry has grown dramatically in the last several years. In the field of food processing and preservation, fluidization methods have been applied for product development, energy efficiency, and overall product quality[7]. The application of FBD technology in yogurt powder production presents an innovative approach to achieving an efficient drying process while maintaining critical qualities such as probiotic viability, flavor integrity, and product stability.

FDB offers a highly efficient means of removing moisture from yogurt, leveraging its unique mechanism where particles are suspended in an upward air stream, creating a fluid-like state. This process allows for uniform heat and mass transfer, which results in faster drying compared to conventional methods. The enhanced heat transfer characteristics of FBD make it an ideal solution for drying heat-sensitive products, such as probiotic-rich yogurt powders, as it can achieve high moisture removal rates without subjecting the product to excessive thermal degradation[8]. This rapid drying reduces the exposure of sensitive bioactive compounds to prolonged heat, preserving their functional qualities. This study aimed to analyze the amount of LAB, dietary fiber, and nutritional content in local legumes and salak powder that it processed with a FDB. The parameters indicate the quality of the yogurt powder produced in the study. Resilience of LAB reflects the presence of probiotics in the yogurt powder, while a high dietary fiber content suggests the presence of prebiotics. The nutritional content parameter represents the quality of the yogurt powder derived from plant sources and is compared to the standards.

METHODS

This study was an experimental design with 4 treatments. The treatments were MYP, RYP, MS-MYP, and MS-RYP. The composition of MYP is 100% made from mung beans, RYP is 100% made from Garut Red Beans, while MS-MYP consists of 100% MYP substituted with 20% MS, as well as MS-RP consists of 100% RYP added with 20% MS. The raw materials to make the yogurt powder were sourced from local markets in the Tasikmalaya, West Java, Indonesia. The raw materials used were flours of Garut Red Beans (*Phaseolus vulgaris L.*), Mung Beans (*Vigna radiata*), and Manonjaya salak (*Salacca zalacca*). The process of making salak flour yogurt and local legumes, as well as testing microbiological properties was carried out at the Food Processing Laboratory of the Department of Nutrition, Health Polytechnic of Tasikmalaya. Meanwhile, dietary fiber and Nutritional Content testing was conducted at PT Saraswati Indo Genetech Bogor.

Parameters in the research were microbiological properties, dietary content, and other nutritional content. The measured microbiological properties were the amount of LAB. Colony count test of Lactic Acid Bacteria using Man Ragosa Sharpe Agar (MRSA).This study also measured other nutritional content, such as calories, ash, moisture, carbohydrate, fat, protein, sugar, cholesterol, sodium, zinc, iron, and calcium. Nutritional content parameters were measured by proximate analysis consisting of energy content, carbohydrates, fat, protein, water content, and total minerals. Micronutrient parameters were measured by standardized tests, such as the Atomic Absorption Spectrophotometer (AAS) based on 18-13-1/MU/SMM-SIG (ICP OES) procedure, namely zinc (Zn), iron (Fe), and calcium (Ca). The tools used are fluid bed dryer, petri dish, stainless spoon, blender, test tube, measuring cup, erlenmeyer, stainless spatula, test tube rack, aluminum foil, autoclave, basin, pot, ladle, sieve, glass jar, incubator, plastic wrap, and thermometer. The materials used are Manonjaya salak, garut red beans, green beans, NaCl, aquades, MRS agar media, mineral water, sugar, and yogurt starter. The process of making Manonjaya salak flour is based on the research results listed in the 2016 Sumarto et al. proceedings article[6]. Meanwhile, the process of making mung beans and Garut Red beans flour involves soaking and boiling them until the epidermis is peeled off, adding water, and then filtering. The bean juice was boiled again, and yogurt starter was added and incubated. After becoming yogurt, it is stored in a cup and put into a fluid dryer for the drying process until it changes color and then blended until smooth into flour. MS-MYP and MS-RYP flour products have the same procedure as the original peanut yogurt, except that when boiling, salak manonjaya flour is added to 20% of the volume of bean juice.

The parameters measured in each treatment were assessed in duplicate. The difference of nutrient content parameter was analyzed by Kruskal-Wallis test. Statistical significance was determined at the 0.05 level. Differences among two or more values will be considered statistically significant when indicated. This study was approved by the Komisi Etik Penelitian Kesehatan Politeknik Kesehatan Tasikmalaya, approval No: DP.04.03/16/80/2023, Date: July 11, 2023.

RESULTS AND DISCUSSIONS

Dehydrated yogurt is still rare, despite being one of the most popular dairy products consumed globally. Yogurt powder is a dietary item that is thought to be healthy and can be added to or used as a supplement in dairy products, drinks, cookies, and ice cream[9]. Yogurt is a dairy product produced from lactic acid fermentation through the activity of *Lactobacillus bulgaricus* bacteria and *Streptococcus thermophilus.* Probiotic microorganisms are present in yogurt. Living microorganisms known as probiotics are those that enter the body in sufficient amounts to boost the host's health. Either vegetable or animal milk can be used as the basic ingredient for yogurt. Mung bean and red bean are one types of vegetable raw materials that can be utilized. Although they are widely available in Indonesia, mung beans have not been utilized to their full potential as a food substitute despite their great nutritional value[10].

How to cite: *Nuraeni, I., Sumarto, S., & Radiati, A. (2025) Microbiological Properties, Dietary Fiber, and Nutritional Content of Fluidized Bed-Dried Local Legumes and Salak Yogurt Powder: Sifat Mikrobiologi, Serat Pangan, dan Kandungan Zat Gizi pada Bubuk Yoghurt dari Kacang-Kacangan dan Salak Lokal yang Diproses melalui Fluidisasi. Amerta Nutrition, 9(3), 506–513.*

Red beans have a greater taste and flavor than other legumes. Red beans contain complex carbohydrates, protein, vitamin B, iron, calcium, phosphorus, fiber, and flavonoids. Red beans yogurt is one of the new fermented red bean products.

Figure 1. The Appearance of yogurt in some treatments

Maintaining probiotic viability in yogurt powder is a significant challenge, as probiotics are susceptible to high temperatures typically used in drying processes. In FDB, the ability to control temperature and airflow more precisely minimizes the thermal damage to probiotics. Studies by another study indicates that FBD technology can maintain the viability of probiotic strains like *Lactobacillus acidophilus* and *Bifidobacterium bifidum* better than traditional spray drying methods[11]. This is particularly important for the commercial production of yogurt powders aimed at the functional foods market, where the preservation of probiotics is critical for health claims. This plant-based yogurt powder supports sustainable diet programs[12].

Additionally, another study reported that FDB is advantageous in retaining other bioactive compounds such as vitamins and enzymes[13]. The efficient heat transfer in FBD prevents the localized overheating commonly seen in methods like spray drying, where the powder particles are exposed to high temperatures during atomization. This supports the production of yogurt powders with enhanced nutritional and functional benefits. The technology has the potential to be applied by SMEs at a relatively low cost. Unlike other technologies that produce high-fiber food products at a high price, this method remains affordable[14].

Table 1. Number of Probiotic LAB Colonies and Dietary Fiber Content in Yogurt Powder with with a FDB Method

Treatment	Lactic Acid Bacteria Count (unit per g or per ml)	Dietary Fiber (%)
MYP	8×10^8	8.74
RYP	5×10^9	10.56
MS-MYP	7×10^9	10.83
MS-RYP	1×10^{10}	14.90

LAB in the yogurt convert lactose to lactic acid as a metabolite. The metabolite is excreted out of the cells and is accumulated in the fermenting liquid. Researchers utilizing local raw materials have comprehensively explored the various synbiotic yogurt products[1]. The result of this study showed that all treatments of yogurt have a total LAB 8×10^8 - 1×10^{10} cfu/g above the min. 10^7 cfu/g (Table 1)**,** which meets the required benchmark for SNI of the Lactic Acid Bacteria population in yogurt[15]. Yogurt is one of the functional foods that has excellent benefits for human health. The bacteria used in the fermentation process are probiotics. Probiotics contained in yogurt are proven to prevent disease and have health benefits, so the daily consumption of yogurt is highly recommended[16]. Other studies report that adequate consumption of probiotics, including those

How to cite: *Nuraeni, I., Sumarto, S., & Radiati, A. (2025) Microbiological Properties, Dietary Fiber, and Nutritional Content of Fluidized Bed-Dried Local Legumes and Salak Yogurt Powder: Sifat Mikrobiologi, Serat Pangan, dan Kandungan Zat Gizi pada Bubuk Yoghurt dari Kacang-Kacangan dan Salak Lokal yang Diproses melalui Fluidisasi. Amerta Nutrition, 9(3), 506–513.*

from LAB, can positively impact the health of children and adolescents[17]. If lactic acid bacteria are in a non-living form, known as postbiotics, they can still have a positive effect on the health of those who consume them[18].

Table 2. Nutritional Content of Local Beans and Salak Yogurt Powder FDB Method

Parameter	Mean±Standar Deviation				p-value
	MYP	RYP	MS-MYP	MS-RYP	
Total Calorie (kcal/100 g)	363.07±0.71	359.90±0.07	365.04±0.18	357.42±1.36	0.083
Calorie from Fat (kcal/100 g)	10.67±0.19	12.87±0.13	10.94±0.19	13.99±0.32	0.092
Ash (%)	1.37±0.04	2.04±0.02	1.53±0.02	2.26±0.03	0.083
Moisture (%)	9.35±0.17	9.78±0.57	8.74±0.09	10.33±0.27	0.083
Carbohydrate (%)	70.68±0.39	68.42±0.14	74.32±0.14	69.02±0.45	0.083
Total Fat (%)	1.19±0.02	1.43±0.01	1.22±0.02	1.55±0.04	0.092
Protein (%)	17.43±0.16	18.36±0.19	14.21±0.23	16.84±0.19	0.083
Total Sugar (%)	25.37±0.03	21.97±0.13	34.12±0.82	25.73±0.48	0.092
Cholesterol (mg/100 g)	Not Detected (<0.18)	Not Detected (<0.18)	Not Detected (<0.18)	Not Detected (<0.18)	-
Sodium (mg/100 g)	31.05±0.13	18.80±0.03	42.54±0.95	16.26±0.05	0.083
Zinc (mg/100 g)	2.04±0.02	1.56±0.01	1.49±0.00	1.29±0.01	0.080
Iron (mg/100 g)	0.63±0.01	3.52±0.03	1.88±0.01	2.76±0.00	0.083
Calcium (mg/100 g)	49.70±0.67	55.24±0.30	88.08±0.25	75.71±0.35	0.080

*) significant, Kruskal Wallis

The nutritional content, especially carbohydrate and fiber, found in the Manonjaya salak flour from this study, can be a source of energy for LAB. The increase in the energy sources can stimulate the growth of LAB in producing lactic acid so that it affects the pH value[1]. According to other research, the fiber content in yogurt powder can promote the growth of lactic acid bacteria and benefit the gastrointestinal system[19]. The high LAB population of yogurt can be good for human health. In this study, MS-RYP had the highest number of lactic acid bacteria and dietary fiber when compared to MS-MYP, MYP, and RYP. Adding Manonjaya salak with high fiber content in yogurt from beans was intended as a prebiotic for its antimicrobial properties, due to its high sugar content.

In another study, mung bean and red bean-based yogurt products enriched with honey have higher total non-fat solids than cow's milk-based yogurt products due to higher fiber content in mung bean and red bean. This is what makes the yogurt product included in the criteria for low-fat yogurt. Likewise, the results of this study that yogurt powder products based on Mung Beans and Garut red beans, whether added with Salak Manonjaya or not, are included in the criteria for low-fat yogurt if 0.6%-2.9%. In this study, all products were in the range of fat content above 1%-1.5%[20] (Table 2).

The data in Table 2 showed that the protein content in MYP, RYP, MS-MYP, and MS-RYP, respectively, from the results of the quantitative analysis carried out twice for the same sample is 1.20%, 1.42%, 1.20%, and 1.53%. The data shows that all yogurt powders have not met the quality characteristics of SNI yogurt because the protein content required by SNI is at least 2.7%, and the results of the analysis that has been carried out obtained protein levels of less than 2.7%. The data aligns with a review conducted on plant-based fermentation products, which reported that these products have relatively low protein content[12]. Based on the data in Table 2, the results of the ash content analysis on the whole yogurt powder have not met the quality characteristics of SNI yogurt, with the results exceeding the maximum ash content of 1.0%. Simplo and duplo quantitative analysis showed a range of ash content of 1.39-2.28%.

The drying process is essential for preserving the shelf life and portability of yogurt. However, the drying conditions can significantly impact the viability of LAB, which are crucial for the nutritional and functional properties of yogurt. The present study investigated the potential of incorporating Manonjaya salak fruit into legume-based yogurt powders to enhance their nutritional value and functional properties. The results demonstrated that the addition of salak fruit significantly increased the dietary fiber content of all yogurt powders, with MS-RYP exhibiting the highest fiber content at 14.90%. This is attributed to the naturally high fiber content of salak fruit, which is known for its prebiotic properties that can promote gut health[21].

Furthermore, the LAB count in all yogurt powders was found to be within acceptable ranges, indicating successful fermentation and the presence of beneficial probiotic microorganisms. MS-RYP exhibited the highest LAB count of 1 x 10^{10} cfu/g, suggesting that the addition of salak fruit did not adversely affect the viability of LAB during the drying process. The increased dietary fiber content and high LAB count of MS-RYP highlight its potential as a functional food with enhanced nutritional benefits. The combination of prebiotic fiber from salak fruit and probiotic LAB could contribute to improved gut health, immune function, and overall well-being[21].

Total ash, iron, and calcium were higher in bean yogurt powder with the addition of Salak Manonjaya. However, the sodium content was lower in bean yogurt which contains salak flour. The content of other nutrients was relatively the same as legume yogurt with or without salak flour added.

The data in Table 2 provides a comparative analysis of the nutritional content of various yogurt powders made from mung beans, Garut red beans, and combinations with Manonjaya Salak, processed using the FDB method. Based on the results of the statistical difference test, it showed there were no differences in nutrient content among 4 groups experiment. The total caloric content of all yogurt powders in this study ranged from 356.45 to 365.16 kcal/100 g, which is in line with typical yogurt powders. Notably, MS-MYP had the highest caloric content at 365.16 kcal/100 g, while MS RYP showed a slightly lower value at 356.45 kcal/100 g. This slight variation is due to differences in the composition of carbohydrates and proteins, which are the primary contributors to the caloric content. The carbohydrate content varied significantly among the powders, with MS-MYP having the highest carbohydrate content (74.22%), followed by MYP (70.40%), and RYP (68.32%). The salak-fruit-based yogurt powders generally exhibited higher carbohydrate values due to the additional sugars from the fruit. The higher carbohydrate levels observed in MS-MYP align with the findings of another study, who reported that fruit-based yogurt powders tend to have elevated carbohydrate levels, as fruits contribute naturally occurring sugars such as glucose and fructose[22]. These high carbohydrate contents make these powders a good energy source.

Protein content, a key indicator of yogurt's nutritional value, was highest in RYP (18.47%), followed by MYP (17.54%). The presence of beans in these powders is known to enhance their protein profile, as beans are a rich source of plant-based protein[23]. In contrast, the Manonjaya Salak yogurt powders exhibited lower protein content, with MS-MYP and MS-RYP at 14.37% and 16.97%, respectively. This reduction in protein could be attributed to the dilution effect of the added salak fruit, which is lower in protein compared to beans. The fat content was relatively low across all samples, ranging from 1.17% to 1.58%. MS-RYP had the highest fat content (1.58%), which could be explained by the slightly higher fat content of the red beans used in this formulation. The low-fat content makes these yogurt powders ideal for consumers looking for low-fat dietary options. FDB's efficiency in reducing moisture while maintaining nutrient composition supports the retention of natural fats in the powders, as described by another study[24].

Sodium content was highest in MS-MYP (43.21 mg/100 g), which is expected due to the presence of natural sodium in the salak fruit. In comparison, RYP showed a notably lower sodium level (18.78 mg/100 g), which makes it a preferable option for individuals on low-sodium diets. Zinc levels followed a similar trend, with MYP showing the highest zinc concentration (2.05 mg/100 g), consistent with findings that legumes are a good source of zinc[25]. This makes mung bean yogurt powder a valuable source of essential micronutrients. The iron content was highest in RYP (3.54 mg/100 g), likely due to the rich iron content of Garut red beans. Iron is a crucial micronutrient for preventing anemia, and thus, RYP may serve as a good dietary source for those needing higher iron intake. Calcium content, on the other hand, was highest in MS-MYP (88.26 mg/100 g). The combination of salak and mung beans likely contributed to this higher calcium content, supporting bone health. Studies by another study confirm that incorporating fruit like salak, which is naturally rich in calcium, can enhance the calcium content of yogurt powders, making them more beneficial for consumers seeking higher calcium intake[13]. Although other minerals were not measured in this study, a limitation of this yogurt powder is its low iodine content, similar to plant-based yogurt in general[26].

The nutritional content of these yogurt powders indicates their potential as functional foods, particularly in addressing nutritional deficiencies. The high protein content in RYP makes it suitable for individuals seeking plant-based protein alternatives, while the higher carbohydrate content in MS-MYP makes it an energy-dense product ideal for athletes or individuals needing higher caloric intake. The low-fat content and relatively high levels of essential minerals (calcium, iron, zinc) make these yogurt powders beneficial for overall health and wellness. The FDB method has been particularly effective in preserving these nutritional components, as it minimizes the loss of heat-sensitive vitamins and minerals compared to traditional drying methods like spray drying or freeze drying[27]. Moreover, the low moisture content achieved in these products (ranging from 8.67% to 10.52%) contributes to their extended shelf life without compromising quality, further supporting the industrial viability of using FBD technology for yogurt powder production.

The plant-derived fermented products from this study have the potential to serve as functional foods and provide health benefits. This is supported by a review of various similar plant-derived fermented products, which report the production of active components such as vitamins, active peptides, minerals, proteins, and bioactive molecules that positively impact human health. The active components can exert antioxidant, antimicrobial, anti-inflammatory, anticarcinogenic, and antidiabetic effects[28]. As a fermented food product, the yogurt powder from this research has the potential to modulate the microbiota-gut-brain axis and support mental health[29].

The yogurt powder from this study is a form of synbiotic, which involves the interaction between probiotics from lactic acid bacteria and prebiotics from Manonjaya salak flour. A review conducted by other researchers has shown that synbiotics have the potential to prevent cancer[30]. According to another study, synbiotic supplementation has been reported to improve liver function and metabolic profiles in patients with Non-Alcoholic Fatty Liver Disease (NAFLD)[31].

CONCLUSIONS

Local bean yogurt powder added with Salak Manonjaya flour has a higher content of LAB and dietary fiber than just bean. Total ash, especially iron and calcium, has a higher content in local bean yogurt with added salak flour than only bean yogurt. Based on the findings, FDB yogurt powders comprising the combination of Mung beans, Garut red beans, and

Manonjaya salak powder components appear to meet Indonesian national standards (SNI). Based on the current results, future studies would encompass testing on the efficacy of this product in vivo for improving gut health.

This study demonstrates that the yogurt powder produced from legumes and Manonjaya snake fruit using a fluidization process contains LAB levels that meet the SNI. Additionally, it has higher levels of nutrients and dietary fiber compared to standard values. However, further verification is needed regarding the viability of probiotics post-fluidization, and in-vivo testing is recommended to validate its functional properties.

ACKNOWLEDGEMENT

We would like to express gratitude to our assistant researchers, Miss Fini, Dinda, Destya, and Nafisa for their support throughout this research project and their assistance in data collection and analysis.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

All authors have no conflict of interest in this article. This research was funded by Poltekkes Kemenkes Tasikmalaya No. DP.04.03/1/1316/2023.

AUTHOR CONTRIBUTIONS

IN: conceptualization, investigation, methodology, supervision, writing original draft and editing; SUM: conceptualization, investigation, methodology, supervision, writing review and editing; AR: supervision, writing review.

REFERENCES

1. Sumarto, Radiati, A. & Nuraeni, I. Physical and Organoleptic Properties of Freeze-dried Local Beans and Salak Yogurt Powder. *J. Trop. Life Sci.* **13**, 311-318 (2023). https://doi.org/10.11594/jtls.13.02.09.
2. B. Sunitha, J. Naga Bhavya, G. Arvind & Sk. Farzana, K. Anusha. Production of Powdered Yoghurt by Spray Drying. *Int. J. Eng. Res.* **V5**, 668-678 (2016). https://doi.org/10.17577/ijertv5is050791.
3. Dhakal, D., T. Younas, RP. Bhusal, L. Devkota, CJ. Henry, S . Dhital. Design Rules of Plant-Based Yoghurt-Mimic: Formulation, Functionality, Sensory Profile and Nutritional Value. Food Hydrocolloids, **142**, September 2023, 108786. https://doi.org/10.1016/j.foodhyd.2023.108786.
4. Zhang, X., Z. Zhang, A. Shen, T. Zhang, L. Jiang, H. El-Seedi, G. Zhang, X. Sui. Legumes as an alternative protein source in plant-based foods: Applications, challenges, and strategies. . Current Research in Food Science, **9**, 2024, 100876. . doi: 10.1016/j.crfs.2024.100876.
5. Cichońska, P. & M. Ziarno. Legumes and Legume-Based Beverages Fermented with Lactic Acid Bacteria as a Potential Carrier of Probiotics and Prebiotics. Microorganisms, 2021 Dec 31;**10**(1):91. doi: 10.3390/microorganisms10010091
6. Sumarto, S., Aprianty, D., Bachtiar, H. R. A. B. & Kristiana, L. Upaya Penyelamatan Salak Manonjaya, Tasikmalaya Melalui Pembuatan Tepung Sebagai Bahan Baku Produk Pangan Bernilai Gizi. in *Seminar Nasional Membangun Ketahanan Pangan Melalui Pemberdayaan Komoditas Lokal* 16-22 (Unpad Press, Bandung, 2016).
7. Senapati, A. *et al.* Fluidized Bed Drying of Food: A Review. *e-planet* **19**, 25-30 (2021).
8. Podda, D., J. Palme, S. Das, M. Gaare, A. Nag, H. Singh. Effect of Fluidized Bed Drying, Matrix Constituents and Structure on the Viability of Probiotic *Lactobacillus paracasei* ATCC 55544 during Storage at 4 °C, 25 °C and 37 °C. *Microorganisms* 2022, **10**(1), 74; https://doi.org/10.3390/microorganisms10010074
9. Dos Santos, G., Nogueira, R. I. & Rosenthal, A. Powdered Yoghurt Produced by Spray Drying and Freeze Drying: A Review. *Brazilian J. Food Technol.* **21**, (2018).http://dx.doi.org/10.1590/1981-6723.12716
10. Irmawan, R. F. Kualitas Yoghurt Kacang Hijau dengan Variasi Penambahan Pisang Ambon sebagai Prebiotik. (Universitas Gadjah Mada, 2017).
11. Jensen, P. R., Hansen, A. M., & Clausen, S. D. Viability of Probiotics in Yogurt Powders Produced Using Fluidized Bed Drying. *Food Science and Technology International*, **26**(8), 678-685 (2020).
12. Karabulut G, Goksen G, Mousavi Khaneghah A.

Plant-Based Protein Modification Strategies towards Challenges. J Agric Food Res [Internet]. 2024;**15**(January):101017. Available from: https://doi.org/10.1016/j.jafr.2024.101017

13. Sharma, T., Bansal, V., & Singh, A. (2019). "Retention of Nutritional and Functional Properties in Yogurt Powder Dried Using Fluidized Bed Technology." *International Dairy Journal*, **98**, 95-102
14. Badan Standardisasi Nasional Indonesia. *Standar Nasional Indonesia 2981:2009 Yogurt*. (2009).
15. Al Faruq A, Farahnaky A, Torley PJ, Buckow R, Eri R, Majzoobi M. Sustainable Approaches to Boost Soluble Dietary Fibre in Foods: A path to Healthier Foods. Food Hydrocoll [Internet]. 2025;**162**(September 2024):110880. Available from: https://doi.org/10.1016/j.foodhyd.2024.110880
16. Pratiwi, I. S. E., Darusman, F., Shalannandia, W. A. & Lantika, U. A. Review: Peranan Probiotik dalam Yogurt sebagai Pangan Fungsional terhadap Kesehatan Manusia. *Pros. Farm.* **6**, 1119-1124 (2020).
17. Sari, S. M., Ningsih, A. W., Anwaril, F. & Nurrosyidah, I. H. Characterstic and Inhibitory Activity of Green and Red Beans Yoghurt Enriched With Honey Against Methicillin-Resistant Staphylococcus Aureus. *Berk. Ilm. Kim. Farm.* **8**, 20 (2021). https://doi.org/10.20473/bikfar.v8i1.31208
18. Sanders, M. E. Probiotics in Human Health. Journal of Nutrition, **140**(3), 355-361 (2010).
19. Mayta-Tovalino F, Maguiña-Quispe J, Barja-Ore J, Hernandez A V. Efficacy of Probiotic Consumption on Oral Outcomes in Children and/or Adolescents: A Meta-Analysis. Int Dent J. 2024;**4**. doi: 10.1016/j.identj.2024.06.013.
20. Zhao X, Liu S, Li S, Jiang W, Wang J, Xiao J, et al. Unlocking The Power of Postbiotics: A Revolutionary Approach to Nutrition for Humans and Animals. Cell Metab [Internet]. 2024;**36**(4):725-44. Available from: https://doi.org/10.1016/j.cmet.2024.03.004
21. Wang, Y., Zhang, S., & Li, J. Effect of Fruit Addition on the Nutritional Composition of Yogurt Powders. *Journal of Food Science and Technology*, **55**(6), 2357-2365 (2018).
22. Singh, J., Patel, R., & Kumar, N. Legume-Based Functional Foods: Nutritional Properties and Health Benefits. *Journal of Plant-Based Foods*, **8**(4), 216-225 (2020).
23. Le DT, Kumar G, Williamson G, Devkota L, Dhital S. (Poly)phenols and Dietary Fiber in Beans: Metabolism and Nutritional Impact in The Gastrointestinal Tract. Food Hydrocoll [Internet]. 2024;**156**(June):110350. Available from: https://doi.org/10.1016/j.foodhyd.2024.110350
24. Kumar, A., & Patel, D. Energy Efficiency in Fluidized Bed Dryers for Yogurt Powder Production. *Journal of Sustainable Food Systems*, **18**(3), 77-89 (2022).
25. Bansal, T., Chawla, R., & Sharma, S. Nutritional Value of Legume-Based Yogurt Powders. *International Journal of Food Science and Nutrition*, **70**(3), 145-152 (2019).
26. Hazlett, R., C. Schmidmeier, JA. O'Mahony. Approaches for Improving the Flowability of High-protein Dairy Powders Post Spray Drying – A Review. Powder Technology 2021;**388**:26-40. DOI: 10.1016/j.powtec.2021.03.021
27. Lundquist H, Hess J, Comeau M, Slavin J. Cow Milk is An Important Source of Iodine for Prenatal Health, and Switching to Plant-Based Milk Can Lead to Iodine Insufficiencies. JDS Commun [Internet]. 2024;**5**(3):181-4. Available from: http://dx.doi.org/10.3168/jdsc.2023-0424
28. Khayatan D, Nouri K, Momtaz S, Roufogalis BD, Alidadi M, Jamialahmadi T, et al. Plant-Derived Fermented Products: An Interesting Concept for Human Health. Curr Dev Nutr [Internet]. 2024;**8**(5):102162. Available from: https://doi.org/10.1016/j.cdnut.2024.102162
29. Balasubramanian R, Schneider E, Gunnigle E, Cotter PD, Cryan JF. Fermented foods: Harnessing

Their Potential to Modulate The Microbiota-Gut-Brain Axis for Mental Health. Neurosci Biobehav Rev [Internet]. 2024;**158**(January):105562. Available from: https://doi.org/10.1016/j.neubiorev.2024.105562

30. Rowaiye A, Ibeanu GC, Bur D, Nnadi S, Mgbeke OE, Morikwe U. Gut Microbiota Alteration - Cancer Relationships and Synbiotic Roles in Cancer Therapies. The Microbe [Internet]. 2024;**4**(May):100096. Available from: https://doi.org/10.1016/j.microb.2024.100096

31. Fadhilah J, Zariyah H, Pramono A, Purnomo HD, Syauqy A, Afifah DN, et al. Effect of Synbiotic Supplementation on Liver Function, Metabolic Profile and Gut Microbiota in Non-Alcoholic Fatty Liver Disease (NAFLD): A Meta-Analysis of Randomized Controlled Trials. Clin Nutr Open Sci. 2024;**56**:128-51. DOI:10.1016/j.nutos.2024.05.014

How to cite: *Nuraeni, I., Sumarto, S., & Radiati, A. (2025) Microbiological Properties, Dietary Fiber, and Nutritional Content of Fluidized Bed-Dried Local Legumes and Salak Yogurt Powder: Sifat Mikrobiologi, Serat Pangan, dan Kandungan Zat Gizi pada Bubuk Yoghurt dari Kacang-Kacangan dan Salak Lokal yang Diproses melalui Fluidisasi. Amerta Nutrition, 9(3), 506–513.*