**April – June, 2026**
Original Article
DOI: http://dx.doi.org/10.30867/action.v11i2.2768

Pages: 430 – 438

**AcTion: Aceh Nutrition Journal**
p-issn 2527-3310; e-issn 2548-5741

# Comparative of storage time and prebiotic sources (Inulin and Unripe Banana Flour) on the nutritional content of synbiotic yogurt

*Perbandingan pengaruh masa simpan dan sumber prebiotik (Inulin vs Tepung Pisang Mentah) terhadap kandungan gizi yogurt sinbiotik*

Ratih Putri Damayati[1*], Stephani Nesya Renamastika[2], Firda Agustin[3], Ayu Febriyatna[4], Sekar Ayu Wulandari[5], M.Rizal Permadi[6]

[1] Clinical Nutrition Program, Department of Health, Jember State Polytechnic, Jember Regency, East Java, Indonesia.
E-mail: ratihputri@polije.ac.id
[2] Clinical Nutrition, Department of Health, Jember State Polytechnic, Jember Regency, East Java, Indonesia.
E-mail: stephani@polije.ac.id
[3] Clinical Nutrition, Department of Health, Jember State Polytechnic, Jember Regency, East Java, Indonesia.
E-mail: firda.agustin@polije.ac.id
[4] Clinical Nutrition, Department of Health, Jember State Polytechnic, Jember Regency, East Java, Indonesia.
E-mail: ayu_febriyatna@polije.ac.id
[5] Agribusiness Management, Department of Health, Jember State Polytechnic, Jember Regency, East Java, Indonesia.
E-mail: sekar.ayu@polije.ac.id
[6] Clinical Nutrition, Department of Health, Jember State Polytechnic, Jember Regency, East Java, Indonesia.
E-mail: rizalpermadi@polije.ac.id

***Correspondence Author:**
Clinical Nutrition Program, Department of Health, Jember State Polytechnic, Jember Regency, East Java, Indonesia.
E-mail: ratihputri@polije.ac.id

**Article History:**
Received: September 03, 2025; Revised: October 29, 2025; Accepted: December 04, 2025; Published: June 02, 2026.

**Publisher:**
Politeknik Kesehatan Aceh
Kementerian Kesehatan RI

© The Author(s). 2026 **Open Access**
This article has been distributed under the terms of the *License Internasional Creative Commons Attribution 4.0*

## Abstract

The consumption of synbiotic yogurt continues to rise; however, Indonesia's reliance on imported inulin as a prebiotic source has also increased by 25.24%. Raw Berlin banana flour (UBF) contains resistant starch that has the potential to serve as a local alternative to inulin. This study aimed to investigate the effects of storage duration and prebiotic sources on the nutritional composition of synbiotic yogurt. A 2 × 3 factorial design was employed, with prebiotic type (Inulin and UBF) and storage time (days 0, 7, and 14) as factors. Each treatment was replicated twice with duplicate analyses. Proximate analyses included moisture, ash, carbohydrate, fat, protein, total energy, and fat energy contents. Data were analyzed using SPSS version 16 with independent t-tests and ANOVA, with significance set at $p < 0.05$. Results indicated that Storage time significantly affected the moisture, carbohydrate, fat, protein, total energy, and energy from fat contents ($p < 0.05$). The prebiotic sources inulin and UBF differed significantly in moisture and carbohydrate content on day 7, ash content on day 14, fat and energy from fat on days 0 and 7, and total energy on day 0. In conclusion, both storage duration and prebiotic source influenced the nutritional composition of the synbiotic yogurt.

**Keywords:** Local prebiotic source, proximate analysis, storage time, synbiotic yoghurt, unripe banana flour

## Abstrak

Konsumsi yogurt sinbiotik terus meningkat, namun ketergantungan Indonesia terhadap impor inulin sebagai sumber prebiotik juga meningkat 25,24%. Tepung pisang berlin mentah (UBF) mengandung pati resisten yang berpotensi menjadi alternatif pengganti inulin dari bahan pangan lokal. Penelitian ini bertujuan untuk mengetahui pengaruh masa penyimpanan dan sumber prebiotik terhadap kandungan zat gizi yoghurt sinbiotik. Penelitian menggunakan rancangan factorial 2x3 dengan faktor jenis prebiotik (Inulin dan UBF) dan waktu penyimpanan (hari ke-0, ke-7 dan ke-14). Jumlah pengulangan 2 kali dengan analisis duplo. Analisis proksimat yang diuji yaitu kadar air, kadar abu, karbohidrat, lemak, protein, energi total, dan energi dari lemak. Data dianalisis menggunakan SPSS 16 dengan uji independent T-test dan Anova signifikansi $p<0,05$. Hasil menunjukkan bahwa masa penyimpanan berpengaruh signifikan terhadap kadar air, karbohidrat, lemak, protein, energi total, dan energi dari lemak ($p<0,05$). Sumber prebiotik inulin dan UBF memiliki berbeda signifikan terhadap kadar air dan karbohidrat pada H7. Kadar abu pada H14, lemak dan energi dari lemak pada H0 dan H7, dan energi total pada H0. Kesimpulan, masa penyimpanan dan sumber prebiotik memiliki pengaruh terhadap kandungan zat gizi yoghurt sinbiotik.

**Kata Kunci:** Analisis proksimat, masa simpan, sumber prebiotik lokal, tepung pisang mentah, yogurt sinbiotik

## Introduction

Global interest in functional foods has increased in parallel with the rising public awareness of healthy lifestyles. In addition to providing energy and essential nutrients, functional foods confer additional health benefits, including the prevention of degenerative diseases (Handayani & Nuraini, 2022). In Indonesia, the consumption of functional foods, such as probiotic and prebiotic products, has increased significantly in recent years, especially in fermented dairy products, such as yogurt. According to Per-BPOM No. 30 of 2018 on Food Consumption Figures, Indonesians consume 155 g of fermented milk, including yogurt, per person per day. This is reflected in the increasing volume of yogurt imports into Indonesia. According to Statistics Indonesia (*Badan Pusat Statistik*, BPS) (2021), the value of yogurt imports increased by 225,98% between 2014 and 2020. Along with the growing demand for yogurt in Indonesia, the public consumption of yogurt has increased (Achmadin et al., 2021).

Prebiotics and probiotics are essential components of functional food. Probiotics are live microorganisms that confer health benefits to the host when administered in adequate amounts, whereas prebiotics are nondigestible compounds that promote the growth of beneficial gut microbiota, including Lactobacillus and Bifidobacterium (Majdiyyah & Farida, 2023). The combination of the two is known as a synbiotic, which is widely used in yogurt and has a synergistic effect on improving digestive health (Roy & Dhaneshwar, 2023).

Synbiotic yogurt contains live microorganisms and ingredients that support the proliferation of beneficial intestinal bacteria. The addition of prebiotics to yogurt improves its nutritional quality and sensory characteristics (Amelia et al. 2022). Inulin is widely used as a commercial prebiotic in the yogurt industry, as it improves viscosity and texture stability without contributing additional calories (Zbikowska et al., 2020). In addition, inulin can improve consumer acceptance of products and support fermentation by probiotic bacteria, producing short-chain fatty acids that play an important role in digestion (Kamel et al., 2021).

The food, chemical, and pharmaceutical industries in Indonesia continue to import inulin from Europe and the United States. Inulin production in Indonesia remains underdeveloped due to the absence of inulin producers, limited potential of natural materials for high-quality inulin, exploratory inulin production technology innovations, and a disconnect between inulin and the community. The price of imported inulin is much lower than that of inulin products processed from local plants (Yuliana et al., 2014). According to data from Statistics Indonesia (BPS), inulin imports increased by 25,24% between 2023 and 2024, rising from 6.097.424 kg to 7.636.568 kg (BPS 2025). This trend highlights Indonesia's growing reliance on imported prebiotic ingredients.

Therefore, there is an increasing need to develop prebiotics derived from local food sources to support the sustainability of the functional food industry. A potential source of prebiotics is unripe banana flour (UBF), particularly from local banana varieties such as Berlin bananas, which are widely available in Jember Regency. UBF is rich in resistant starch (up to 74 %), a type of carbohydrate that is largely resistant to digestion in the small intestine and is subsequently fermented by intestinal microbiota, thereby exerting prebiotic effects (Burkhart et al., 2022). The resistant starch content of unripe Berlin banana flour is higher than that of ripe Berlin banana flour because of sugar conversion (Febriyatna et al., 2018).

Although UBF contains a relatively low amylose fraction, it exhibits resistance to thermal processing and amylase activity, which is beneficial for food industry applications. This property is especially important for dairy and yogurt products, as UBF has a neutral aroma, flavor, and good solubility, thereby enhancing its suitability for functional food formulations (Munir et al., 2024). The addition of UBF can affect the content of lactic acid bacteria (LAB) in yogurt and has the potential to be a functional food beneficial to health (Agustin et al., 2025).

Many studies have separately evaluated inulin and UBF as prebiotics; however, only a few have directly compared their effects on the nutritional quality of synbiotic yogurt, particularly during its storage. Previous research has developed a synbiotic yogurt using UBF, with the best formulation containing 2% UBF (Agustin et al., 2024). The addition of UBF to synbiotic yogurt can increase ash levels, energy, resistant starch, and viscosity compared to yogurt supplemented with inulin as a prebiotic source (Agustin et al., 2025).

Yogurt quality is strongly affected by storage conditions, with extended storage periods and higher temperatures leading to significant deterioration in sensory attributes, particularly taste and aroma (Jakubowska & Karamucki, 2019). Storage conditions may affect starch activity in yogurt, resulting in textural degradation and alterations in nutritional components, such as proteins and lipids (Saleh et al., 2020; Stella et al., 2013).

Based on the results of previous research, the researcher wanted to develop a study by comparing the effect of local prebiotic ingredients, such as unripe banana flour with inulin as prebiotic sources in synbiotic yogurt, on the changes in nutritional content observed on days 0, 7$^{th}$, and 14$^{th}$ to analyze the effect of shelf life simultaneously. This study aimed to compare the effects of adding inulin and banana berlin flour as prebiotics on the nutritional profile of synbiotic yogurt and to evaluate the changes in nutritional value during shelf life.

## Methods

This study was an experimental investigation using a 2 × 3 factorial design with two types of prebiotics (inulin and unripe Berlin banana flour [UBF]) and three storage periods (0, 7, and 14 days). This study evaluated the effects of prebiotic type and storage duration on the nutritional composition of synbiotic yogurt. Each treatment was replicated twice, and all analyses were performed in triplicate.

Flour production was carried out in the Food Engineering Laboratory, and yogurt production was conducted in the Food Technology Laboratory at Jember State Polytechnic. Proximate analyses, including moisture, ash, carbohydrate, fat, protein, total energy, and energy from fat, were performed at the PT laboratory. Saraswanti Indo Genetech, Surabaya, Indonesia. Yogurt samples designated for analysis were packaged in sealed glass containers and stored in a refrigerator at 4°C in the testing laboratory. Analyses were performed on days 0, 7, and 14, following a duplicate testing system for each sample. This study was approved by the Jember State Polytechnic (approval number: 1466/PL17.4/PG/2024).

### Material

Unripe Berlin bananas (Musa acuminata) were sourced from a local market in Jember Regency and processed into unripe banana flour (UBF). Yogurt was prepared using skim milk, sugar, a commercial starter culture, and inulin. The starter culture (Yogourtmet®) consisted of Lactobacillus bulgaricus, Streptococcus thermophilus, and Lactobacillus acidophilus.

### Unripe Banana Flour (UBF) Production

Unripe banana flour (UBF) was prepared by peeling the bananas, washing them under running water, and slicing them into 1 mm thick slices. Banana slices were soaked in sterile water at a water-to-material ratio of 4:1 (v/w) for 24 h in a closed container. After soaking, the slices were drained and dried using a dehydrator at 60 °C for 8 h. The dried samples were then ground using a grinder and sieved through a 100-mesh screen to obtain a fine flour. The resulting banana flour was stored for subsequent analysis.

### Preparation of Yogurt Starter

The stages of starter preparation included mixing 114 g of skim milk powder with 1 liter of water and heating the mixture to 82°C. Thereafter, let it sit until 42-44°C, then add 3 g of yogurt and mix until smooth (Prepare Your Yogurt, 2024). The mixture was then poured into a sterilized container and incubated at 37 °C for 18 h. After incubation, the yogurt starter was stored under refrigeration until use.

### Synbiotic Yogurt Preparation

The formulation of synbiotic yogurt was based on previous research by Agustin et al. (2024) and was prepared by mixing skim milk, sugar, and prebiotic ingredients, inulin (2%) or UBF (1%). The mixture was dissolved in 100 mL of water and stirred until homogeneous, followed by heating at 82 °C. The mixture was then cooled to 42–44 °C, after which 3% (v/v) yogurt starter was added. The inoculated mixture was poured into sterilized, tightly sealed glass containers and incubated at 37 °C for 18 h. Upon completion of fermentation, the yogurt samples were stored at refrigeration temperature (1–3 °C) for 14 d before analysis. Observations and analyses were conducted on days 0, 7, and 14 of storage.

### Proximat Analysis

The moisture content was analyzed using the SNI 01-2891-1992 method (point 5.1). The ash content was analyzed using the SNI 01-2891-

1992 method (point 6.1). Fat content analysis was performed using the Weibull's method. Protein levels were analyzed using titrimetric analysis. Carbohydrates were divided into different categories (100 – ∑other components), total energy, and energy from fat based on the calculations. The Atwater conversion factors for protein (protein × 4), fat (fat × 9), and carbohydrate (carb × 4) were used to estimate the gross energy value of the flour based on dry weight and expressed in kcal/100 g (Ayo-Omogie, et. al., 2021).

**Statistical Analysis**
Data were analyzed using SPSS version 16. Data were tested for normality using the Shapiro-Wilk test. Normally distributed data were analyzed using an independent t-test to test differences between prebiotic groups at each storage time and a two-way ANOVA to test the interaction between prebiotic type and storage time on proximate levels. The storage interval test for each prebiotic group was performed using a one-way ANOVA. Turkey's follow-up test with p<0,05.

## Result and Discussion

Unripe Berlin banana flour is a rich source of prebiotics, nutrients, bioactive components, flavonoids, and resistant starch (Mota et al., 2000; Agustin et al., 2019). Based on the proximate analysis in Table 1, it can be seen that the moisture and protein contents are lower, while the ash content is higher than those reported by Agustin et al. (2019). This difference is thought to be closely related to variations in flour-making methods, which affect the proximate levels of the flour. In this study, unripe Berlin bananas were fermented in sterile water for 24 h. In contrast, Agustin et al. (2019) soaked bananas in citric acid solution for 10 min. According to Ayo-Omogie et al. (2021), the 24-hour fermentation process significantly increased the protein and ash contents of banana flour. This increase may be attributed to microbial activity during fermentation, which enhances nitrogen availability and mineral concentration. The moisture content of banana flour in the present study complied with the Indonesian National Standard (SNI) for Grade A banana flour, which specifies a maximum moisture content of 5% (Badan Standardisasi Nasional, 1995). Low moisture content has positive implications for flour shelf life, as it can suppress the growth of spoilage bacteria and extend the product's shelf life. Adding protein sources to yogurt can help buffer pH changes. In addition, adding a protein source increases yogurt viscosity because the solid content of the protein helps retain water. This procedure can reduce syneresis, thereby improving yogurt quality (Setiadi et al., 2023).

**Table 1.** UBF proximate analysis results per 100 g dry material weight

| Nutrients | n |
|---|---|
| Moisture content (%) | 4,54 |
| Ash content (%) | 3,62 |
| Carbohydrate (%) | 86,89 |
| Fat (%) | 1,07 |
| Protein (%) | 3,87 |
| Total Energy (kcal/100 g) | 372,73 |
| Energy from fat (kcal/ 100 g) | 9,67 |

The results of the proximate analysis of yogurt (Table 2) formulated with UBF and inulin showed significant changes (p < 0,05) in the moisture, carbohydrate, fat, and protein contents, as well as total energy and energy from fats during storage. The moisture content in both groups increased on day 7 and decreased on day 14. The moisture content of yogurt according to SNI is 83-84%. The moisture content on the seventh day of storage increased significantly, exceeding 84%, and UBF yogurt had a higher moisture content than inulin yogurt did. An increase in moisture content in the middle of the shelf life is thought to be related to syneresis or whey release, which can be triggered by proteolytic enzymes produced by lactic acid bacteria (LAB). On the seventh day of storage, the increase in water content was due to LAB fermentation of lactose, which lowered the pH and caused water to be released from the protein matrix. The high moisture content of yogurt can affect its texture and taste ( Matela et al., 2019). The yogurt exhibited a thinner texture, resulting in a juicier mouthfeel. On day 7, the moisture content of yogurt differed significantly among the treatments containing inulin and UBF. This difference is associated with the functional properties of inulin, which can bind water within the protein matrix, thereby reducing syneresis and enhancing water-holding capacity. Consequently, yogurt supplemented with inulin has a lower moisture content than yogurt containing UBF (Falah et al., 2021). Prolonged storage results in a progressive decrease in nutrient availability in yogurt, as these nutrients are continuously utilized as substrates by LAB during ongoing metabolic activity, ultimately leading to the depletion of substrates (Pangestu et al., 2021). This process contributed to the decrease in moisture content observed on day 14 of storage. Nevertheless, the moisture content of yogurt on day 14 remained within the limits specified by the SNI.

Based on the analysis, the ash content of yogurt was not significantly affected by the storage period. However, the prebiotic type significantly influenced ash content at the beginning of storage and on day 14. Yogurt formulated with raw Berlin banana flour exhibited a higher ash content than that with inulin. This difference is attributable to the inherently lower ash content of inulin (0,39%) compared to raw Berlin banana flour (Putri et al., 2023).

Raw Berlin banana flour contains an ash content of 3,62%. The ash content of yogurt reflects its mineral composition, which serves as an essential source of nutrients for humans and LAB in the intestine ( Matela et al., 2019). The ash content of the yogurt in this study complied with the Indonesian National Standard (SNI 2981:2009), which specifies a maximum ash content of 1% (Badan Standarisasi Nasional, 2009).

Storage time significantly affected the carbohydrate content of yogurt. On day 7 of storage, the carbohydrate levels decreased, whereas a significant increase was observed on day 14 of storage. The initial reduction in carbohydrate content can be attributed to the metabolic activity of yogurt starter cultures, which convert carbohydrates to lactic acid and other metabolites via glycolysis. Carbohydrates in milk, primarily in the form of lactose, serve as the main sources of energy and carbon for LAB growth in yogurt (Chen et al., 2017). The prebiotic type at the beginning of storage and on day 7 significantly affected the carbohydrate content of the yogurt. Yogurt supplemented with inulin exhibited a higher carbohydrate content than that supplemented with UBF. This difference can be attributed to the higher level of inulin added in this study (2%) compared to that in the UBF (1%). A higher inulin concentration consequently increases the total carbohydrate content (Kuntz et al., 2013).

Shelf life significantly affected the total fat content of yogurt. Overall, prolonged storage was associated with a decrease in fat content. However, on day 7th of storage, both groups exhibited an increase in total fat content. This may be due to the fermentation process in yogurt, which breaks down milk fat into free fatty acids (lipolysis)(Chen et al., 2017). The total fat content of yogurt ranges from 0,05 to 0,62%. Based on SNI 2981:2009, this fat content falls within the range of non-fat yogurt, except for UBF yogurt, which is categorized as a low-fat yogurt after 7 d of storage. In addition to the beneficial functional role of yogurt in lipid metabolism, its low-fat content enhances the value of this product as a functional food for individuals with dyslipidemia. Furthermore, low-fat yogurt is often preferred by consumers because of its dense, smooth, and creamy texture (Dias et al., 2020). On the 14th day of storage, the fat content of both groups decreased. This is in line with the findings of Falah et al. (2021), who reported that storage duration was associated with a reduction in yogurt fat content. In addition, the prebiotic type significantly influenced fat content, with inulin-supplemented yogurt exhibiting a higher fat content than yogurt containing UBF. Therefore, the addition of inulin contributes to an increase in the fat content of yogurt (Falah et al., 2021)

**Table 2.** Results of proximate analysis difference test during storage

| Nutrients | Storage Period | | | p-value[2] |
|---|---|---|---|---|
| | H0 | H7 | H14 | |
| Moisture content (%) | | | | |
| Inulin | 83,85±0,04[a] | 84,64±0,04[b] | 83,68±0,28[a] | 0,022* |
| UBF | 84,25±0,12[a] | 84,85±0,00[b] | 83,45±0,15[c] | 0,003* |
| p-value[1] | 0,052 | 0,027* | 0,436 | |
| Prebiotic source*storage period[3] | | | | 0,057 |
| Ash content (%) | | | | |

| | | | | |
|---|---|---|---|---|
| Inulin | 0,83±0,01$^{a}$ | 0,80±0,02$^{a}$ | 0,83±0,00$^{a}$ | 0,188 |
| UBF | 0,90±0,01$^{a}$ | 0,89±0,02$^{a}$ | 0,90±0,01$^{a}$ | 0,635 |
| p-value[1] | 0,038* | 0,051 | 0,022* | |
| Prebiotic source*storage period3 | | | | 0,675 |
| Carbohydrate (%) | | | | |
| Inulin | 10,89±0,04$^{a}$ | 9,91±0,15$^{b}$ | 10,95±0,28$^{a}$ | 0,020* |
| UBF | 10,38±0,08$^{a}$ | 9,36±0,00$^{b}$ | 11,16±0,07$^{c}$ | <0,001* |
| p- value[1] | 0,018* | 0,037* | 0,416 | |
| Prebiotic source*storage period3 | | | | 0,015* |
| Fat (%) | | | | |
| Inulin | 0,34±0,00$^{a}$ | 0,38±0,00$^{b}$ | 0,11±0,00$^{c}$ | <0,001* |
| UBF | 0,30±0,00$^{a}$ | 0,62±0,01$^{b}$ | 0,05±0,00$^{c}$ | <0,001* |
| p-value[1] | 0,012* | 0,002* | - | |
| Prebiotic source*storage period3 | | | | <0,001* |
| Protein (%) | | | | |
| Inulin | 4,10±0,02$^{a}$ | 4,29±0,07$^{ab}$ | 4,44±0,00$^{b}$ | 0,012* |
| UBF | 4,18±0,04$^{a}$ | 4,30±0,00$^{ab}$ | 4,44±0,07$^{b}$ | 0,030* |
| p-value[1] | 0,170 | 0,873 | 1,000 | |
| Prebiotic source*storage period[3] | | | | 0,487 |
| Total Energy (kcal/ 100 g) | | | | |
| Inulin | 62,98±0,11$^{a}$ | 60,16±0,24$^{b}$ | 62,55±1,13$^{ab}$ | 0,046* |
| UBF | 60,88±0,60$^{ab}$ | 60,18±0,12$^{a}$ | 62,85±0,56$^{b}$ | 0,024* |
| p- value[1] | 0,040* | 0,911 | 0,779 | |
| Prebiotic source*storage period[3] | | | | 0,051 |
| Energy from fat (kcal/ 100 g) | | | | |
| Inulin | 3,06±0,00$^{a}$ | 3,38±0,06$^{b}$ | 0,99±0,00$^{c}$ | <0,001* |
| UBF | 2,66±0,06$^{a}$ | 5,58±0,12$^{b}$ | 0,45±0,00$^{c}$ | <0,001* |
| p- value[1] | 0,012* | 0,002* | - | |
| Prebiotic source*storage period[3] | | | | <0,001* |

All results are reported on a wet weight basis (per 100 g); [1]Independent T test; [2]Anova test; [3]two way Anova test; *sig p<0,05; Different superscript letters in the same row indicate significant differences p<0,05

The type of prebiotic also affected the fat content on days 0 and 7 of the experiment. The fat content of UBF yogurt on day 0 was lower than that of inulin yogurt. These results align with those of Abdallaand& Ahmed (2019), whofound thattthee addition of UBF reduced the fat content of yogurt. However, on day 7 of storage, the fat content of UBF-supplemented yogurt increased and exceeded that of inulin-supplemented yogurt.

The protein content of yogurt was significantly affected by the storage period but not by the type of prebiotic. Prolonged storage is associated with increased protein levels. This increase may be attributed to the proteolytic activity of LAB, which hydrolyzes milk proteins and utilizes the resulting peptides and amino acids as nitrogen sources for growth during storage (Li et al., 2019). The protein content of the yogurt complied with SNI 2981:2009, which specifies a minimum protein content of 2,7 g. The use of skim milk contributed to the high protein content of the yogurt, providing approximately 32 g of protein per 100 g of milk. The milk protein in yogurt exhibits different physical and biological properties from unfermented milk protein due to fermentation and processing of yogurt. Milk protein in yogurt is a soft, acidified gel; therefore, it does not clump firmly in the stomach. These characteristics facilitate mixing with gastric fluids through gastric peristalsis, predigestion with pepsin, and transport to the small intestine (SI). Milk protein that reaches the small intestine is neutralized and rapidly digested by pancreatic enzymes. Therefore, overall, milk protein intake, such as that from yogurt, is expected to increase protein absorption in the body. This process increases the supply of amino acids to the skeletal muscles, thereby promoting the synthesis of skeletal muscle protein (Sumi et al., 2023). Increased protein levels favor lower postacidification, better texture, higher water-holding capacity, and the absence of syneresis (Marini et al., 2022).

The type of prebiotic, whether inulin or UBF, did not significantly affect yogurt protein content. This finding suggests that UBF can serve as an alternative local prebiotic source for developing functional yogurt products, potentially reducing the reliance on imported inulin. These results differ from those reported by Li et al. (2019), who observed that prebiotic supplementation influenced the protein content of yogurt.

The total energy content of yogurt was significantly affected by the storage period. At the beginning of storage, the total energy content differed significantly among the prebiotic types. The total energy content of yogurt ranged from 60,16 to 62,95 kcal/100 g, corresponding to approximately 2,79–2,92% of the adult Recommended Dietary Allowance (RDA). Yogurt supplemented with inulin exhibited a higher energy content than yogurt containing UBF. This finding is consistent with the higher carbohydrate and fat contents observed in inulin-supplemented yogurt at the beginning of the storage period. Sucrose was added at the same level in all treatments (2,5 g per 100 g) to standardize the energy contribution across groups. This level of sugar addition complies with BPOM regulations for low-sugar claims (BPOM, 2016). Health-conscious consumers increasingly prefer low-sugar food products because of their beneficial effects on glucose metabolism, including diabetes prevention and improved glycemic control in individuals with diabetes. In addition, the use of UBF as a prebiotic source contributes to the lower energy content of yogurt, making it a choice for functional foods with low energy.

The energy content from fat significantly increased on day 7 and decreased on day 14 in both groups of rats. On day 0, the inulin yogurt had higher energy from fat than the UBF yogurt, but on day 7, the energy from fat was higher in the UBF yogurt than in the inulin yogurt. These data are in line with the fat content of yogurt: on day 0, the fat content in inulin yogurt was greater, while on the seventh day, the fat content in UBF yogurt was greater.

The choice of prebiotic source and storage time can affect yogurt proximate composition. Two-way ANOVA showed that the moisture, ash, protein, and total energy content were not affected by the interaction between prebiotic type and storage period. Carbohydrates, fats, and energy from fats were affected by the interaction between prebiotic types and yogurt storage period.

This study has limitations in its method, which uses only two repetitions; further research is needed to use more repetitions to improve the reliability and validity of the data. However, the test was performed using duplicate analyses to improve data accuracy.

## Conclusion

The results of this study show that the storage period affects the moisture content, carbohydrate, fat, protein, total energy, and energy from fat of synbiotic yogurts. The longer the storage period, the lower the moisture content, fat, and total energy from fat, and the higher the protein and carbohydrate content. Prebiotic sources, such as inulin and UBF, can also affect the water content, ash content, carbohydrates, fat, total energy, and energy from fat. The use of UBF can be considered a local source of prebiotics for developing synbiotic yogurt products.

Further research should focus on in vivo testing to evaluate the effects of yogurt consumption, as well as market tests with a broader range of panelists to obtain a more representative picture of consumer preferences, so that yogurt products can become functional foods that improve public health.

## Acknowledgements

We thank all the parties involved in the implementation of this study.

## References

Abdalla, A. K., & Ahmed, Z. F. R. (2019). Physicochemical and sensory properties of yoghurt supplemented with green banana flour. *Egyptian Journal of Dairy Science, 47*(1), 1–9.

Achmadin, N., Wardani, A., Sasmita, F., Hasanah, N., & Moentamaria, D. (2021). Studi kelayakan industri yoghurt. *Distilat, 7*(9), 310–319.

Agustin, F., Damayati, R. P., & Febriyatna, A. (2024). Effect of the addition of unripe Berlin banana flour on the organoleptic characteristics of synbiotic yogurt. *International Journal of Technology, Food and Agriculture, 1*(2), 48–54. https://doi.org/10.25047/tefa.v1i2.4593

Agustin, F., Putri, R., & Febriyatna, A. (2025). Effect of unripe Berlin banana flour on synbiotic yogurt: Physicochemical and microbiological properties. *Jurnal Gizi dan Dietetik Indonesia, 13*(1), 64–69.

Amelia, F. Y., Warkoyo, W., Manshur, H. A., & Husna, A. (2022). Karakteristik organoleptik yoghurt sinbiotik dengan penambahan inulin pure pisang Barangan (Musa acuminata Colla). *Food Technology and Halal Science Journal, 5*(1), 32–44. https://doi.org/10.22219/fths.v5i1.18760

Ayo-Omogie, H. N., Jolayemi, O. S., & Chinma, O. (2021). Fermentation and blanching as adaptable strategies to improve nutritional and functional properties of unripe Cardaba banana flour. *Journal of Agriculture and Food Research, 6*, 100214. https://doi.org/10.1016/j.jafr.2021.100214

Burkhart, S., Underhill, S., & Raneri, J. (2022). Realizing the potential of neglected and underutilized bananas in improving diets for nutrition and health outcomes in the Pacific Islands. *Frontiers in Sustainable Food Systems, 6*(March). https://doi.org/10.3389/fsufs.2022.805776

Chen, C., Zhao, S., Hao, G., Yu, H., Tian, H., & Zhao, G. (2017). Role of lactic acid bacteria on the yogurt flavour: A review. *International Journal of Food Properties, 20*(1), S316–S330. https://doi.org/10.1080/10942912.2017.1295988

Dias, P. G. I., Sajiwani, J. W. A., & Rathnayaka, R. M. U. S. K. (2020). Consumer perception and sensory profile of probiotic yogurt with added sugar and reduced milk fat. *Heliyon, 6*(April), e04328. https://doi.org/10.1016/j.heliyon.2020.e04328

Falah, F., Vasiee, A., & Yazdi, F. T. (2021). Preparation and functional properties of synbiotic yogurt fermented with *Lactobacillus brevis* PML1 derived from a fermented cereal-dairy product. *2021*.

Handayani, I., & Nuraini, N. (2022). Effect of concentration of Ambon banana flour and addition of *Lactobacillus casei* on chemical characteristics of synbiotic yogurt. *Jurnal Agrotek Ummat, 1*. https://journal.ummat.ac.id/index.php/agrotek/article/view/8452

Kamel, D. G., Hammam, A. R. A., Alsaleem, K. A., & Osman, D. M. (2021). Addition of inulin to probiotic yogurt: Viability of probiotic bacteria (*Bifidobacterium bifidum*) and sensory characteristics. *Food Science and Nutrition, 9*(3), 1743–1749. https://doi.org/10.1002/fsn3.2154

Li, S., Tang, S., He, Q., Hu, J., & Zheng, J. (2019). Changes in proteolysis in fermented milk produced by *Streptococcus thermophilus* in co-culture with *Lactobacillus plantarum* or *Bifidobacterium animalis*. *Molecules, 24*(20), 3699. https://doi.org/10.3390/molecules24203699

Majdiyyah, M., & Farida, E. (2023). Pengaruh masa simpan terhadap karakteristik fisik dan mikrobiologi yoghurt sinbiotik ubi jalar kuning (*Ipomoea batatas* L.). *Indonesian Journal of Public Health and Nutrition, 3*(1), 80–87. https://doi.org/10.15294/ijphn.v3i1.60012

Marini, T., Aparecida, D., Harumi, E., Nunes, A., Anaya, K., Elisabete, A., Antunes, C., Teresa, M., & Pacheco, B. (2022). Development of probiotic yoghurts with high protein content by ultrafiltration. *NFS Journal, 29*(October), 16–25. https://doi.org/10.1016/j.nfs.2022.09.003

Munir, H., Alam, H., Nadeem, M. T., Almalki, R. S., Arshad, M. S., & Suleria, H. A. R. (2024). Green banana resistant starch: A promising potential as functional ingredient against certain maladies. *Food Science and Nutrition, 12*(6), 3787–3805. https://doi.org/10.1002/fsn3.4063

Pangestu, A. D., Kuriniawan., & Supriyadi. (2021). Pengaruh variasi suhu dan lama penyimpanan terhadap viabilitas bakteri asam laktat (BAL) dan nilai pH yogurt. *Borneo Journal of Medical Laboratory Technology, 3*(2), 231–236.

Roy, S., & Dhaneshwar, S. (2023). Role of prebiotics, probiotics, and synbiotics in management of inflammatory bowel disease: Current perspectives. *World Journal of Gastroenterology, 29*(14), 2078–2100. https://doi.org/10.3748/WJG.V29.I14.2078

Saleh, A., Mohamed, A. A., Alamri, M. S., Hussain, S., Qasem, A. A., & Ibraheem, M. A. (2020). Effect of different starches on the rheological, sensory and storage attributes of non-fat set yogurt. *Foods, 9*(1). https://doi.org/10.3390/foods9010061

Sanett Matela, K., Karuppiah Pillai, M., Matebesi-Ranthimo, P., & Ntakatsane, M. (2019). Analysis of proximate compositions and physiochemical properties of some yoghurt samples from Maseru, Lesotho. *Journal of Food Science and Nutrition Research, 2*(3), 245–252. https://doi.org/10.26502/jfsnr.2642-11000023

Setiadi, O. Y., Sumarmono, J., & Setyawardani, T. (2023). Bulletin of applied animal research. *Bulletin of Applied Animal Research, 5*(September), 6–18.

Sumi, K., Tagawa, R., Yamazaki, K., Nakayama, K., Ichimura, T., Sanbongi, C., & Nakazato, K. (2023). Nutritional value of yogurt as a protein source: Digestibility/absorbability and effects on skeletal muscle. *Nutrients, 15*(20), 1–16. https://doi.org/10.3390/nu15204366

Zbikowska, A., Szymańska, I., & Kowalska, M. (2020). Impact of inulin addition on properties of natural yogurt. *Applied Sciences, 10*(12). https://doi.org/10.3390/app10124317