



## The Effect of Purple Sweet Potato (*Ipomea Batatas L.*) Fermentation Time on Carbohydrate and Protein Levels

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### Abstract

Yogurt is a fermented milk product produced by *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, which confer a distinctive sour taste. Lactic acid bacteria require a carbohydrate source during growth, which can be obtained from purple sweet potatoes. This study aimed to determine the effect of fermentation time on carbohydrate and protein levels in purple sweet potato yoghurt. This study comprises 3 samples: sample A (yoghurt fermented for 7 hours), sample B (yoghurt fermented for 14 hours), and sample C (yoghurt fermented for 21 hours). The study employed a quantitative design, with carbohydrate testing using the Luff-Schoorl method and protein testing using the Kjeldahl method. The carbohydrate content was 10.36% in sample A, 10.41% in sample B, and 10.02% in sample C; the protein content was 2.23% in sample A, 3.93% in sample B, and 4.03% in sample C.

**Keywords:** Carbohydrate, fermentation time, protein, purple sweet potato, yogurt

### Introduction

Purple sweet potato is among the most commonly cultivated sweet potatoes in Indonesia, alongside white, yellow, and red varieties (Hamidah et al., 2021). The purple color in sweet potatoes is caused by the presence of purple anthocyanin pigments that spread from the skin to the flesh of the sweet potato (Ningsih & Marlina, 2024). This anthocyanin concentration causes purple sweet potatoes to exhibit a purple coloration that differs from that of other sweet potatoes (Mukhoiyaroh et al., 2022).

Purple sweet potato has several advantages over other-colored sweet potatoes, particularly with respect to vitamin A and E content (Laveriano-Santos et al., 2022). Purple sweet potatoes are a source of fiber, complex carbohydrates, vitamin B6, folic acid, and are low in calories. The content of sweet potato can be determined using phytochemical screening (Irfan et al., 2022). Given its many health benefits, purple sweet potato is a promising candidate for functional food development. One such innovation is purple sweet potato yogurt, which combines the nutritional advantages of both ingredients.

Yogurt is a dairy product produced through a fermentation process by lactic acid bacteria, mainly *Streptococcus thermophilus* and *Lactobacillus bulgaricus* (Arab et al., 2023). This fermentation process not only imparts yogurt's characteristic sour taste but also extends its shelf life

by producing lactic acid, which inhibits the growth of spoilage bacteria (Sionek et al., 2023). The thick texture and low acidity (pH) of yogurt contribute to its durability (Daszkiewicz et al., 2024). Yogurt is widely consumed for its rich nutritional content, including protein, vitamins, and minerals, as well as its benefits for digestive health, owing to its prebiotic content (Ifadah et al., 2022).

The addition of purple sweet potato ingredients to yogurt aims to increase antioxidant content, provide prebiotic oligosaccharides that support the growth of beneficial bacteria, and enhance the product's sensory appeal through its bright color (Purwantiningsih et al., 2022). The oligosaccharides in sweet potatoes are particularly beneficial for the proliferation of probiotic bacteria, such as *Lactobacillus acidophilus* and *Bifidobacterium* spp., thereby enhancing the health benefits of yogurt (Dong et al., 2024).

However, factors such as fermentation time and ingredient additions, including sugar, can significantly affect the final product's quality and nutritional composition (Sahbani et al., 2023). Longer fermentation times in purple sweet potato yogurt affect its nutritional content, particularly carbohydrates and protein (Setiawan & Agustini, 2024). During extended fermentation, carbohydrates are broken down by lactic acid bacteria. At the same time, proteolytic activity increases protein content—the increase in protein results from the accumulation of bacterial biomass

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and proteolysis products during fermentation. Furthermore, longer fermentation times lower the yogurt's pH and affect the product's texture and viscosity (Siddiqui et al., 2023). Therefore, optimizing fermentation times is crucial for producing purple sweet potato yogurt with optimal nutritional value and sensory properties. This study sought to determine how fermentation duration in purple sweet potato yogurt affected protein and carbohydrate content.

## Methods

### Materials and Tools

The materials used were purple sweet potato, water, *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, liquid skim milk, sugar, purple sweet potato yoghurt, luff school solution, HCl 3 %, NaOH 40 %, distilled water, H<sub>2</sub>SO<sub>4</sub> 25 %, KI 15 %, amylum 1 %, Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> 0.1 N, distilled water, selenium, H<sub>2</sub>SO<sub>4</sub>, NaOH 30 %, NaOH 0.1 N and HCl (Wulanningsih, 2022).

The equipment used are knives, cutting boards, basins, steaming pots, blenders, incubators, digital scales, thermometers, volume pipettes, bunsen, beakers, erlenmeyers, electric stoves, autoclaves, round bottom flasks, digital balances, drip pipettes, spatulas, funnels, reflux devices, burettes, statives, volumetric flasks, measuring cups, beakers, stirring rods, pH meters, analytical balances, a set of deconstruction tools, a set of kjehdal tools, and hot plates (Arziyah et al., 2022).

### Yogurt preparation

Purple sweet potatoes (300 g) were thoroughly washed, peeled, and steamed at 100°C for 25 minutes to soften the tubers. The steamed potatoes were mashed into a homogeneous paste using a mechanical blender. Skim milk and sugar were added to the paste, and the mixture was stirred until uniform. Pasteurization was conducted at 80 °C for 15 minutes to eliminate endogenous microbes, followed by rapid cooling to 40 °C to prepare the substrate for bacterial inoculation. The starter culture suspension (2 % v/v) was aseptically introduced into the mixture, which was then divided into three batches. These batches were incubated at room temperature (25–28 °C) for 7 hours (Sample A), 14 hours (Sample B), and 21 hours (Sample C) to assess the effects of fermentation time (Ahmad et al., 2022).

### Carbohydrate analysis

Carbohydrate content was quantified using the Luff-Schoorl method. Samples were subjected to acid hydrolysis with 3% HCl to break down complex carbohydrates into reducing sugars. The hydrolyzed solution was neutralized to pH 7 with 40% NaOH, then refluxed for 2.5 hours. The resulting solution was titrated with a standardized 0.1 N sodium thiosulfate solution after reaction with the Luff-Schoorl reagent (copper(II) sulfate in alkaline tartrate) (Handayani & Hidayati, 2024).

### Protein analysis

Protein content was determined via the Kjeldahl method. Samples (1 g each) were digested with 15 mL concentrated sulfuric acid and selenium catalyst tablets at 420°C for 3–5 hours until a clear digestate formed. The digestate was distilled with 30 % NaOH to liberate ammonia, which was trapped in 0.1 N HCl. Unreacted HCl was back-titrated with 0.1 N NaOH using methyl orange indicator (Li et al., 2024).

### Data analysis

All experiments were conducted in triplicate. Carbohydrate and protein values were averaged across replicates and reported as mean percentages. Statistical significance between fermentation durations was assessed using one-way ANOVA ( $p < 0.05$ ) with Tukey's post-hoc test for pairwise comparisons. Data were processed using Microsoft Excel 365 and GraphPad Prism 9.0.

## Results and Discussion

### Carbohydrate content

Carbohydrate levels in purple sweet potato yogurt varied significantly with fermentation duration show in **Table 1**.

**Table 1.** Carbohydrate Content Test Results

Sample	Fermentation Time (hour)	Carbohydrate Content (%)
A	7	10.36
B	14	10.41
C	21	10.02

The research samples used were purple sweet potatoes originating from Palu City. The determination of carbohydrate content in purple sweet potato yoghurt (Sample A, Sample B, and Sample C) was carried out using the Luff-Schoorl method (Ariyanto et al., 2023). The carbohydrate analysis based on titration data yielded values of 10.36%, 10.41%, and 10.02% for Samples A, B, and C, respectively. These results are not significantly different from those of Hastuti & Junardi (2024), who reported that the average carbohydrate content in yoghurt is >5.4%, ranging from 15.1969% to 16.8381%. According to the SNI 2009 quality standard, the minimum carbohydrate content in yoghurt should be 5.4 %. Furthermore, the addition of certain types of milk can affect the carbohydrate content of yoghurt, as the primary carbohydrate in milk is lactose, the milk sugar (Panseri et al., 2021). In the study by Noreen et al. (2024), the carbohydrate content of purple sweet potato yoghurt was lower, at 5.4 %.

In Sample A, lactic acid bacteria began to consume carbohydrates derived from purple sweet potatoes as an energy source for their growth and metabolic activities (Tong et al., 2024). At this stage, carbohydrates were still relatively abundant, so the yoghurt retained a high carbohydrate content. In Sample B, as fermentation progressed, the number of microorganisms increased due to an adequate carbohydrate source. However, at this stage, the

bacteria also began to metabolize carbohydrates into products such as lactic acid and alcohols (Anumudu et al., 2024). This process caused the measured carbohydrate content in the yoghurt to increase because of the release of simple sugars from the breakdown of sweet potato starch that had not yet been fully metabolized, resulting in a higher carbohydrate content compared to Sample A. In Sample C, after a longer fermentation period, the lactic acid bacteria had consumed most of the available carbohydrates. As a result, the carbohydrate content in the yoghurt decreased again because the carbohydrates had been converted into lactic acid and other metabolites. In addition, the decrease in pH during prolonged fermentation can inhibit bacterial activity, thereby reducing the production of new carbohydrates from the remaining substrate.

### Protein content

Protein content was directly correlated with fermentation time, as shown in **Table 2**.

**Table 2.** Protein content test results

Sample	Fermentation Time (hour)	Protein Content (%)
A	7	2.23
B	14	3.93
C	21	4.03

The protein content of Samples A, B, and C was determined by the Kjeldahl method, which comprises three stages: digestion, distillation, and titration. The results showed protein levels of 2.23%, 3.93%, and 4.03% for Samples A, B, and C, respectively. These findings align with previous research by Hastuti & Junardi (2024), which reported protein levels in purple sweet potato yoghurt exceeding 2%. However, according to the SNI 2009 quality standard, the minimum protein content for yoghurt is 2.7%.

Yoghurt is produced by fermentation with lactic acid bacteria (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*), which convert lactose to lactic acid while utilizing nutrients from added ingredients such as purple sweet potatoes. During fermentation, these bacteria grow and multiply by metabolizing carbohydrates from the sweet potatoes as their primary energy source. As fermentation progresses, the population of lactic acid bacteria increases. These bacteria contribute to protein content, as their cellular structures are composed of proteins and amino acids. The accumulation of microbial biomass during fermentation raises the total protein content in yoghurt, as bacterial proteins are included in the chemical analysis of the final product.

### Conclusions

Based on analyses of research samples, the longer the fermentation time, the lower the carbohydrate content. Conversely, protein content increases with fermentation time. The results of this

study can inform the public on how to manage sweet potatoes to maintain their nutritional content.

### Conflict of Interest

Authors declare no financial/commercial conflict of interest in this research.

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