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Sensory, Nutrient, and Shelf Life of Moringa Yogurt

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Abstract. Moringa yogurt was a type of yogurt produced with cow's milk and Moringa leaves (Moringa oliefera leaf). The goal of this study was to determine the level of preference for moringa yogurt, as well as its nutritional composition and shelf life. Sensory test results showed that 90% of people loved the colour, 86% liked the aroma, 94% liked the texture, 84% liked the consistency, and 84% liked the yoghurt flavour. Nutritional value of moringa yogurt: carbohydrates: 69.57 g; protein: 4.75 g; fat: 2.84 g; iron: 6.277 mg; calcium: 3.087 mg; vitamin A: 2.885 mg; vitamin C : 14,652 mg. Moringa yogurt shelf life indicated gradual changes during four weeks, including a reduction in water content (from 87.53% to 84.21%) and lactic acid bacteria (LAB) (from 10.23×10^2 to 9.91×10^2 CFU/ml), alongside an increase in lactic acid quantity (0.34% to 0.56%). These results demonstrate that Moringa yoghurt complies with Indonesian National Standards (SNI 2981:2009) for yoghurt quality throughout storage, specifically in terms of its appearance as a thick liquid-solid, its normal and typical yoghurt smell, its typical sour taste, and its homogeneous consistency. Beyond meeting quality requirements, the product offers potential health benefits due to its antioxidant vitamin C content and represents a promising innovation for functional food development and commercialization.

1 Introduction

Yoghurt is a dairy product produced through a fermentation process involving the bacteria Lactobacillus bulgaricus and Streptococcus thermophilus. These bacteria convert lactose (milk sugar) into lactic acid, which causes a drop in pH and the formation of clots due to the coagulation of milk proteins by acids, resulting in a taste. It is distinctive because it contains flavorings like diacetyl, acetaldehyde, and carbon dioxide. Lactose will be converted to lactic acid by the bacterium. Regular yoghurt consumption promotes the growth and activity of beneficial bacteria in the human gastrointestinal system. These bacteria are also thought to

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play a role in maintaining immunity, preventing constipation, reducing sleeplessness, and lowering stress levels in human brain. Moringa yogurt is made from whole cow's milk, skim milk, sugar, bacteria, and moringa leaves. The moringa yoghurt product is one of the efforts to diversify yoghurt products that have undergone sensory tests, nutritional content analysis, and shelf life evaluation. This product is expected to be widely marketed, which can create "income generation" for the institution.

To further enhance yogurt's functional properties, natural plant-based fortifications are increasingly explored. Such enrichment strategies aim to enhance the nutrient content while introducing bioactive compounds with antioxidant, antimicrobial, and therapeutic properties. Among the various options, Moringa oleifera leaves stand out due to their exceptional nutrient density and pharmacological value.

Moringa oleifera, often referred to as the "miracle tree," contains high levels of proteins, essential amino acids, vitamins (A, C, and E), and minerals such as calcium and iron. For instance, its leaves provide up to seven times more vitamin C than oranges, ten times more vitamin A than carrots, and seventeen times more calcium than milk [1]. In addition, moringa leaves are rich in flavonoids, phenolic acids, and carotenoids that act as strong antioxidants and anti-inflammatory agents [2].These compounds contribute to free-radical scavenging, reduce oxidative stress, and lower the risk of chronic diseases such as cancer, atherosclerosis, and neurodegenerative disorders [3] [4].

Evidence also shows that fortifying yoghurt with herbal and plant-based additives can enhance its nutritional quality and functional value without compromising consumer acceptability. For example, mango-enriched yogurt demonstrated increased vitamin content and antioxidant activity [5]. More recently, studies have demonstrated that fortification with Moringa oleifera can improve mineral composition, phenolic content, and even stimulate the growth of probiotic bacteria, while maintaining desirable sensory properties [6] [7].

Apart from nutrition, shelf life is another critical determinant of yogurt's quality and consumer safety. Parameters such as water content, lactic acid concentration, and viable LAB counts are crucial for maintaining product stability, texture, flavor, and probiotic viability [8]. Since moringa leaves contain bioactive compounds that may influence microbial growth and fermentation dynamics, their incorporation could affect yogurt stability during storage. Therefore, comprehensive evaluation of both sensory attributes and shelf-life characteristics is essential to determine the feasibility of developing moringa-based yogurt as a functional and commercially viable product.

Based on these considerations, this study was designed to evaluate the sensory acceptance, nutritional composition, and shelf life of yogurt enriched with Moringa oleifera leaves. The findings are expected to provide scientific evidence for the potential of moringa-fortified yogurt as a functional food innovation that combines health benefits with market applicability.

2 Materials and Method

2.1 Materials

The main ingredients used in making moringa yogurt was cow's milk, skim milk, sugar, bacteria (*Lactobacillus acidophilus, Lactobacillus bulgaricus,* and *Streptococcus thermophilus*), and Moringa leaves. The material for the sensory test was 100 mL of moringa yoghurt, which was placed in a bottle for each respondent. Materials for analysing chemical characteristics include levels of carbohydrates, protein, fat, iron, calcium, vitamin A, vitamin C, water content, lactic acid bacteria, and lactic acid. By using a solution of 0.1 N NaOH, petroleum ether, phenolphthalein, alcohol, and aquadest.

2.2 Tool

The tools used in making moringa yoghurt were a pot, blender, sieve, stirrer, stove, and thermometer. The tools for sensory testing were 100 ml plastic bottles. The tools for analysing chemical characteristics were as follows: porcelain dish, desiccator, oven, Kjeldahl heater, 30 mL/50 mL Kjeldahl flask, complete distillation apparatus with a 125 mL Erlenmeyer flask, 25 mL/50 mL burette, Soxhlet extraction apparatus, paper-free fat filter, and analytical balance.

2.3 Method

2.3.1 Sensory test

Using 50 panelists, a preference test was conducted with the following parameters: color, aroma, texture, thickness, and taste, on a scale of "like," "quite like," "detest," and "dislike."

2.3.2 Chemical analysis

Chemical analysis was carried out by measuring carbohydrate content using the difference formula and protein content using the Kjeldahl micro method. Fat content by the Soxhlet method. Water content is determined using the Gravimetry method by inserting a 2 – 5 gram sample of the yoghurt into an aluminium cup, which has been weighed to determine its empty weight. The cup is then placed in the oven and dried at a temperature of 105 °C for 3 hours. Then it was cooled in a desiccator and weighed again. Samples were returned to the oven at a temperature of 105 °C for 1 hour, then cooled in a desiccator and weighed again. Lactic acid levels using the AOAC method, as much as 10 mL of yogurt is put into an Erlenemeyer flask and 2-3 drops of 1% phenolphthalein solution are added as an indicator. The burette was filled with a 0.1 N NaOH solution. The yoghurt solution was then titrated using NaOH solution until the color changed to reddish. Minerals and vitamins were determined using standard AOAC methods. All chemical analyses were conducted in triplicate to ensure reproducibility.

2.3.3 Microbiological analysis

Total bacteria were counted using the TPC (Total Plate Count) method. One millilitre of sample was inserted into a tube reaction containing 9 ml of 0.85% NaCl physiological solution, which had been last homogenised (dilution 10-1). The dilution of 10-2 was prepared from a 1 mL suspension sample and added to the tube reaction, which contained 9 mL of physiological 0.85% NaCl solution and was shaken until homogeneous. Dilution was subsequently carried out in the same manner, until a solution of 10-9 was obtained. At the dilutions of 10-7, 10-8, and 10-9, 1 ml of the suspension sample was transferred and inserted into a sterile petri dish, in duplicate. Filled a petri dish with 15-20 mL of MRSA media and 0.5% glacial acetic acid. Those activities involved performing a playback of the cup to form figures of eight in order to get suspensions and media evenly mixed, and then letting them stand until they became solid. Incubated at a temperature of 37 ° C for 48 hours by placing the cup in a position reversed. Each microbiological test was performed in duplicate plating from three independent yogurt batches (n = 3) to ensure accuracy.

FTIR characterization was carried out to identify the element of complex groups contained in the sample. Sample preparation for measurement using an FTIR spectrometer was performed by mixing 2 mg of sample with 100 mg of KBr and then pressing the mixture to form a pellet. Samples were characterized using Shimadzu IRPrestige-21 FTIR using wave number of 400- 4000 cm^{-1}.

3 Results and Discussion

3.1 Sensory test

The quality of yoghurt products is determined by: colour, aroma, texture, thickness, and taste [9]. Sensory test results on the level of preference for moringa yoghurt include colour, aroma, texture, thickness, and taste, as shown in Table 1.

Table 1. Results of favorite yogurt moringa leaves.

Degree of favorability	Criteria				
	Color	Odor	Texture	Thickness	Flavor
Like	45 (90%)	43 (86%)	47 (94%)	42 (84%)	42 (84%)
Quite Like	5 (10%)	4 (8%)	3 (6%)	4 (8%)	6 (12%)
Detest	0	3 (6%)	0	4 (8%)	2 (4%)
Dislike	0	0	0	0	0
Total	50 (100%)	50 (100%)	50 (100%)	50 (100%)	50 (100%)

The colour of the yoghurt produced was influenced by the addition of moringa leaves in the manufacturing process, resulting in a bright green colour. The aroma of yoghurt was slightly sour, typical of yoghurt, which is due to the activity of LAB fermentation, especially L. bulgaricus bacteria, through the production of lactic acid and acetaldehyde. In the process of formation of lactic acid, lactose in milk is hydrolyzed by the starter into glucose and galactose by the enzyme beta-D-galactosidase and beta-D-phosphogalactosidase produced by S. thermophilus and L. bulgaricus. In the metabolic process, glucose is converted into lactic acid through the glycolysis pathway, while galactose is accumulated. The sour taste produced is the result of fermentation, where sugar is converted into organic acids by LAB. Therefore, the sour taste depends on the total amount of LAB contained in yoghurt. During the fermentation process, LAB produces a special taste caused by the formation of organic acids [5]. Sensory test results showed that more than 80% of respondents liked moringa yoghurt products in terms of colour, aroma, texture, thickness, and taste.

3.2 Nutritional composition

The content of vitamin C in Moringa Yoghurt (14,652mg) can be utilised as an antioxidant to counterbalance the effects of oxidation. Antioxidants can stabilize free radicals and even inhibit their formation. The roles of antioxidants in the prevention and treatment of cancer are; (1) cancer: antioxidants protect DNA, thereby reducing DNA damage caused by free radicals. (2) Alzheimer, the content of low antioxidant activity is associated with the occurrence of Alzheimer's disease. (3) atherosclerosis, by preventing free-radical oxidation reactions in LDL cholesterol. Vitamin C is a secondary antioxidant group that functions as a binder of metal ions, oxygen catchers, and decomposers of hydroperoxides into non-radical compounds and absorbs UV radiation [10].

Fig. 1. Moringa yogurt.

Beyond its vitamin C content, the overall nutritional composition of Moringa yogurt also reflects its potential as a functional food. Table 2 presents a comparison of the nutrient profiles of Moringa yoghurt, plain commercial yoghurt, and the Indonesian National Standard (SNI 2981:2009). This comparison not only highlights compliance with national quality requirements but also emphasizes the superior levels of certain micronutrients, particularly iron and vitamin C, that distinguish Moringa yogurt from conventional yogurt products.

Table 1. Nutritional composition of moringa yogurt compared with commercial yogurt and SNI standard (per 100 g).

Nutritional Elements	Moringa Yogurt (research results)	Moringa Yogurt (Plain Commercial)*	SNI 2981:2009
Protein (g)	4.75	3.0 – 4.0	≥ 2.7
Carbohydrate (g)	69.57	4.7 – 7.0	Not specified
Fat (g)	2.84	3.0 – 3.5	0.6 – 2.9
Calcium (mg)	3.087	120 – 150	Not specified
Iron (mg)	6.277	~0 (very low)	Not specified
Vitamin A (mg)	2.885	~0.02 – 0.05	Not specified
Vitamin C (mg)	14.652	~1 – 2 (negligible)	Not specified
LAB (log CFU/mL)	10.23 – 9.91	$10^5 – 10^7$	≥ 10^7

*Source: [17] [18]

This comparative analysis highlights the superior micronutrient profile of Moringa yogurt. While its protein and fat levels are within the typical range for yoghurt and comply with SNI 2981:2009, the key distinction lies in its high iron and vitamin C contents, which are negligible in plain commercial yoghurt. These nutrients enhance yoghurt's functional benefits by addressing common deficiencies, particularly iron-deficiency anaemia and low antioxidant intake. In addition, vitamin A and calcium contribute to immunity, vision, and bone health, strengthening the case for Moringa yogurt as both a probiotic dairy product and

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a fortified functional food. Thus, beyond meeting national standards, Moringa yoghurt offers added nutritional value compared to conventional yoghurt products.

3.3 Shelf life analysis

3.3.1 Water content

To determine the shelf life/storage of Moringa yogurt using parameters of water content, total LAB, and total lactic acid with storage times of 0 weeks, 1 week, 2 weeks, 3 weeks, and 4 weeks. The length of storage affects the water content of moringa yogurt, the longer the storage, the lower the water content. At 0 weeks of storage, the water content was 87.53 and decreased until 4 weeks of storage, when it reached 84.21.

Table 3. Moisture content of moringa yogurt.

Storage Time	Water content (%)
0 week	87.53
1 week	86.74
2 weeks	85.53
3 weeks	85.41
4 weeks	84.21

Water, unlike other components of food, cannot be synthesised by bacteria; instead, it acts as a growth medium required by most microorganisms and can affect the rate or speed of growth [8]. The water content produced in this study ranged from 84.21 to 87.53%. According to Winarno and Djojosoebagio (2012) [13], yoghurt generally contains about 85–89% water, indicating that the water content in Moringa yoghurt remains normal after 4 weeks of storage.

3.3.2 Lactic acid bacteria (LAB)

Table 4. Number of lactic acid bacteria (LAB) moringa yogurt.

Storage Time	Total LAB (log CFU/ml)
0 week	10.23
1 week	10, 18
2 weeks	10,15
3 weeks	9, 98
4 weeks	9.91

Based on Table 4, it is evident that the longer the storage period, the amount of LAB produced tends to decrease. The decrease in the amount of LAB during storage was caused by the increasing amount of lactic acid produced and the cold storage temperature (50^0C) which inhibited LAB activity, resulting in a decrease in total LAB. This situation was known as the "bacterial decline phase." The decline phase occurred after LAB went through the growth phase and the stationary phase [14]. The amount of LAB obtained in this study ranged from 9.91 to $10.23x10^2$CFU/ml.

3.3.3 Lactic acid levels

Table 5. Amount of lactic acid in moringa yogurt.

Storage Time	Total Lactic Acid (%)
0 week	0.34
1 week	0.41
2 weeks	0.46
3 weeks	0.52
4 weeks	0.56

The amount of LAB contained in yoghurt is one of the key factors determining the feasibility of this product, which is categorised as a functional food. The recommended dose of probiotics in the diet for making yoghurt is between 10^6 and 10^7 cells/gram or millilitre. The minimal amount of a probiotic strain in the food product is 10^6 CFU/g, to compensate for a possible reduction in the number of probiotic bacteria in the digestive tract. The total amount of LAB is still included in the recommended probiotic content limit in standard probiotic products, which ranges from 10 ^5 to 10^9 colonies/mL [15].

The results of the total lactic acid test in Moringa yogurt during the storage period showed that the amount increased with the length of storage, starting from 0.34 at week 0 and increasing to 0.56 at week 4. Lactic acid (C3H6O3) is the largest acid component formed by the fermentation of milk into soya yogurt. The amount of lactic acid formed during the fermentation process, which is the result of the breakdown of lactose by LAB. This acid is one component that contributes to the flavor and aroma of soy yogurt. According to SNI 2981:2009, the optimal lactic acid levels in yoghurt are 0.5-2.0%.

Lactic acid can reduce or kill pathogenic bacteria (disease-causing bacteria) and suppress the production of harmful compounds, such as amines, phenols, skatol, and H2S produced by pathogenic bacteria. Lactic acid-producing bacteria also produce antibiotics that can inhibit the growth of pathogenic bacteria. Therefore, yogurt has medicinal value for injured stomachs and intestines [1].

3.4 Relationship between LAB and lactic acid

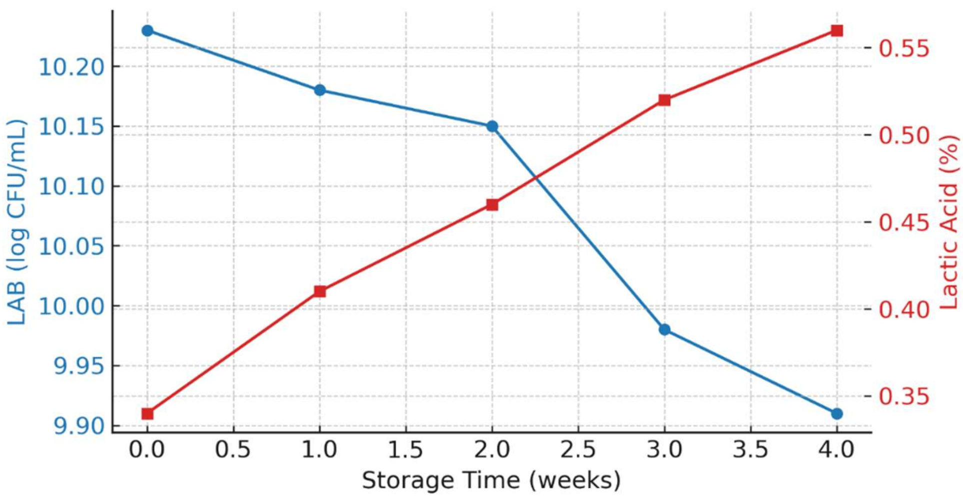

Fig. 2. Relationship between LAB counts and lactic acid during storage.

Figure 2. illustrates the relationship between LAB counts and lactic acid concentration during four weeks of storage. A clear inverse trend is observed: as storage time increased, the number of viable LAB gradually decreased from 10.23 to 9.91 log CFU/mL, while lactic

acid levels increased from 0.34% to 0.56%. This pattern reflects the metabolic activity of LAB, in which lactose is converted into lactic acid during fermentation. Over time, the accumulation of lactic acid and low-temperature storage conditions led to a decline in LAB viability, a phase commonly referred to as the bacterial decline phase. Nevertheless, the LAB counts remained within the acceptable range for probiotic yoghurt products, and the lactic acid concentration remained consistent with the Indonesian National Standard (SNI 2981:2009). These findings confirm that Moringa yogurt maintained functional and safety standards throughout the storage period.

4 Conclusion

Moringa yoghurt has met most of the quality requirements of yoghurt in accordance with the Indonesian National Standard (SNI 2981:2009), specifically a thick liquid consistency, normal odour, sour/typical taste, and homogeneous texture. Its fat content (2.84 g/100 g) was within the minimum standard range of 0.6–2.9 g, and its protein content (4.75 g/100 g) exceeded the required minimum of 2.7 g. However, the viable lactic acid bacteria (LAB) count was 1.2×10^4 CFU/mL, which is below the recommended threshold of 10^7 CFU/mL, indicating the need for optimization in fermentation or storage conditions to improve microbial viability. Beyond compliance with most SNI parameters, Moringa yoghurt also demonstrated superior micronutrient density, particularly in iron (6.277 mg/100 g) and vitamin C (14.652 mg/100 g), which are typically negligible in conventional yoghurt. These findings underscore its potential not only as a functional food but also as a scalable product for commercialization, offering opportunities to address micronutrient deficiencies while aligning with growing consumer demand for health-oriented products. Future research should extend shelf-life evaluation beyond four weeks, with emphasis on sensory changes, microbial stability, and nutrient retention under commercial storage and distribution conditions, to further support product development and market readiness.

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