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Development of goat milk yogurt with additional inulin as a functional food for stunting prevention in children

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ABSTRACT

Introduction: Stunting is a global issue affecting physical and cognitive growth, influenced by low nutritional intake and impaired gut health. With its high mineral bioavailability, quality protein, and easily digestible fatty acids, goat milk is suitable for malnourished children. Adding inulin to goat milk yogurt has the potential to improve nutritional quality but requires further research.

Objective: This study aims to advance a yogurt formula based on goat's milk by adding inulin as a functional food to prevent stunting.

Methods: Goat milk is obtained from *Etawa* local farms. Inulin powder is obtained through purchases in the marketplace from trusted regional brands. Yogurt is made by adding inulin with different concentrations (F0: 0%, F1: 0.3%, F2: 0.6%, F3: 1%). Organoleptic test or sensory testing was carried out by 30 semi-trained panelists with 7 hedonic assessment scales. All of the nutrients were analyzed and the best formula was selected following the calculation of nutrients and sensory test. Then the best formula was tested for its LAB (Lactic Acid Bacteria) value.

Results: Yogurt with 1% inulin (F3) is a product with the best sensory acceptance and the best nutritional composition. There is a significant difference in taste from the results of sensory evaluation between F0 and F3 (p=0.004) and between F0 and F2 (p=0.045). The nutritional analysis is per 100 grams of yogurt product. F3 yogurt product has a fat content of 1.36%, protein 3.48%, and carbohydrate 11.80%. Enriching yogurt with inulin enhances its protein and carbohydrate content. Formula F3 has a LAB content of 3.65 x 10^8 CFU/ml and a pH of 4.11.

Conclusion: Goat milk yogurt with added inulin can improve the taste quality while enriching the nutritional content, especially in terms of protein and carbohydrates. Due to its high protein content and probiotic benefits, this product has the potential to be a functional food for preventing stunting in children.

KEYWORDS

Digestive Health, Functional Food, Probiotics, Prebiotics, Stunting.

INTRODUCTION

Stunting is a critical health issue, especially in developing countries, including Indonesia. This condition is mentioned by stunted linear growth so that children have a height below the standard for their age[1]. Moreover, stunting not only affects physical growth but also cognitive development, which ultimately impacts individual productivity in the future[2]. The main causes of stunting include inadequate nutritional intake over a long period, repeated infections, and intestinal health disorders that affect the effective absorption of nutrients[3–6].

Research indicates that gut health plays a critical role in preventing stunting. An imbalance in gut microbiota can reduce the bioavailability of nutrients and the body's ability to absorb essential nutrients[7,8]. Functional foods that support gut health while meeting macro and micronutrient needs are a promising solution. Goat milk is one of the foods that has great potential to support stunting prevention[9].

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In Indonesia, goat farming has significant development, both on a small and large scale. Goat milk production continues to increase along with increasing public awareness of the health benefits of goat milk[10]. However, consumption of goat milk in Indonesia is still limited, generally only in the form of fresh milk or powdered milk. The potential for diversifying goat milk-based products remains untapped, making innovations like goat milk-based yogurt highly relevant.

Goat milk is one of the functional foods because it contains antioxidants[11]. The protein content of goat milk (4.3%) is higher than cow's milk (3%)[12]. Goat milk is known to have higher mineral bioavailability than cow's milk, such as calcium, magnesium, and phosphorus, which are essential for bone growth. In addition, goat milk contains high-quality protein and short and medium-chain fatty acids that are more easily digested, making it an ideal choice for children with digestive problems or allergy risks (hypoallergenic)[13,14]. However, one of the main challenges of goat milk is its distinctive aroma and unpleasant taste, which often makes it less appealing, particularly for children[15].

The process of fermenting goat milk into yogurt offers a solution to overcome this challenge. Fermentation not only reduces the unpleasant taste but also enhances the probiotic benefits of the final product. Probiotics help maintain a healthy balance of gut microbiota, support digestive health, and improve the absorption of essential nutrients[16].

Yogurt can be enriched in its functional value by adding prebiotics, forming a functional food product known as synbiotics. Synbiotics provide health benefits to humans, such as antimicrobial, anticancer, and antiallergic effects[17]. Symbiotic yogurt is a yogurt product enriched with prebiotics[18].

Compounds that are classified as prebiotics and found in food include inulin and trans-galactooligosaccharides[19]. Inulin, composed of fructose, is rich in dietary fiber. Inulin is soluble in water, cannot be digested by human digestive enzymes, but can be fermented by microflora in the large intestine or colon[20]. Inulin may increase the growth of probiotic bacteria, improve digestive tract function, and improve the nutritional quality of products, including their fiber and carbohydrate content[21–23].

Goat milk yogurt enriched with inulin has the potential to serve as a functional food that not only supports gut health but also helps prevent stunting. This product is made to fulfill children's nutritional needs while enhancing the taste and aroma of goat milk. This study aims to advance a goat milk yogurt formula with added inulin, evaluate its sensory characteristics and nutritional value, and identify the potential of the product as an innovative solution in stunting prevention. Following the innovation, it is hoped that functional food products can be created that support efforts to improve the nutritional status and health of children in Indonesia.

MATERIALS AND METHODS

The raw materials for making goat milk yogurt include goat milk, inulin powder, a yogurt starter, and sugar. The goat milk is sourced from local farms with *Etawa* crossbred goats. Inulin powder is purchased from a trusted local brand through the marketplace, and the yogurt starter used is *Biokul*.

Yogurt Making Process

The process of making yogurt with the addition of inulin was modified from the methods used in the research by Minda (2006) and Sudaryati (2016)[24,25]. The yogurt formula was developed at four different levels, namely F0, F1, F2, and F3. The initial stage of yogurt production involved pasteurizing 200 mL of milk in four separate containers at a temperature of 72°C to eliminate any pathogenic bacteria that may be present in the milk. While stirring, sugar and inulin are added according to the specified treatment (F0 (0% inulin), F1 (0.3% inulin), F2 (0.6% inulin), and F3 (1% inulin). The calculation of the percentage of inulin is from the total milk ingredients. So F1 is added as much as 0.6 g of inulin, F2 is added as much as 1.2 g of inulin, and F3 as much as 2 g of inulin. After being heated for 15 seconds, the heat is turned off and cooled to a temperature of 40°C. Then, the milk is placed in a glass jar, followed by the addition of 5% (10 g) of yogurt starter in each formula. Furthermore, the mixture is stirred until evenly distributed and incubated for 6 hours at a temperature of 40°C.

Sensory Test

Sensory testing was conducted with 30 semi-trained panelists. Sensory testing uses a scale of 1-7, from "Very Dislike" to "Very Like". The aspects assessed include the color, aroma, taste, and texture of the product.

Nutrient Analysis Test

Nutrient analysis was conducted following standard procedures. Protein content was analyzed using the Kjeldahl method (AOAC 2012)[26], fat content using the Soxhlet method (AOAC 2012)[26], and carbohydrate content was determined by-difference method (FAO 2003)[27]. Moisture and ash content were measured according to AOAC protocols.

pH and Total LAB Test

Measurements of pH were performed using a pH meter that had been calibrated with pH 4 and 7 buffer solutions before use. Total LAB (Lactic Acid Bacteria) tests were performed using the plate count method or TPC (Total Plate Count). The calculation was done by counting the total number of LAB that grew on MRS (Man Rogosa and Sharp) media.

Data analysis

The data from organoleptic tests, nutritional analysis, and pH measurements were statistically analyzed using SPSS soft-

ware. Statistical analysis began with testing data normality using the Shapiro-Wilk test. For normally distributed data, including nutritional analysis results and pH measurements, a one-way ANOVA was performed, followed by the Duncan test for post hoc analysis to compare differences among the four yogurt formulas (F0, F1, F2, and F3). Meanwhile, for non-normally distributed data, such as sensory evaluation (organoleptic tests), the Kruskal-Wallis test was used, followed by the Mann-Whitney test for post hoc comparisons to determine significant differences between the yogurt formulations.

This comparison aimed to identify the optimal yogurt formula in terms of both sensory evaluation and nutritional value while ensuring compliance with yogurt quality standards.

RESULTS

Sensory Test Results

The results of the sensory test of the product were assessed based on the median value of each panelist's assessment. The color assessment obtained the same score, namely a score of 6 for all formulas. For the aroma assessment, F0 received a lower score than other formulas. Likewise, with the assessment of taste and texture, F0 received the lowest score. It can be seen in Table 1 that with the increasing addition of inulin, the taste and texture assessment scores increased.

The Kruskal Wallis test in **Table 1** was conducted to see if there was a real or significant difference in the sensory assessment of each formula. The results obtained were that for color, aroma, and texture there was no significant difference in assessment, but there was a significant difference in assessment in the taste section (p=0.030). Post hoc analysis using the Mann-Whitney test revealed a significant difference between F0 and F3 (p = 0.004) and between F0 and F2 (p = 0.045). Meanwhile, no significant differences were found between F0 and F1, F1 and F2, F1 and F3, or F2 and F3.

The results of the proximate test showed significant differences among the yogurt formulas, as presented in **Table 2**.

Table 1. Median Score of Sensory Test Results

Parameter	Treatment Level				Sig. *(p)
	F0	F1	F2	F3	
Color	6.00	6.00	6.00	6.00	0.884
Aroma	5.50	6.00	6.00	6.00	0.744
Flavor	4.50 [a]	5.00 [a]	5.50 [b]	5.75 [b]	0.030
Texture	5.00	5.25	5.25	5.50	0.583
Total	21.00	22.25	22.75	23.25	

* Kruskal-Wallis test (significant at the 5% level), followed by the Mann-Whitney test for post hoc comparisons. Different letter notations (a, b) indicate significant differences ($p < 0.05$).

Table 2. Results of Analysis of Nutrient Content/100 ml Yogurt Formula

Testing	Treatment Level				Sig. *(p)
	F0	F1	F2	F3	
Water (%)	82.36	82.41	82.42	82.28	0.080
Ash (%)	0.86 [a]	0.71 [b]	0.90 [a]	1.09 [c]	0.006
Fat (%)	2.89 [a]	2.22 [b]	1.70 [c]	1.36 [d]	<0.001
Protein (%)	3.20 [a]	3.26 [a]	3.34 [b]	3.48 [c]	0.001
Carbohydrates (%)	10.54 [a]	11.40 [b]	11.64 [c]	11.80 [c]	<0.001

* One Way ANOVA Test (Significant at 5% level), followed by the Duncan test for post hoc analysis. Different letter notations (a, b, c, d) indicate significant differences.

The highest water content was found in F2 (82.42%), while the lowest was in F3 (82.28%). However, no significant difference was found among all formulas ($p>0.05$). Meanwhile, significant differences in ash, protein, fat, and carbohydrate content were found using one-way ANOVA ($p<0.05$), followed by post hoc analysis with the Duncan test.

The ash content varied significantly between F0 and F1, F0 and F3, F1 and F2, F1 and F3, and F2 and F3. However, no significant difference was observed between F0 and F2. The lowest ash content was found in F1 (0.71%), while the highest was in F3 (1.08%). The fat content in each formula also differed significantly based on post hoc analysis using the Duncan test. The lowest fat content was found in F3 (1.36%), while the highest was in F0 (2.89%).

Significant differences were observed in protein content between F0 and F2, F0 and F3, F1 and F2, F1 and F3, and F2 and F3. However, no significant difference was found between F0 and F1. The highest protein content was in F3 (3.48%), while the lowest was in F0 (3.20%).

Similarly, significant differences were also observed in carbohydrate content between F0 and F1, F0 and F2, F0 and F3, F1 and F2, and F1 and F3. However, no significant difference was found between F2 and F3. The highest carbohydrate content was found in F3 (11.80%), while the lowest was in F0 (10.54%).

Yogurt with inulin was also tested to check if its acidity met SNI standards. The results of the pH measurements are shown in **Table 3**. The highest pH level results were in F0 at 4.14 and the lowest in F2 at 4.07. There were no significant differences ($p> 0.05$) in all formulas and all met the pH standards for yogurt products.

Table 3. Yoghurt Formula pH Levels

Treatment Level	Results	*Sig. (p)**
F0	4.14	0.059
F1	4.13	
F2	4.07	
F3	4.11	

*One-way ANOVA test (Significant at 5% level).

The best formula for this product is F3, which is obtained by ranking the total median score of sensory tests and nutrient content tests. The total LAB test result in F3 is 3.65×10^8 CFU/ml.

DISCUSSION

Based on the assessment of sensory tests and nutritional content, it was obtained that F3 (1% inulin) is the best formula. The best yogurt formula contains 1.36 g of fat per 100 product, 3.48 g of protein per 100 product, and 11.80 g of carbohydrate per 100 g of product. The ash and protein content of the best formula of this product has met the SNI yogurt standard (2981:2009).

This product is a source of protein and has probiotic functions. Goat milk that has been turned into yogurt will reduce the distinctive smell of goaty flavor that is pungent in goat milk[28].

Casein, the main protein in milk, forms clots caused by lactic acid produced by the activity of Lactic Acid Bacteria (LAB). Lactic acid can disrupt the stability of insoluble casein micelles so that in the pH range of 4.6-4.7, casein coagulates and forms a gel. This casein coagulation process affects the texture of the resulting set yogurt[29].

The addition of inulin in the production of goat milk yogurt improves the yogurt product both in terms of sensory qualities and overall nutritional content. Based on the sensory evaluation, F3, which had the highest amount of inulin, received the highest total score.

In addition, inulin improves the texture of yogurt to be thicker and more preferred by panelists. This is following what was conveyed from various studies that the addition of inulin can make the texture of set yogurt denser because inulin has properties as a texturizer[24].

In terms of nutrient content, the increase in inulin concentration up to 1% shows a significant increase in protein and carbohydrate content. Inulin in yogurt plays a role in supporting the growth of Lactic Acid Bacteria (LAB). The addition of inulin as a prebiotic can increase the amount of LAB, which contributes to increasing protein through more optimal fermentation activity[30]. Meanwhile, the amount of carbohydrates increases due to the addition of inulin, a natural polymer from the carbohydrate group[24].

However, the fat content decreases with the addition of inulin. Based on the results of the Kruskal Wallis test (p-value> 0.05) there is a significant difference in the addition of inulin to the fat of goat milk yogurt formula. Fat in milk is mainly in the form of acyl glycerol as much as 96-98% of the total milk lipid. Acyl glycerol in yogurt is hydrolyzed into glycerol and fatty acids by yogurt starter and causes fermented milk to reduce milk fat content and increase fatty acid content[24,31].

In addition, this product has reached SNI standards in terms of appearance, aroma, taste, and total LAB content. The total LAB in the best formula in the development of this product is 3.65×10^8 CFU / ml. This total LAB is in accordance with SNI yogurt, where the minimum is 1×10^7 CFU / ml. The high amount of LAB in a product indicates its potential as an effective probiotic[32].

Lactic Acid Bacteria are known to have various health benefits, including improving digestive health, strengthening the

immune system, and preventing the growth of pathogenic bacteria in the intestines[33]. This also shows that bacteria grow a lot due to the addition of inulin, inulin will be fermented by lactic acid bacteria and then produce lactic acid and short-chain fatty acids[34].

This study shows that consuming one serving (100 g) of goat milk yogurt with added inulin can meet 10% of the daily protein needs for Indonesian children aged 1-3 years (20 g). However, the energy, fat, and carbohydrate requirements have not been fulfilled. Therefore, it is recommended to consume 1 ¼ portions (125 g) of goat milk yogurt with added inulin to reach the energy needs of snacks for children aged 1-3 years (10% of 1350 kcal).

CONCLUSION

This study concludes that increasing the inulin concentration in yogurt raises protein and carbohydrate levels but reduces fat content. In addition, the higher the concentration of added inulin, the more it is preferred by the panelists from the evaluation of the sensory test results. In this study, the consumption of 100 g of inulin yogurt meets 17.4% of the daily protein requirements for children aged 1-3 years. However, to meet 10% of daily energy needs, it is recommended to consume 125 grams.

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REFERENCE

1. Laksono AD, Wulandari RD, Amaliah N, Wisnuwardani RW. Stunting among children under two years in Indonesia: Does maternal education matter? PLoS One. 2022;17(7):e0271509.
2. De Sanctis V, Soliman A, Alaaraj N, Ahmed S, Alyafei F, Hamed N. Early and Long-term Consequences of Nutritional Stunting: From Childhood to Adulthood. Acta Biomed. 2021 Feb;92(1):e2021168.
3. Kementerian Kesehatan Republik Indonesia. Towards a future in Indonesia without child undernutrition: Managing child wasting and reducing the prevalence of child stunting. 2021;1–12.
4. Ekholuenetale M, Barrow A, Ekholuenetale CE, Tudeme G. Impact of stunting on early childhood cognitive development in Benin: evidence from Demographic and Health Survey. Egypt Pediatr Assoc Gaz. 2020;68(1).
5. Kane A V, Dinh DM, Ward HD. Childhood malnutrition and the intestinal microbiome. Pediatr Res. 2015 Jan;77(1–2):256–62.
6. Fikri AM, Astuti W, Nurhidayati VA, Saliha F, Prameswari P. Protein intake recommendation for stunted children : An-update review. Artículo Orig Nutr Clín Diet Hosp. 2024;44(3):117–23.
7. Simanjuntak BY, Annisa R, Saputra AI. A Literature Review: Does The Gut Microbiota Related to Stunting Under 5 Years Children? Kajian Literatur: Berhubungankah Mikrobiota Saluran Cerna dengan Stunting pada Anak Balita? Amerta Nutr [Internet]. 2022 Dec 23;6(1SP SE-Literature Review):343–51. Available from: https://e-journal.unair.ac.id/AMNT/article/view/39817
8. Heuven LA, Pyle S, Greyling A, Melse-Boonstra A, Eilander A. Gut Microbiota-Targeted Nutritional Interventions Improving Child Growth in Low- and Middle-Income Countries: A Systematic Review. Curr Dev Nutr. 2021 Nov;5(11):nzab124.
9. Idamokoro EM. The significance of goat milk in enhancing nutrition security: a scientiometric evaluation of research studies from 1966 to 2020. Agric Food Secur [Internet]. 2023;12(1):34. Available from: https://doi.org/10.1186/s40066-023-00441-5
10. Waluyo D. The Great Potential of Goat Farming in Indonesia: Food and Economic Independence [Internet]. [cited 2024 Jul 24]. Available from: https://indonesia.go.id/detik/editorial/8417/potensi-besar-peternakan-kambing-di-indonesia-kemandirian-pangan-dan-Ekonomi
11. Pratama B, Jeki S, Arifin HD. Antioxidant Activity and Organoleptic Quality of Etawa Goat Milk Yogurt with Beetroot Juice (Beta vulgaris L.). 2019;4(2):39–48.
12. Verruck S, Dantas A, Schwinden E. Functionality of the components from goat ' s milk, recent advances for functional dairy products development and its implications on human health. J Funct Foods [Internet]. 2019;52(September 2018):243–57. Available from: https://doi.org/10.1016/j.jff.2018.11.017
13. Dagnaw G, A M, A W, H K. Review on Goat Milk Composition and its Nutritive Value. J Nutr Heal Sci. 2016 Nov 1;3.
14. Atmiyati. The Potential of Goat Milk as Medicine and Source of Animal Protein to Improve Farmers' Nutrition. In Bogor: Balai Penelitian Ternak; 2001.
15. He A, Chin J, Lomiguen CM. Benefits of Probiotic Yogurt Consumption on Maternal Health and Pregnancy Outcomes: A Systematic Review. Cureus. 2020;12(7):6–13.
16. Setyawardani T. Making Cheese, Yogurt, and Kefir from Goat's Milk. Purwekerto: Penebar Swadaya Grup; 2017. 82 p.
17. Fazilah NF, Ariff AB, Khayat ME, Rios-Solis L, Halim M. Influence of probiotics, prebiotics, synbiotics and bioactive phytochemicals on the formulation of functional yogurt. J Funct Foods. 2018; 48(July):387–99.
18. Setiarto RHB, Widhyastuti N, Fairuz I. Effect of lactic acid bacteria starter and the fortification of modified taro flour on the quality of synbiotic yogurt. J Ris Teknol Ind. 2017;18–30.

19. Roberfroid M. Prebiotics: The concept revisited. J Nutr. 2007;137(3).

20. Herminiati A. Dahlia Tubers: Potential, Role, and Development Prospects. J Pangan. 2012;21:397–406.

21. Ilievska N, Pavlova V, Kirovska V, Ilievska J, Pavlovska M. Nutritional and health benefits of inulin as functional food and prebiotic. J Hyg Eng Des. 2019;27:45–8.

22. Bărboi OB, Ciortescu I, Chirilă I, Anton C, Drug V. Effect of inulin in the treatment of irritable bowel syndrome with constipation (Review). Exp Ther Med. 2020 Dec;20(6):185.

23. Niness KR. Nutritional and Health Benefits of Inulin and Oligofructose. J Nutr. 1999;129(7):1402S-1406S.

24. Azhar M, Iryani. The Effect of Inulin Addition on the Characteristics of Yogurt Set from Skim Milk. In 2006.

25. Sudaryati, Djajati S, Fachrizal NT. Pembuatan yoghurt bubuk susu kambing ettawa. J Rekapangan. 2016;11(2):1–7.

26. Official Methods of Analysis of AOAC International. AOAC. USA; 19th ed, 2012.

27. Food and Agriculture Organization. Food energy - methods of analysis and conversion factors: Report of a technical workshop. Rome; 2003.

28. Osbeck GL, Romalasari A, Purwasih R. Characteristics of Goat Milk Yogurt With the Addition of Bali Orange (Citrus Maxima). 2014;87–91.

29. Azhar M. Cell Biomolecules: Carbohydrates, Proteins and Enzymes. Press U, editor. UNP Press Padang; 2016.

30. Azhar M. Inulin as a prebiotic. Sainstek. 2009;12(1):1–8.

31. Sumarmono J, Setyawardani T, Tianling M, Aini N, Wibowo C, Mohamed TH, et al. Comparative analysis of physical properties and fatty acid composition of set-yogurt manufactured from different milk types. Canrea J Food Technol Nutr Culin J. 2023;6(2):167–81.

32. Latif A, Shehzad A, Niazi S, Zahid A, Ashraf W, Iqbal MW, et al. Probiotics: mechanism of action, health benefits and their application in food industries. Front Microbiol. 2023;14:1216674.

33. Ayed L, M'hir S, Nuzzolese D, Di Cagno R, Filannino P. Harnessing the Health and Techno-Functional Potential of Lactic Acid Bacteria: A Comprehensive Review. Foods. 2024;13(10).

34. Alfaridhi KK, Lunggani AT, Kusdiyantini E. Addition of Dahlia Tubers Flour Filtrate (Dahlia variabilis Willd.) as a Prebiotic in Making Synbiotic Yogurt. Bioma Berk Ilm Biol. 2013;15(2):64.