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Consumption of prebiotic sources significantly affects children's height in a stunting locus village in Bogor Regency, Indonesia

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ABSTRACT

Background: Stunting is a condition of growth failure in children due to chronic nutrient deficiencies for a long time, especially during the first 1000 days of life. The results of the Indonesian Nutrition Status Survey (SSGI) also showed a decrease in the stunting rate from 27.7% in 2019 to 21.6% in 2023. The 2022 SSGI data recorded that 18.7% of children in Bogor Regency were still stunted. The current reduction in stunting is still far from the target of the 2020-2024 National Medium-Term Development Plan, where the number of stunted children in Indonesia is only 14%. Children are classified as stunted if the length/height z-score-for-age is <-2 SD. Stunting can occur due to poor gastrointestinal conditions. Prebiotics and probiotics play an important role in helping to maintain gastrointestinal health.

Objective: The purpose of this study was to analyze the relationship between the consumption of prebiotic and probiotic food sources and the z-score of height/length for age.

Materials and Methods: This cross-sectional study included 100 children aged 6-59 months in the stunting locus village of Bogor Regency. Height/length data were obtained using a stadiometer and infantometer. Assessment of food consumption of prebiotic and probiotic sources was conducted through interviews using the Semi Quantitative-Food Frequency Questionnaire form. Bivariate test used Pearson correlation test and multivariate test used multiple linear regression test.

Results: The data showed that 48% of children were stunted, and 52% were normal. Bivariate test showed correlations of food consumption of prebiotic sources (r =0.274, p=0.006) and probiotics (r=0.264, p=0.008) with height/length z-score. Multivariate test results showed that consumption of prebiotic sources influenced length/height z-score for age (β=0.007, 95%CI: 0.002-0.011, p=0.003).

Conclusion: Consumption of prebiotic food sources in children can improve the z-score of height-for-age.

Keywords : Consumption; height; probiotics; prebiotics; stunting

BACKGROUND

The global stunting population in 2022 reached 148.1 million. Two out of five stunted children live in South Asia, while three out of five live in Africa. By 2030, the number of stunted children is targeted to reach only 13.5%, but in fact from 2012 to 2022 the reduction in stunting in the world was only about 1.65% per year. If this trend continues, then in 2030 around 128.5 million children (19.5%) will still be stunted [1].

Basic Health Research data showed that the number of stunting in Indonesia in 2013 was 37.2%, decreased to 30.8% in 2018[2]. The results of the Indonesian Nutrition Status Survey (SSGI) also showed a decrease in the stunting rate from 27.7% in 2019 to 21.6% in 2023. The 2022 SSGI data recorded that 18.7% of children in Bogor Regency were still stunted. The current reduction in stunting is still far from the target of the 2020-2024 National Medium-Term Development Plan, where the number of stunted children in Indonesia is only 14%[3].

Stunted children experience a syndrome in the small intestine caused by exposure to fecal-oral contamination. This condition causes pathogenic microbiota to dominate in the gastrointestinal tract, so that nutrients obtained from food cannot be absorbed properly.[4] The imbalance of microbiota in the gastrointestinal tract disrupts the process of food digestion. Although food intake is sufficient, growth disorders can still occur because the nutrients in the food cannot be absorbed properly.

Prebiotics and probiotics have been proven to maintain gastrointestinal health. In addition, prebiotics and probiotics have also been widely researched as one of the methods in handling and preventing stunting.[5] Proper feeding is important for children to maintain and improve the condition of the microbiota in the gastrointestinal tract so that nutrient absorption can take place optimally. In addition, gastrointestinal health is important for maintaining children's immunity.[6]

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Prebiotics are compounds that can stimulate the growth and activity of several types of non-pathogenic microorganisms in the gastrointestinal tract so that they are beneficial to health.[7] Prebiotics function in increasing the growth of probiotic bacteria in the gastrointestinal tract. Probiotics are types of bacteria that play a good role in gastrointestinal health. Probiotics can be added to food to have a beneficial effect on human health.[8]

Consumption of foods containing prebiotics and probiotics has been shown to show significant results in children's height growth.[6] Studies in developing countries have been conducted to examine the effects of probiotics on children's weight and height growth. A systematic evaluation of 12 studies with different intervention durations revealed that probiotic supplementation was successful in helping malnourished children gain height and body weight. Supplementation or feeding of local food sources containing probiotics is suggested as an effective intervention for child growth.[9]

In the study by Waliyo et al., feeding local food-based prebiotic sources has been conducted and has been shown to improve height for age z-score (HAZ) of stunted children with a mean of 0.08±0.16. The local food in that study was divided into two food formulas with the composition of kepok banana, fern leaves, garlic, eggs, milk flour, and salt. Stunted children are given a local food-based prebiotic formula consisting of fern vegetables (16 g), kapok bananas (22 g), garlic, and additional animal protein sources from chicken eggs (20 g) and skim milk flour (6 g) once a day for an entire 30-day period in the study. Prebiotic food sources have a positive effect on stunted children because they can increase non-pathogenic bacteria and prevent environmental enteric dysfunction (EED) which is commonly experienced by stunted children. EED causes metabolic demands to increase and nutrient absorption to be inhibited, affecting children's growth.[10]

Food sources of prebiotics in Indonesia are easily found such as shallots, garlic, tomatoes, and bananas.[11] Tubers and fruits are one of the foods that contain prebiotics, for example sweet potatoes, taro, cassava, and apples.[12] Supplementary feeding for stunted children with additional probiotic sources from local foods, namely curd, has been shown to have a better effect than without curd. Probiotics are non-pathogenic microbiota that are beneficial to health. Non-pathogenic microbiota that dominate in the gastrointestinal tract can help prevent stunting because they can increase the body's immunity and help nutrients to be absorbed optimally. [6] Probiotics can be found in various foods such as yoghurt, cheese and chocolate. One of the local foods rich in probiotics is tempeh.[13]

Based on previous studies, the researcher aimed to analyze the correlation between food consumption of prebiotic and probiotic sources with height/length-for-age z- score of children. The study was conducted in the stunting focus area (locus), Bogor Regency. The determination of the stunting focal area by the government is based on several indicators, namely the number of stunted children, the prevalence of stunted children, and the poverty rate in the area.[14]

MATERIALS AND METHODS

This cross-sectional study was conducted to describe the correlation between food consumption of prebiotic and probiotic sources with HAZ in the stunting locus area in Bogor Regency. This study was conducted from July 2023 to February 2024. Sampling in this study was conducted using a multistage random sampling method.

The number of samples in this study were 100 children aged 6-59 months with inclusion criteria, namely children have lived for at least six months in the stunting locus area, parents are willing to be interviewed during the study, and can communicate well. Exclusion criteria in this study were sick such as diarrhea, pneumonia, tuberculosis, did not follow the research until the end, or children who moved domicile.

Data collected included age, gender, body height or length, and food consumption of prebiotic and probiotic sources. Height data taken using a stadiometer, and body length data determined using an infantometer, and food consumption of prebiotic and probiotic sources (grams per day) were recorded during the last month through interviews with mothers or caregivers of children using Semi-quantitative Food Frequency Questionnaire (SQ-FFQ) sheets and food photo books. The list of food ingredients containing prebiotics and probiotics was taken from previous national and international journals,[11,13,15–18] then compiled into an SQ-FFQ questionnaire. Validation of the questionnaire was conducted prior to field work at the research site. The SQ-FFQ for probiotic and prebiotic food sources was validated prior to data collection. Food items were compiled through literature review and a market survey of locally available products. The questionnaire was pilot-tested on 20 respondents with similar characteristics to the target population. For criterion validity, SQ-FFQ data were compared with two non-consecutive 24-hour dietary recalls conducted in a sub-sample of

30 respondents. Correlation analysis was performed, and food items with coefficients <0.3 were considered invalid and excluded from the final SQ-FFQ.

Determination of the category of stunting or non-stunting children is taken from the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2020 concerning Child Anthropometric Standards.[19] The data collected were then analyzed using statistical software. The analytical tests used in this study were Pearson correlation test for bivariate analysis and multiple linear regression test for multivariate analysis. The significance level was set at p-value <0.05. This research has received ethical approval from the Research Ethics Commission of Universitas Esa Unggul.

RESULTS

Table 1 showed that 64% of children were aged 24-59 months, and 36% were aged 6-23 months. Most of them (52%) were boys and 48% were girls. Forty-eight percent of the children were stunted, and 52% were not stunted. The overall consumption of prebiotic and probiotic food sources in children, in each of normal and stunted children could be seen in Table 2. On average, children consumed 70.8±54.35 grams of prebiotic food sources per day, and 41.7±41.38 grams of probiotic food sources per day in the last month.

Table 1. Characteristics of the sample of children aged 6-59 months in the stunting locus area of Bogor Regency

Characteristics	n (%)	Mean±SD
Age (months)		
6-23	36 (36%)	
24-59	64 (64%)	
Gender		
Female	48 (48%)	
Male	52 (52%)	
Nutrition status		
Stunting	48 (48%)	-2.65+0.52[a]
Normal	52 (52%)	-0.77+0.93[a]

[a] z-score

Table 2. Consumption of prebiotic and probiotic sources among children under 6-59 months (g/day)

	N	Prebiotics	Probiotics
		Mean±SD	Mean±SD
Overall	100	70.8±54.35	41.7±41.38
Stunting	48	46.4±29.05	29.9±24.42
Normal	52	93.2±62.33	52.6±50.20

Based on nutritional status, stunted children consume fewer prebiotic and probiotic food sources than non-stunted children. The average consumption of prebiotic sources or stunted toddlers is 46.4+29.05 grams per day, while normal toddlers are 93.2±62.33 grams per day during the last month. Stunted children consumed an average of 29.9±24.42 grams of probiotic sources per day, while normal children consumed an average of 52.6±50.20 grams of probiotic food sources per day (Table 2).

The results of the Pearson correlation bivariate test showed that there was a significant correlation between consumption of prebiotic sources and HAZ among children aged 6-59 months (r=0.274, p=0.006). A significant correlation was also found in the consumption of probiotic sources with the HAZ of children aged 6-59 months (r=0.264, p=0.008). The results of the bivariate analysis are shown in Table 3. In normal children, the most frequent sources of prebiotics are cassava, sweet potato, banana, onion, garlic, and soybean products, while the most common probiotics are tempeh, tofu-based fermented products such as tauco, and various types of pickles.

The multiple linear regression analysis, adjusted for child age, demonstrated that the intake of prebiotic food sources was significantly associated with the HAZ among children aged 6–59 months (β = 0.007; 95% CI: 0.002–0.011; p = 0.003). This indicates that higher consumption of prebiotic sources contributed positively to linear growth. In contrast, the intake of probiotic food sources showed no significant association with the HAZ (β = 0.000; 95% CI: 0.000–0.000; p = 0.113). (Table 4).

Table 3. Pearson's correlation test of prebiotic and probiotic source consumption with HAZ of children under five years old

Consumption of sources	r	p
Prebiotics	0.274	0.006*
Probiotics	0.264	0.008*

*p <0.05

Table 4. Multiple linear regression test of independent variables affecting the TB/U z-score of children under 6-59 months after controlling age

Independent Variable	Coefficient (95%CI)	p
Prebiotic sources	0.007 (0.002-0.011)	0.003*
Probiotic sources	0.000 (0.000-0.000)	0.113

*p <0.05

DISCUSSION

Consumption of prebiotic sources significantly influenced the HAZ of children under five ($p<0.01$) after controlling for age. Prebiotics promote the growth of specific beneficial bacteria in the gut, which can improve the absorption of nutrients and enhance the overall health of the gut microbiome. This, in turn, can support healthy growth and development, particularly in children.

Previous studies have shown that prebiotic consumption can improve calcium absorption and bone health through changes in gut microbiota composition, short-chain fatty acid production, changes in gut pH, biomarker modification, and immune system regulation.[20] Calcium is essential for child growth. Low calcium consumption may result in a higher risk of stunting compared to children who consume sufficient calcium. This is because calcium deficiency can inhibit bone mineralization, leading to stunted growth. Calcium is also an important micronutrient in supporting children's growth and development. An inhibited bone mineralization process causes children to be unable to reach their full height.[21]

Prebiotics in the gastrointestinal tract are fermented by intestinal flora that can stimulate non-pathogenic bacteria in the gastrointestinal tract, thus modifying their growth and activity with beneficial effects on health.[7] Prebiotics are transported to the colon intact, here they are broken down by gut flora and selectively fermented to produce specific secondary metabolites. These metabolites are then absorbed by the intestinal epithelium or carried to the liver via the portal vein and may provide benefits to the body.[22]

The specific advantage of prebiotics refers to enhancing the growth of target microorganisms. Upon consumption of certain prebiotics e.g. inulin, fructo-oligosaccharides (FOS), and galacto-oligosaccharides (GOS), they can promote the growth of beneficial flora to compete with other species by protecting or r promoting the production of non-pathogenic bacteria that are beneficial to health. In addition, prebiotics are not only beneficial to the digestive system but also to the central nervous, immune, and cardiovascular system.[8]

The direct causes of stunting are dietary intake and infectious diseases. Both factors are influenced by the microbiota of the gastrointestinal tract.[23] Prebiotics are beneficial in maintaining a healthy gastrointestinal tract by enriching non- pathogenic microbiota and preventing the emergence of pathogenic microbiota.[24] An imbalance in the composition of pathogenic and non-pathogenic microbiota can cause infectious diseases in children. Good immunity can prevent the occurrence of infectious diseases as a contributing factor to stunting.[25] Prebiotics help nutrient metabolism run optimally by stimulating the growth of good bacteria such as Bifidobacteria and Lactobacillus. Good nutrient metabolism provides benefits to immunity as a prevention of infectious diseases, and can help nutrients to be absorbed optimally.[26] Research using pisang kepok as a source of prebiotics has shown to reduce E. coli bacteria in stunted children. The study showed significant results in reducing the number of E. coli bacteria in the gut. The use of banana flour shows promising potential in improving gut health.[5]

To our knowledge, there are no previous studies from Indonesia or elsewhere that quantify intake of whole food prebiotic and probiotic sources in grams per day for children in the same way as our study does (i.e., summing up commodities consumed). Most prior studies focus on isolated prebiotic ingredients (e.g., inulin, FOS) or supplements, often administered as part of controlled interventions (e.g., arrowroot cookies providing ~30 g/day in prebiotic components)[27].

There is also limited data on routine dietary consumption of fermented or prebiotic-rich foods quantified per day among children under five, especially in low-resource settings. The absence of comparable

studies underscores the novelty of our approach in quantifying total food-based prebiotic and probiotic intake in grams per day. Future research in similar contexts could use our methodology as a reference point and further validate or compare these findings.

In our study, the primary sources of prebiotics consumed by young children include locally abundant and affordable foods such as cassava, sweet potato, taro, banana, tomato, onion, garlic, and soybean-based products**.** Probiotic intake was mainly from traditional fermented foods like tempeh, tauco, and pickled vegetables**.** Probiotic sources can be found in a variety of fermented food stuffs, including *asinan*.[28] *Asinan* is one of Bogor's local foods. *Asinan* in Bogor consists of pickled vegetables, pickled fruits, and mixed pickled fruits and vegetables.[29]

Probiotics are beneficial in boosting the immune system and can maintain the balance of the gut microbiota by suppressing the growth of pathogenic bacteria in the digestive system.[30] Probiotics inhibit the growth of pathogens in the gut that cause children to develop infectious diseases. One of them that often occurs in children is diarrhea.[31] Consumption of probiotics at least 5 x 10^9 colony forming units (CFUs) daily has been shown to significantly reduce cases of diarrhea in children. *Lactobacillus rhamnosus* and *S. boulardii* are the most appropriate probiotic species in preventing diarrhea in children.[32] Probiotics prevent diarrhea by competing with pathogenic microbiota, or by producing bacteriocins such as nisin.[33] Diarrhea is one of the causes of stunting as it can interfere with nutrient absorption and elimination.[34] Late handling and unbalanced intake when experiencing diarrhea can cause children to experience growth failure.

Consumption of probiotic sources did not significantly affect HAZ in multivariate test after controlling age. Some types of probiotics have difficulty reaching the gut as they can be destroyed by the acid in the stomach.[35] Probiotics contain live microorganisms that can confer health benefits when administered in adequate amounts. While probiotics can also improve child growth through modulation of the gut microbiota and immune system, their effects are often strain-specific and may not be as consistent as those of prebiotics.[36] Additionally, probiotics are not as effective in promoting the growth of specific beneficial bacteria as prebiotics, which can have a more targeted effect on the gut microbiome. Therefore, increasing probiotic bacteria can be done by consuming prebiotics. Prebiotics are fertilizers for microbes in the gut, causing more good bacteria to grow in the gut.[37] Meanwhile, the health effects of probiotics are generally considered to be strain-specific.[38]

This study has some limitations that should be acknowledged. First, the study quantified food-based sources of prebiotics and probiotics, but did not analyze their actual prebiotic or probiotic content (e.g., specific oligosaccharides, live microbial counts), which may differ across food types and preparation methods. Second, the study was conducted in a single geographic setting, which may limit generalizability to other regions with different dietary patterns and food availability.

CONCLUSIONS

Higher consumption of prebiotic sources contributed positively to linear growth. In contrast, the intake of probiotic food sources showed no significant association with the HAZ. Probiotics can also help children grow by modulating the gut microbiota and immune system, although their benefits are generally strain-specific and may not be as consistent as prebiotics. Furthermore, probiotics are less effective in promoting the growth of specific beneficial bacteria than prebiotics, which have a more targeted effect on the gut microbiome. Consuming prebiotics can help to increase probiotic microorganisms. Prebiotics fertilize microbes in the gut, causing more beneficial bacteria to develop. Meanwhile, the health benefits of probiotics are thought to be strain-specific.

Based on our findings, increasing the intake of affordable and culturally acceptable food sources rich in prebiotics and probiotics is recommended for young children. In the Indonesian context, prebiotic-rich foods commonly consumed by normal children include cassava, sweet potato, taro, banana, tomato, onion, garlic, and soybean-based products. For probiotic sources, tempeh, and pickled vegetables are widely available and inexpensive, making them practical dietary options for families with limited resources. Encouraging the regular inclusion of these foods in children's diets may help support healthy growth and gut health.

Future studies should aim to quantify not only the amount of food-based prebiotic and probiotic intake but also the specific functional components (e.g., inulin, FOS, or GOS) to better understand their biological impact. Longitudinal or intervention studies are also warranted to establish causal relationships between consumption of these foods and child growth outcomes. In addition, comparative studies across different

regions and socioeconomic groups in Indonesia would provide broader insights into dietary diversity and the role of traditional foods as functional prebiotic and probiotic sources for children.

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