

Synbiotic Potential of Probiotics *Lactobacillus plantarum* and Inulin from Dahlia Tubers (*Dahlia Pinnata*) and Fortification of Nano-Fe as Stunting Management: Future Perspective in Indonesia

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Abstract

Stunting is still a recent child health problem, including in Indonesia. The study found that conditions of disturbed microflora balance in the digestive tract were correlated with the incidence of stunting in children. Provision of weaning food in the form of synbiotics as a combination of probiotics and prebiotics are suspected to be able to manage stunting by optimizing nutritional status, balancing the gut microbiota and digestive tract health. Inulin from Dahlia tuber (*Dahlia pinnata*) has the potential as a source of prebiotics which is safe for consumption and has no toxic effects. In addition, *Lactobacillus plantarum* isolate is a probiotic that can optimize the environment in the digestive tract. On the other hand, supplementing iron with nanoparticles helps meet the needs of the micronutrient iron and its absorption, which plays a role in the formation of hemoglobin in red blood cells, which is important for child growth. This literature review aims to explore the synbiotic potential of probiotic *Lactobacillus plantarum* and prebiotic inulin from Dahlia tubers with nano-Fe fortification as weaning food for stunting management in Indonesia.

Keywords: Dahlia tubers, Inulin, *Lactobacillus plantarum*, Stunting, Synbiotic

1. Introduction

Stunting is a condition of children aged 0-59 months, where the child's height for age is below minus 2 Standard Deviations (< -2SD) from the World Health Organization (WHO) median standard^[1]. Stunting is caused by multifactorial, including infectious diseases and inadequate nutritional intake^[2]. Other factors such as mothers' lack of knowledge, wrong parenting styles, low health services, and poor hygiene and sanitation also contribute to the incidence of stunting. Poor hygiene and sanitation can cause infectious diseases (e.g. diarrhea and intestinal worms) which can interfere with the absorption of nutrients in the digestive process^[2]. If this condition occurs for a long time and is not accompanied by sufficient additional intake for the healing process, it can result in stunting^[3].

The Indonesian government has attempted to address the stunting problem, which until now has not received satisfactory results through strategic policies and programs. Through Presidential Regulation Number 42 of 2013, the Government began to focus on handling stunting by improving the nutritional status of

toddlers in children through the National Movement for the First Thousand Days of Life^[4,5]. During the early life of the baby, nutritional fulfillment is provided through exclusive breast milk until the baby is 6 months old. Unfortunately, the increasing age of the baby is also followed by an increase in nutritional needs. When a baby reaches the age of 6-12 months, breast milk can only meet around 60% of their nutritional needs, so complementary food is needed to cover this deficiency^[6]. However, choosing the right and quality of weaning food is a new challenge in meeting nutritional needs, especially in managing stunting.

Appropriate and quality of weaning food approaches, especially those that utilize local food commodities as the primary source of nutrition, have the potential to be a strategic step in handling children with stunting. Synbiotic products which are a combination of the goodness of probiotics and prebiotics can be the right solution by optimizing the nutritional value contained in the product and the health of the digestive tract in children^[7]. Studies say that the prebiotic inulin content in dahlia tubers (*Dahlia pinnata*) combined with the probiotic lactic acid bacteria *Lactobacillus plantarum* is the best combination that mutually maximizes their potential^[8]. On the other hand, fortification using nano-sized iron micronutrients (nano-Fe) is proven to be able to increase the iron content in food and its absorption in the body optimally^[9]. This literature review aims to see the potential of synbiotic products containing inulin from dahlia tubers with *Lactobacillus plantarum* isolates and nano-Fe fortification to have the potential to be stunting management.

2. Synbiotics as Stunting Management

Synbiotics are defined as a synergistic combination of the goodness of prebiotics and probiotics where prebiotics help increase the survival of probiotics in the intestine^[10]. Probiotics are live, non-pathogenic microorganisms that can benefit the health of their host by improving the balance of gut microbes and participating in metabolism^[10]. Several commonly used lactic acid bacteria such as *Lactobacillus sp* and *Bifidobacterium sp* are categorized as probiotics. Probiotics as beneficial bacteria work by 1) improving the function of the intestinal defense layer, 2) having immunity to digestive tract conditions, 3) colonizing and competing with pathogenic bacteria for nutrition, 4) strengthening the immune system, 5) producing substances beneficial substances (vitamins, organic acids, and neurochemicals), 6) and prevent harmful microbial pathogenesis^[11]. The mechanism of action and ideal properties of probiotics can be seen in Figure 1.

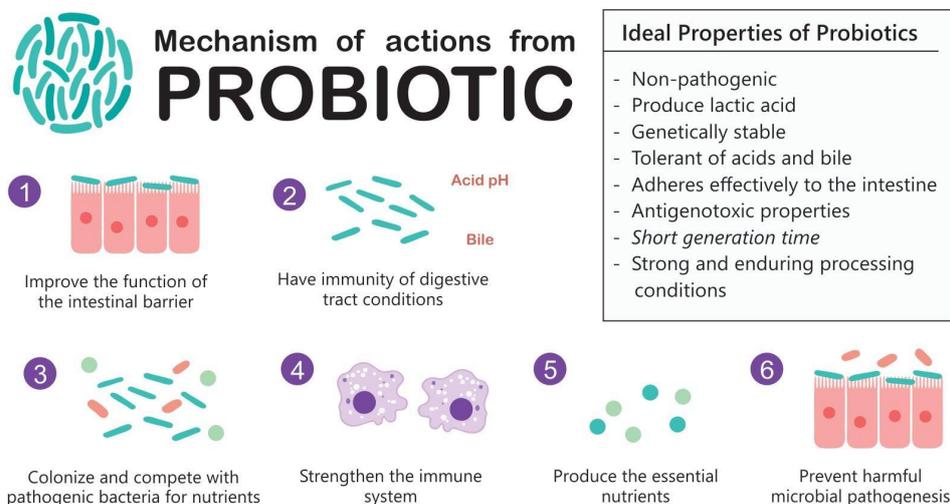


Figure 1. Mechanism and ideal properties of probiotics^[11].

In general, probiotic isolates can be added to food and beverages, one of which is milk, to produce fermented products^[10]. The study found that babies after 6 months of age experienced an increase in intestinal microbiota diversity after being introduced to complementary foods which had a positive impact on their metabolic performance^[12]. In addition, there is a significant relationship between changes in the composition of the good microbiota in the gut and malnutrition or even stunting in children^[13]. An increase in pathogenic bacteria followed by a decrease in beneficial probiotic colonization in the gut correlates with manifestations of malnutrition^[14]. This relationship pattern can be seen in Figure 2. In conclusion, an approach that combines optimizing nutritional status through complementary foods and gastrointestinal health with probiotics can be a solution to the problem of malnutrition in children.

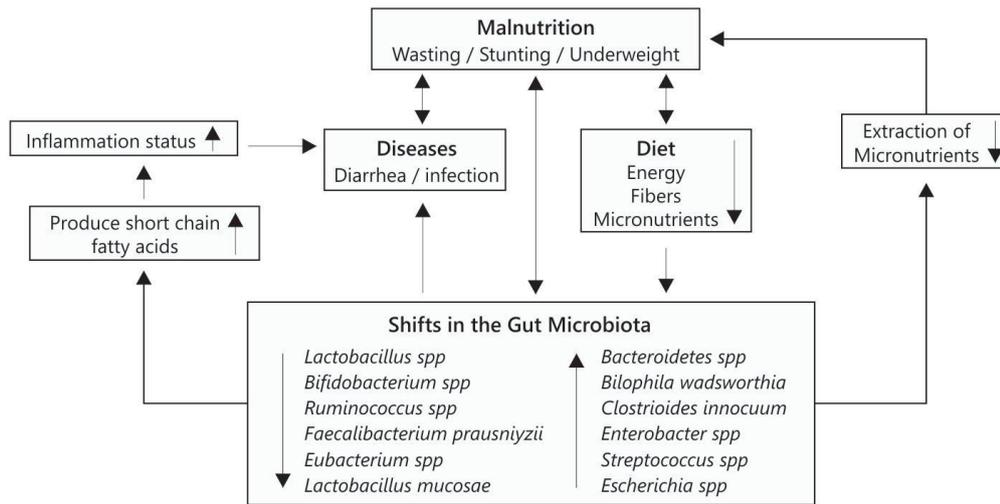


Figure 2. The pattern of the relationship between the composition of the microbiota in the gut and the manifestations of malnutrition in children^[14].

Prebiotics are food ingredients that are difficult for the body to digest but have a beneficial effect on the health of the body by selectively stimulating the growth and/or activity of good microbiota (probiotics) in the gut^[15]. The types of prebiotics that are commonly studied, such as inulin, fructooligosaccharides (FOS), and galactooligosaccharides (GOS), are commonly found in Indonesian local commodity food ingredients. Prebiotics as undigested fiber work by being fermented by intestinal bacteria to produce short-chain fatty acids and gas production, and affect stool mass as a result of increased biomass which plays an important role in maintaining normal intestinal function^[16]. Prebiotics metabolized by probiotic bacteria will increase mineral solubility, increase the absorption surface of intestinal enterocytes, provide anti-inflammatory effects, and produce short-chain fatty acids as an energy source for epithelial cells while simultaneously lowering the pH of the lumen to limit the growth of several pathogenic bacteria^[7,13]. The mechanism of action and the ideal properties of prebiotics can be seen in Figure 3. In conclusion, the combination of probiotics and prebiotics in synbiotics has the potential to be a treatment for stunting.



Mechanism of actions from PREBIOTIC

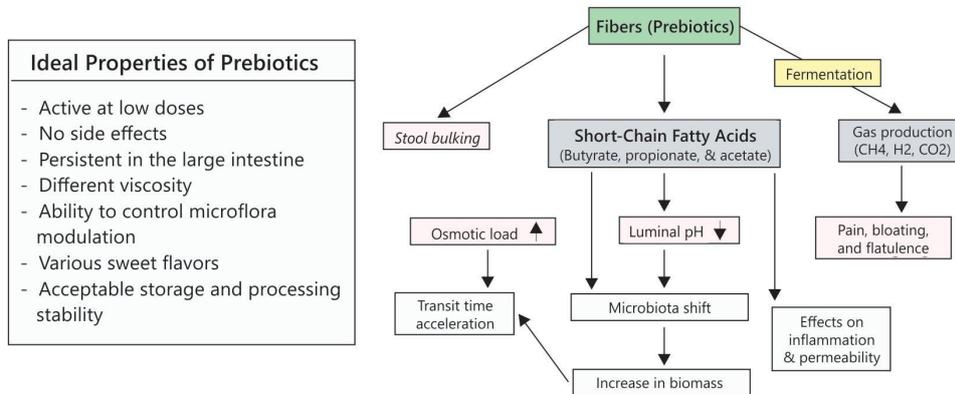


Figure 3. Mechanism and ideal properties of prebiotics^[10,15].

3. Potential of Inulin in Dahlia Tuber (*Dahlia pinnata*) as a Prebiotic Source in Overcoming Stunting

The dahlia flower plant is a bulbous shrub plant that is generally spread in the highlands of Java and Sumatra, Indonesia. Sources of prebiotic inulin can be found in many bulbous plants, one of which is dahlia tubers. Dahlia tubers contain about 72.6% inulin, which becomes 41.7% of the dry weight after the extraction process^[16]. Inulin is a polysaccharide chain composed of linked fructose molecules and is beneficial for the gut microbiota^[17]. Compared to other types of prebiotics, inulin has a high tolerance for consumption so it is safer and does not cause side effects or toxicity in humans and animals with a recommended dose of 10-15 g/day^[18]. The mechanism of action of inulin from dahlia tubers as a prebiotic can be seen in Figure 4.

Dahlia Plants and Tubers

Chemical structure of inulin

Mechanism of Actions from Inulin

- Reduce caloric intake
- Stimulation of the immune system against infections that cause diarrhea
- Better absorption of nutrients and modulation of plasma lipid levels
- Antioxidant and anti-inflammatory effects on inulin
- Selective stimulation of bacterial growth
- Produce short chain fatty acids for bacterial growth
- Produce antimicrobial protein

Figure 4. Inulin in dahlia tubers as a source of prebiotics and their mechanism of action.

Studies have found that inulin extract from dahlia tubers is proven to optimally support the growth of the probiotic *Bifidobacterium bifidum*, increase lactose degradation, and accelerate lactic acid production^[19]. This potential is also supported by other publications showing the role of dahlia tuber inulin in supporting the

probiotic *Lactobacillus casei* successfully inhibiting the growth of the bacteria *Helicobacter pylori* and *Shigella dysenteriae* significantly^[19]. In addition, the synbiotic combination of dahlia tuber inulin and *Lactobacillus plantarum* is the best combination which can increase the amount up to 2.80×10^{10} CFU/ml, 1.29% total acid, and 2.05% total sugar^[8].

4. Potential of *Lactobacillus plantarum* as a Source of Probiotics in Overcoming Stunting

The symbiotic interactions between microorganisms in the digestive tract greatly contribute to the maintenance of intestinal homeostasis. Members of the gut microbiota in the human colon exhibit a wide range of enzymatic activities with a potential impact on human health through the biotransformation of secondary metabolites and xenobiotic compounds. Changes in the microbiome caused by environmental changes in humans and animals (e.g. diet, antibiotics, xenobiotics, stress, age, and viral, bacterial and parasitic infections) can lead to significant changes in the composition of the gut microflora^[20]. Disturbances of the intestinal microflora such as dysbiosis can increase an individual's susceptibility to infection and disease. In this study, the effect of long-term administration of probiotic *Lactobacillus plantarum* has an effect on the prevention of atherosclerosis, colon cancer, and dysbiosis^[21].

Disturbances in the balance of the intestinal microbiota cause gastrointestinal infections which result in weak protection of the gastrointestinal tract resulting in impaired permeability. The impact of impaired permeability of the digestive tract is the occurrence of malabsorption. Malabsorption results in a lack of nutritional intake. This is an explanation of the causes and effects of nutritional events^[2]. Research proved that there is a relationship between stunting and gut microbiota, it is stated that stunted children experience a decrease in the population of good bacteria, while the population of unfavorable bacteria has increased. Bacteria whose population has decreased are good bacteria belonging to the genera *Bifidobacterium*, *Lactobacillus*, *Faecalibacterium*, *Butyrivibrio*, and *Roseburia*; While the less beneficial bacteria are species of Proteobacteria, namely *Escherichia*, *Klebsiella*, and *Enterobacter* which has known as coliform, and the pathogen *Shigella*^[22]. Research conducted in Indonesia states that there is growing evidence that intestinal microbiota disorders affect body weight and in his research related to the consumption of probiotic powder indigenous *Lactobacillus plantarum* by stunted children in Lombok managed to prove that this bacterium was able to improve the intestinal environment with indications of increasing concentrations of short-chain fatty acids (butyric acid, propionic acid, acetic acid), as well as decreasing the pH of the stool^[22].

5. Potential of Nano-Fe Fortification in Food as Iron Supplementation in Overcoming Stunting

Although needed in small amounts, micronutrients are one of the most important substances a child's body needs for development and growth^[23]. The provision of micronutrients such as iron (Fe), vitamin A, and zinc (Zn) has been associated with weight gain and improved nutritional status in children with malnutrition, so they can be an additional approach to stunting management^[23]. Micronutrients, especially iron, have an important role in the formation of hemoglobin in red blood cells which is responsible for transporting oxygen in the blood, thus playing a direct role in the growth of children^[24]. Studies have found that dual supplementation using the micronutrients iron and zinc in children under 5 years of age increases the frequency of meals by up to 5 times per day^[25]. In addition, the addition of the probiotic *Lactobacillus plantarum* can significantly increase iron absorption so that its use is maximized^[24]. This shows that iron fortification in complementary foods can be the next step in fulfilling children's nutrition.

Oral iron supplementation using ferrous sulfate is the gold standard that is commonly used today. Unfortunately, the absorption of ferrous sulfate has specific side effects on the gastrointestinal tract in the form of nausea, bloating, abdominal pain, diarrhea, and constipation which is supported by systematic review studies and meta-analyses^[26]. The study found that nano-iron(III) oxide-hydroxide (nano-Fe) with a smaller particle size has a larger surface area, increases its solubility in gastric juices, and results in better bioavailability, thereby playing a major role in the absorption of iron in the stomach significantly^[27]. The use

of nano-Fe which is formed endocytically obtained nano so that it has a lower risk of side effects and has better bioavailability (Figure 5). This is supported by research showing that the administration of nano-Fe increased its absorption and formation of hemoglobin in iron-deficient rats significantly^[28]. Other studies also mention that administration of nano-Fe offers efficient results without the risk of free radical formation and side effects in the murine model^[29].

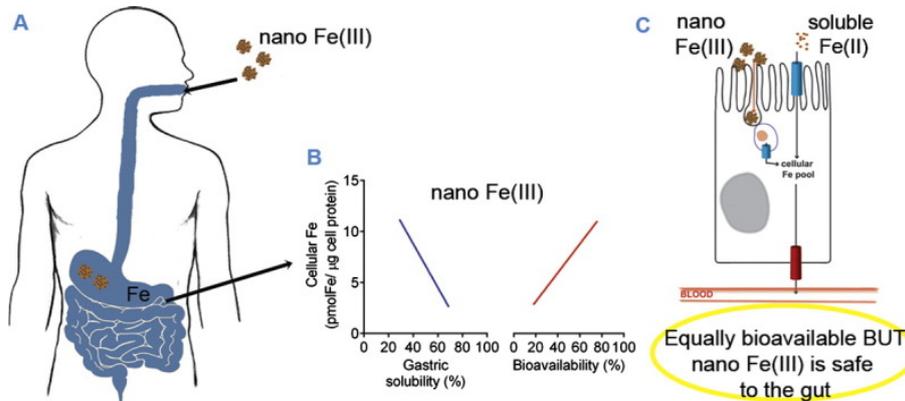


Figure 5. Use of nano-Fe which has lower side effects and better bioavailability^[28].

6. Conclusion

The provision of weaning food in the form of a synbiotic product made from dahlia tubers with a mixture of *Lactobacillus plantarum* isolates and nano-Fe fortification has the potential to be a treatment for stunting by optimizing nutritional status, balancing intestinal microbiota and digestive tract health. The content of prebiotic inulin in dahlia tubers maximizes the role of the probiotic *Lactobacillus plantarum* by increasing its viability in the digestive tract. Nano-Fe supplementation can meet the needs of children's micronutrients which play a role in the formation of red blood cells and hemoglobin. It can be concluded that synbiotics with nano-Fe have the potential to become recommendations for weaning food for stunting management in Indonesia in the future. Nevertheless, further clinical research needs to be done to strengthen existing research.

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