



EFFECTIVENESS OF PROVIDING HIGH-PROTEIN SNACKS FROM TEMPE ON WEIGHT GAIN IN MALNOURISHED CHILDREN: A LITERATURE REVIEW

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ABSTRACT

Malnutrition can lead to growth retardation. Untreated malnutrition can trigger weight faltering, which can lead to a 15-20 point decrease in IQ scores and impact a child's learning ability and cognitive function. Malnutrition in children is caused by diets that do not meet nutritional needs, particularly low-protein diets. This deficiency can potentially lead to an imbalance in the gut microbiota and interfere with optimal nutrient absorption. Therefore, innovations are needed in the form of practical, protein-rich snacks from tempe. This study aims to review the effectiveness of providing high-protein snacks from tempe on weight gain in malnourished children based on recent research findings. This study employed a literature review method by searching relevant articles online through Google Scholar, ScienceDirect, and PubMed databases. The inclusion criteria were full-text articles, involving Children aged 1 to 12 years, published within the last five years (2020–2025), written in English or Indonesian, and relevant to the research topic. The literature search was conducted through several scientific databases using relevant keywords, resulting in 434 articles in the initial identification stage and five eligible articles were reviewed and analyzed to evaluate the impact of providing high-protein snacks from tempe on weight gain in malnourished children. Providing high-protein tempeh snacks has a significant effect on weight gain in malnourished children, with weight gain ranging from 0.2 kg to 0.5 kg. Providing high-protein snacks can increase the weight of children with malnutrition.

Keywords: child malnutrition; high-protein; snack; tempe; weight gain

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INTRODUCTION

Children aged 2 to 12 are in their second growth spurt after toddlerhood, a crucial phase for physical and cognitive development. During this period, children have the potential for growth recovery or catch-up growth, thereby catching up on previous growth delays. (Narchi et al., 2021) Nutritional issues among school-aged children remain a global public health challenge. A systematic review by Khan et al. (2022) shows that nutritional issues such as underweight and stunting remain high among school-aged children, with 25.1% of children underweight and 23% stunted(Khan et al., 2022). In line with these findings, the results of the UNICEF–WHO–World Bank Joint Child Malnutrition Estimates survey 2024 placed Indonesia among the 20 countries with the highest child malnutrition burden in the world, along with India, Nigeria, and Pakistan (JME, 2024). Based on the World Food Programme (WFP) report, Indonesia was ranked 67th out of 127 countries in the 2024 Global Hunger Index (GHI), in the food shortage category (WFP, 2024).

Malnutrition in school-age children can lead to growth retardation. According to Sjarif (2021), untreated malnutrition can trigger weight faltering, which can lead to a 15-20 point decrease in IQ scores and impact a child's learning ability and cognitive function(Sjarif, 2021). Malnutrition in school children is caused by a diet that does not meet nutritional needs, particularly a low-protein diet. Research by Khan et al. (2022) found that children with malnutrition consumed less protein than children with normal nutritional status. To meet protein needs, snacks can contribute 20% of the total nutritional intake required each day. According to research by Kamil et al. (2021), children with malnutrition consumed an average of 33.8 grams of snacks per day. This issue stems from the

prevalence of readily available snacks that are energy-dense yet lack essential nutrients (Kamil et al., 2022).

Tempeh is a functional food rich in nutrients. The fermentation process used in tempeh production using the fungus *Rhizopus oligosporus* can increase its nutritional value. Tempeh is excellent for consumption by all age groups because the compounds it contains include short peptides, free amino acids, fatty acids, and simpler carbohydrates that are easily absorbed by the body. The mold that grows on tempeh produces the enzymes protease, lipase, and amylase, which play a role in the process of breaking down proteins, fats, and complex carbohydrates into simpler compounds (Fujiana et al., 2021).

The amino acid content in tempeh is 24 times higher than that of soy milk. The fermentation process can also increase folic acid and produce vitamin B12 from bacteria, which are not found in other plant-based products. Addressing malnutrition in children requires adequate nutritional intake to meet the body's protein needs. Tempeh is a functional food of choice, containing all the nutrients needed to address malnutrition in children (Hadi, et al., 2021). Several studies have reported that providing high-protein and probiotic snacks can increase the weight of children experiencing malnutrition. Research by Mushollini et al. (2024) Reported that purple sweet potato cookies with 10% tempeh added, given 50 g/day for 30 days, increased the average upper arm circumference of malnourished toddlers in the intervention group (Mushollini, et al., 2024). A quasi-experimental study by Yulianto et al. (2024) involving 60 children aged 1-5 years, the result showed biscuits tempeh flour to changes in body weight in undernourished toddlers, The average body weight in the treatment group before the intervention was 9.73 kg and after the intervention was 10.36 kg with a difference in weight change of 0.595 kg (Yulianto et al., 2022). Therefore, providing high-protein snacks made from tempeh can be an effort to address malnutrition in children. Based on these findings, this study aims to review the scientific literature on the effectiveness of providing high-protein snacks made from tempeh in increasing the weight of children with malnutrition.

METHOD

This study employed a literature review approach to examine various research findings related to the effectiveness of providing high-protein snacks from tempeh in increasing body weight in children with malnutrition. The data analysis process was carried out through four main stages: organizing, synthesizing, identifying, and advanced analysis. The literature sources included both national and international publications obtained from three major databases: Google Scholar, ScienceDirect, and PubMed. Article searches were conducted using the keywords "high-protein snack," "tempeh," "child malnutrition," "wasting," "stunting," and "weight gain". The publication period was limited to 2020–2025 to ensure that the evidence collected reflected recent and relevant advancements in health education technology. All identified articles were downloaded using Mendeley Desktop version 1.19.8, and duplicate entries were manually removed before further screening. The selection process was conducted systematically based on title and abstract relevance, availability of full text, and alignment with the research objectives. The inclusion criteria were as follows: 1) Research articles that assessed the impact or effectiveness of providing high-protein snacks from tempeh in increasing body weight in children with malnutrition. 2) Study participants were children aged 1-12 years. 3) Articles published between 2020 and 2025, written in either Indonesian or English. 4) Articles available as free full-text and containing a clear research methodology. The exclusion criteria included: 1) Articles that did not specifically discuss providing high-protein from tempe snacks in increasing body weight in children. 2) Studies focusing on topics unrelated to malnutrition prevention, such as general nutrition or other diseases. 3) Articles that did not present quantitative data or measurable outcomes increasing body weight in children. 4) Non-scientific publications such as narrative reviews, conference proceedings, editorials, or descriptive reports without data analysis.

Articles that met the inclusion criteria were included in the final analysis. Each article was classified according to research information, including the author's name, year of publication, research design, study location, sample characteristics, and key findings related to in increasing the weight of children with malnutrition. The final stage of analysis involved identifying thematic patterns and comparing findings across studies to draw general conclusions about the effectiveness of providing high-protein snacks made from tempeh in increasing the weight of children with malnutrition.

RESULT

This study used a literature review approach to assess the effectiveness of providing high-protein tempeh-based snacks on weight gain in malnourished children. The literature search was conducted through several scientific databases using relevant keywords, resulting in 434 articles in the initial identification stage. Based on the selection results, five articles were identified as relevant and met the inclusion criteria for analysis in this study.

Table 1.

Description of research on the effectiveness of providing high-protein snacks from tempeh on weight gain in malnourished children.

Title/ Author (Year)	Study Design	Population and Sample	Findings
<i>The effectiveness of giving pumpkin flour biscuits and tempeh flour on changes in body weight in malnourished toddlers at the Punti Kayu Community Health Center, Palembang.</i> (Yulianto et al., 2022)	Quasi experiment	Population : toddlers aged 2-5 years. Sample : 60 (30 toddlers for the treatment group and 30 toddlers for the control group)	There was an effect of giving tempeh-enriched biscuits for 21 days on body weight in the treatment group. The average body weight in the treatment group before the intervention was 9.73 kg and after the intervention was 10.36 kg, with a difference in weight change of 0.595 kg.
<i>Effect of Purple Sweet Potato and Tempeh Cookies on Weight Gain in Wasting Incidents in Toddlers in the Sako Palembang Community Health Center Work Area</i> (Nasibar & Sari, 2022)	Quasi experiment	Population : toddlers under 5 years old; Sample : 60 (30 toddlers for the treatment group and 30 toddlers for the control group)	There is an effect of giving Purple Sweet Potato Tempeh Cookies for 30 days on toddler weight gain. The weight of toddlers in the treatment group increased by 0.56 kg and in the comparison group increased by 0.12 kg. The statistical test results obtained a p-value of 0.000.
<i>Tempe Broth as a Specific Intervention in Stunting Prevention</i> (Yarmaliza, 2020)	Experiment	Population : 222 toddlers. Sample : 75 toddlers from poor families	There is an effect of providing powdered tempeh broth with the addition of 5 grams of powdered tempeh broth at each toddler meal (3 times a day) for 90 days on the weight and height of toddlers, and the statistical test result obtained is p-value = 0.000.
<i>The Effectiveness Of Consumption Of Tempeh Nuggets On Weight Gain Of Undernourished Toddlers</i> (Simatupang & Nainggolan, 2022)	Quasi experiment	Population : 15 undernourished children aged 2-3 years Sample : 15 undernourished children aged 2-3 years	There was an effect of providing tempeh nuggets for 14 days on body weight before and after the intervention. The average weight gain in malnourished toddlers was 0.38 kg, with a P-value = 0.000.
<i>Analysis of the Effect of Tempeh Nuggets on Children's Body Weight</i> (Imbransyah et al., 2022)	Case study	Population : Toddlers under 5 years old, Sample : toddlers with malnutrition	There is an effect of giving 150 gr of tempeh nuggets/day for 6 days on body weight. weight gain of 200 gr during the intervention

Based on the identification results, all studies findings indicate that providing high-protein tempeh snacks on weight gain in malnourished children ranges from 0.2 kg to 0.5 kg

DISCUSSION

Tempeh is a functional food with a high protein content and a relatively affordable price, making it popular among the public. Tempeh is made from soybeans. Soybeans have a higher protein content than other grains, at 46.2 g per 100 g of dry soybeans (Pilco et al., 2019). The nutritional content of tempeh per 100 g is 201 kcal of energy, 20.8 g of protein, 8.8 g of fat, and 13.5 g of carbohydrates. Other nutrients found in tempeh include fiber, calcium, phosphorus, iron, potassium, copper, zinc, beta-carotene, vitamins B1, B2, and niacin (Kemenkes 2020).

Tempeh is rich in amino acids such as tryptophan, phenylalanine, lysine, threonine, methionine, leucine, isoleucine, and valine. The essential amino acid content of tempeh is nearly equivalent to that of animal protein, making it a good alternative for people with limited financial resources to consume meat or milk (Winarti et al., 2024). Tempeh flour, a derivative of tempeh, is easily processed into other products such as biscuits and boasts a high protein content. 100 g of tempeh flour contains 50.18% protein, 25.02% fat, 22.88% carbohydrates, and 53.08 mg of total isoflavones (Sigit et al., 2023).

The high protein content of tempeh flour is a result of the activity of proteolytic enzymes in tempeh during the fermentation process. This enzyme activity results in the release of amino acids, which can increase the digestibility and protein content of tempeh (Santoso, 2020). Tempeh protein is easily digested, making it suitable for weight gain, especially in toddlers (Ahnan et al., 2021). Protein is a macronutrient that functions to build, repair, and maintain the function of body tissues and organs (Almatsier, 2010). Protein plays a vital role in the growth and repair of body cells and helps maintain good health. School-age children require increased protein intake due to the growth and development that occurs during this period (Suryana et al., 2022).

Animal studies have shown that growth retardation occurs when one or more amino acids are missing from the diet consumed by these animals. Therefore, to achieve optimal growth, children require protein intake in both quantity and quality. High-quality protein means containing the complete range of essential amino acids needed for the synthesis of new cells or tissues for growth and replacement of damaged tissue (Millward, 2021).

The mechanism of protein in weight gain begins with the hydrolysis of dietary protein by digestive enzymes into peptides and free amino acids, which are then absorbed by enterocytes and enter the circulation to be used as anabolic precursors. These amino acids serve as substrates for building bone, muscle, and organ tissue, thus supporting the accumulation of tissue mass and weight gain in children previously experiencing nutritional deficiencies (Layman, 2024). In addition to their substrate function, adequate intake of essential amino acids also influences growth hormone regulation. Amino acid availability contributes to the synthesis of IGF-1 in the liver, which acts as a primary mediator of growth hormone in the epiphyses of bones and stimulates tissue accretion (Rehman et al., 2023).

At the cellular level, certain amino acids, particularly leucine, function as nutritional signals that activate the mTORC1 (mammalian target of rapamycin complex 1) pathway, which is a key driver of translation initiation and cellular protein synthesis, cell proliferation, and muscle hypertrophy. Activation of mTORC1 by amino acids increases the efficiency of protein synthesis, thus supporting catch-up growth in malnourished children (Panwar et al., 2023).

Protein also plays a role in nitrogen balance. During the growth period, a positive nitrogen balance (nitrogen retention > excretion) indicates that the body is in an anabolic state, supporting new tissue growth. Protein deficiency causes a shift to a negative nitrogen balance, triggering somatic protein catabolism to meet metabolic needs, which further inhibits growth rate and worsens nutritional status (Layman, 2024). Therefore, nutritional interventions that ensure adequate quality protein

(availability of essential amino acids) are crucial to facilitate weight gain and nutritional recovery in malnourished children.

Malnourished children have lower protein intakes than adequately nourished children. Zulaekha's research in Kendal Regency showed a strong correlation between protein consumption and children's nutritional status, based on the weight-for-age index, with a correlation coefficient of 0.655. This suggests that higher protein consumption, better children's nutritional status (weight-for-age) (Xiong et al., 2023)

Based on the results of a literature review, most studies show that toddlers who receive snacks supplemented with tempeh experience consistent weight gain after the intervention period. This finding indicates that tempeh, as a source of quality vegetable protein, positively contributes to improving toddler nutritional status, particularly in increasing body weight as an indicator of response to energy and protein intake.

CONCLUSION

Based on a literature review of several related journal articles, it was found that providing high-protein snacks can increase the weight of children with malnutrition. Based on these findings, it is recommended to strengthen nutritional interventions to address malnutrition in children and to increase the use of tempeh, a local Indonesian food.

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