Review

The effect of high protein products consumption on albumin serum in stunted children: A systematic review and meta-analysis

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Abstract. *Objective:* This study aimed to evaluate the effect of high-protein products on serum albumin levels for preventing stunting in children, by combining evidence from multiple eligible studies to provide a more precise estimate of the intervention's impact. *Data Sources:* A comprehensive search was carried out in Web of Science, Scopus, PubMed, and Semantic Scholar, covering publications between 2015 and 2024. *Methods:* The review followed PRISMA guidelines for systematic reviews and meta-analyses, using Review Manager (RevMan) 5.4 software. Study selection was guided by the PICOTS framework (participants, intervention, comparison, outcomes, timing, and study design). Eligible studies included clinical trials assessing the effects of high-protein products on serum albumin levels in children with stunting. *Results:* Meta-analysis using RevMan 5.4 showed considerable heterogeneity ($I^2 = 92\%$, $\chi^2 = 59.29$, $p < 0.01$). The intervention demonstrated a positive trend toward improving serum albumin levels in stunted children, although the overall effect was not statistically significant. Funnel plot analysis indicated no significant publication bias, suggesting that the results of the included studies are reasonably reliable, although potential limitations should still be considered. *Conclusions:* The findings demonstrate that adequate protein supplementation improves serum albumin levels and plays an important role in supporting growth and preventing stunting.

Key words: child malnutrition**,** nutrition, protein, serum albumin

Introduction

Stunted growth in children is a long-standing condition emanating from protracted malnutrition. Children suffering from stunted growth often exhibit low serum albumin levels, which can hinder their growth and development. Malnutrition is a global health crisis among children. Albumin is a major protein constituent of blood plasma that performs a host of vital functions related to maintaining blood osmotic pressure, transporting hormones, vitamins, and other substances, and participating in the immune process. Its normal value in children typically lies between 3.5 and 5.5 g/dL, and low levels are a significant indicator of poor nutritional status, particularly insufficient protein intake. High-protein products are a key nutritional intervention commonly used to increase serum albumin levels and improve nutritional status. Various studies have shown that high-protein products help increase serum albumin levels and promote healthy

growth in children. However, children in Indonesia continue to have relatively low protein intake, especially in rural and remote areas where access to quality protein sources is limited. This low intake contributes significantly to the high prevalence of stunting, which reached approximately 21.6% in 2022. Previous studies have shown that high-protein interventions can significantly increase serum albumin levels in stunted children. For example, supplementation with rebon shrimp-based feeding over 90 days led to a notable improvement in serum albumin levels. Another study conducted in Indonesia reported that stunted children consumed considerably less protein than their non-stunted peers , although serum albumin levels did not show a statistically significant difference. These findings highlight the importance of adequate protein intake for improving serum albumin levels and addressing stunting. Current dietary guidelines recommend protein intake for stunted children to be between 2.8 to 5.4 g/kg/day to support catch-up growth. Serum albumin, synthesized by the liver, is crucial for maintaining osmotic balance, transporting nutrients, and acting as an index of nutritional status (9). Low serum albumin are strongly associated with stunted children, as they reflect poor nutritional status and, more specifically, insufficient protein intake. Protein consumption among children in Indonesia remains low , particularly in isolated and rural locations where access to high-quality animal and vegetable protein sources is very limited. Data show that many children fail to meet their daily protein requirement according to their daily needs, especially at important periods of growth. This insufficient intake contributes substantiall to the high prevalence rate of stunting,which was estimated at around 21.6% in 2022. Prolonged protein deficiency can impair growth and development while lowering serum albumin levels, leading to chronic malnutrition (14,15). Systematic reviews and meta-analyses are research methods that synthesize findings from multiple studies to provide stronger evidence and clearer conclusions (16). Systematic reviews identify and evaluate all available studies that meet the selected criteria for inclusion, usually by critical analysis (17). Meta-analysis combines the statistical results from the individual studies identified in a systematic review to generate a more precise overall estimate of the effect. The results of this study are expected to improve knowledge of the efficacy of nutritional interventions with high-protein products and evidence-based recommendations on how to deal with nutritional problems within this population.

Methods

This paper adopts a systematic review and meta-analysis approach to collect, evaluate, and synthesize research findings. This approach aims to provide robust and comprehensive conclusions on the effect of high-protein products on serum albumin levels in stunted children.

Study design and search strategy

The study followedthe PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, ensuring transparent and comprehensive reporting of systematic reviews and meta-analyses (18). The PRISMA checklist and flow diagram were used to document all stages of the review, from the identification and selection of studies to the presentation of results (19). An electronic search was conducted by the authors across multiple databases, including Web of Science, Scopus, PubMed, and Semantic Scholar, covering publications from early 2015 to 2024. The search strategy utilized the following keywords: ((high protein product) OR (serum albumin)) AND (stunted children) AND (clinical trial); in web PubMed and select article clinical trial; “intervention in stunted children regarding serum albumin” in web semantic scholar, web of science, and Scopus. In this study, a total of five papers met the inclusion criteria and were included in the final analysis.

Selection criteria

The review followed the PICOTS framework, consisting of participants, intervention, comparison, outcomes, timing, and study design (20). These allowed for the development of various inclusion and exclusion criteria for publications for the review. his framework guided the development of inclusion and

exclusion criteria, ensuring the selection of studies relevant to the research question while maintaining consistency and rigor in the review process (21). In this study, we analyzed pre- and post-intervention data from the included trials. The data were expressed as mean ± standard deviation (SD).

Inclusion criteria

The authors screened the titles and abstracts of all articles to ensure eligible studies and, in the next step, reviewed the full manuscripts for the inclusion criteria of the selected studies:

1. Studies investigating the effects of high-protein product consumption on serum albumin levels.
2. Trial studies focusing on stunted children.
3. The study measures albumin levels in stunted children.
4. Studies comparing the administration of high-protein products on serum albumin levels in stunted children.

Exclusion criteria

1. Studies that did not report changes in serum albumin concentrations.
2. Research that did not specifically involve stunted children.
3. Non-intervention studies (e.g., reviews, observational studies, or case reports).
4. Articles lacking sufficient statistical data (mean and SD) required for meta-analysis.

Data extraction

The first author carried out data extraction, and all research members held discussions regarding the preparation of the article. Article author, year of publication, study sample size, gender, duration of intervention, inclusion and exclusion criteria research, dose of product administration, associated mean±Standard Deviation (SD) of serum levels albumin in stunted children, and the human ethics committees.

Result

The results show study selection, study characteristics and meta-analysis of the effect of high protein product on albumin serum.

Study selection

Based on a comprehensive keyword-based search, 104 studies were initially identified tained. Furthermore, duplicate studies were reduced, resulting in 98. Screening of titles and abstracts yielded 24 potentially relevant article. Furthermore, the articles were read in full and 9 were obtained that met the inclusion criteria, especially in sample treatment. Ultimately, this PRISMA diagram in Figure 1 had six papers that satisfied the intended inclusion criteria.

Study characteristics

Studies published between 2015 and 2024 qualified. The included cohorts' sample sizes ranged from 30 to 88 participants. The duration of administration of high protein products varies from 7 days to 12 weeks. Table 1 provides a summary of the included studies' characteristics. The Cochrane Collaboration risk of bias tool was used to evaluate the risk of bias in the included studies. Details of the risk of bias assessment are shown in Figure 2. The graph above presents the evaluation of bias risk across various aspects of the reviewed studies, including their respective proportions. The majority of research showed that the danger of bias in random sequence creation was minimal, with approximately 75% of studies categorized as low risk, indicating that the randomization process was conducted appropriately. Similarly, allocation concealment showed predominantly low risk in about 65% of studies, although a smaller proportion (20%) had unclear risks. However, A significant percentage of research showed a high risk of bias in participant and staff blinding (25%) and in blinding of outcome assessment (30%), highlighting challenges in ensuring proper blinding procedures. Additionally, incomplete outcome data revealed a high risk of bias in about 15% of studies, reflecting issues with missing or incomplete data that could potentially influence the final

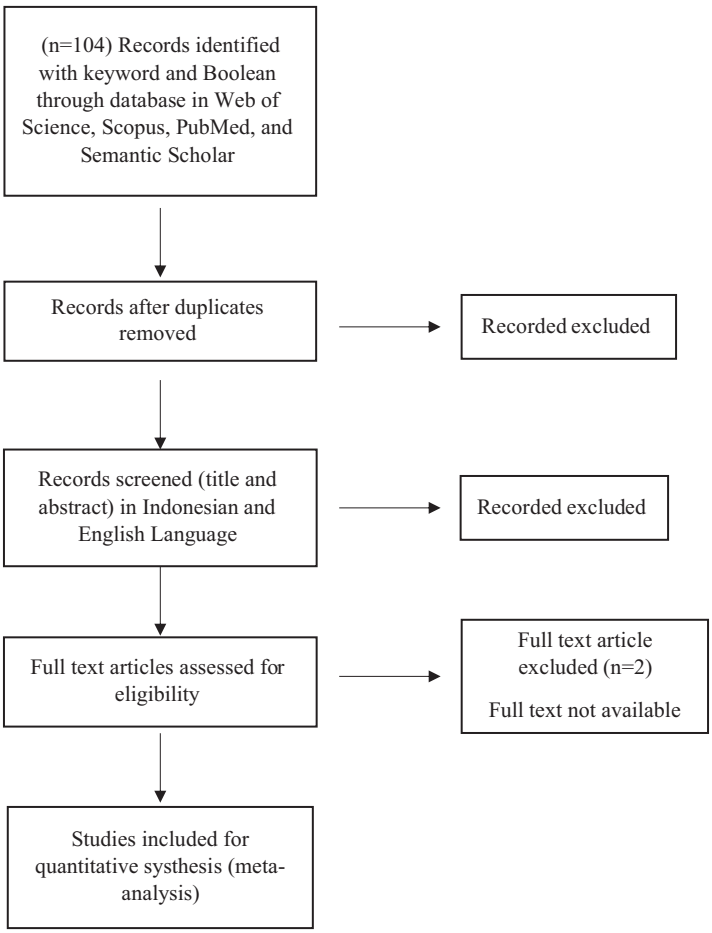

Figure 1. PRISMA flow diagram for steps to find references about the effect of high protein products consumption on albumin serum

results. In contrast, selective reporting predominantly showed a low risk of bias in 80% of studies, suggesting adequate reporting of findings, while the other bias category also reflected mostly low risk (70%), despite some remaining uncertainties (10% unclear risk). To improve future research, greater emphasis should be placed on enhancing blinding procedures and implementing robust strategies for managing missing data to address these critical shortcomings.

Meta analysis of effect of high protein product on albumin serum

The results of the analysis using Revman version 5.4 of the selected articles can be seen in Figure 3. The pooled effect size was 0.85 (95% CI: –0.03 to 1.72). Since the confidence interval includes zero, this indicates that the overall effect was not statistically significant. Although the Z value was 5.90, which typically suggests strong significance, this discrepancy reflects the serious inconsistency caused by the high heterogeneity (I^2 = 92%) among the included studies. Therefore, the apparent significance of the Z value should be interpreted with caution, and the results should be considered inconclusive. Although the meta-analysis suggested a positive effect of high-protein products on serum albumin levels, the inconsistency between the non-significant pooled effect (CI crossing zero) and the high Z value indicates that the results should be interpreted with caution. The overall results of the meta-analysis suggest that the intervention in the experimental group has a significant positive effect

Table 1. characteristics of included studies

Author	Year	Subject	Duration	Sample size (age)	Inclusion Criteria	Exclusion Criteria	Intervention	Results	The Human Ethics Committees
Yuristi, et al (22)	2018	There are 20 stunting children and 20 non-stunting children.	Not mentioned	40 stunted children in Elementary School 27, Bengkulu City, aged 8-11 years (grade 3 until 5).	Parents who consent to their children participating in the study and are willing to sign an informed consent form; students in grades 3 through 5 who are 8 to 11 years old, healthy, and not physically impaired; and TB/U that is less than -2 SD (Case) or -2 to 2 SD (Control).	students who quit during the research period and did not attend classes at the time of the study.	Protein and calcium intake were measured using the Semi Quantitative Food Frequency Questionnaires (SQ-FFQ) form.	• Children who are stunted and those who are not have different protein intakes (p=0.017). • There is no difference between those who are stunted and those who are not (p=0,809 and p=0,087) in terms of calcium consumption and serum albumin levels. • The albumin rerata score (g/dL) is 4.23 ± 0,165.	The study protocol was approved by the Poltekkes Kemenkes Bengkulu.
Fatmah et al (23)	2022	30 subjects	8 weeks	Every child in the Pancoran Mas Sub-District, Depok City, Indonesia, working area of a community health centre, aged 11 to 57 months.	Children who live in one of the three urban neighbourhoods and range in age from 12 to 57 months. The subjects' Z-score of W/A was less than negative two standard deviations (SD), suggesting low nutritional state, and they had no viral or chronic illnesses.	11 mothers refused to have their children's blood collected because they were frightened that their children would experience fever. The father would not allow blood sampling. The children were ill.	Each day, 50 g of orange almond potato biscuits. There were 237.7 kcal, 28.8 g of carbs, 3.5 g of protein, 12.1 g of fat, 0.25 mg of vitamin C, 2.5 mg of vitamin E, 1.5 mg of iron, and 1.1 mg of zinc in every 50 g of orange almond potato cookies.	• Weight: Increased with a notable improvement in the weight-for-age Z-score of 0.4 kg. • Height: Increased by 1.98 cm. • Hemoglobin Level: Increased by 0.1 g/dL (not statistically significant). • Albumin Level: Increased by 0.1 g/dL (not statistically significant).	the Ministry of Health's Health Research Ethics Commission for Research and Development Agency, with Ethical Clearance Number LB.02.01/2. KE.374/2021

Table 1 (*Continued*)

Author	Year	Subject	Duration	Sample size (age)	Inclusion Criteria	Exclusion Criteria	Intervention	Results	The Human Ethics Committees
Nainggolan et al (6)	2023	Two groups of 26 stunting toddlers were given cookies with and without red beans, making a total sample size of 52.	12 weeks	stunted children aged 13-36 months in Durian and Kuba Sentang Village.	• Toddlers identified as stunted, having a height-for-age Z-score (HAZ) of less than -2 SD, as shown by screening using microtoise measuring devices that have an accuracy of 0.1 cm. • Children whose blood albumin levels, height, and age are known. • Children whose nutritional intake data was gathered over two days before to intervention and whose homogeneity between treatment and control groups was confirmed using the 24-hour food recall approach. • Children whose nutritional intake over the two days following the intervention was tracked using a 24-hour food recall technique.	-	The sample was divided into two groups based on the village after a statistical calculation, namely, the treatment group gave red bean cookies to as many as 26 people in the Durian Village. The control group was given cookies without red beans to as many as 26 people in the village of Kuba Sentang. Provision of cookies with and without red beans given every day as much as 5 pieces (20 g/chip) weighing 100 g.	a. Treatment Group (Cookies with Red Beans): • Average height increased from 80.05 cm to 81.30 cm. • Z-score difference before and after intervention: 1.36 mg/dL, with a significant difference between treatment and control groups ($p = 0.025$). • Average albumin levels increased significantly from 4.09 g/dL to 4.64 g/dL ($p < 0.05$). • Proportion of short toddlers reduced from 69% to 38%, and normal height status increased from 31% to 62%. • Low blood albumin levels decreased from 65% to 23%, while normal albumin levels increased from 35% to 77%. b. Control Group (Cookies without Red Beans): • Average height increased from 77.6 cm to 77.9 cm, but the difference was not significant ($p > 0.05$). • Z-score difference before and after intervention: 1.02 mg/dL. • Average albumin levels increased significantly from 3.18 g/dL to 3.57 g/dL ($p < 0.05$). • Proportion of short toddlers reduced from 77% to 50%. • Normal blood albumin levels increased slightly from 38% to 46%.	the Ethics Committee, No: 036/KEPK/ POLTEKKES KEMENKES MEDAN/2017

								Significant Findings: • Cookies with Red Beans were more effective in improving height, Z-scores, and albumin levels compared to cookies without red beans. • The intervention led to a greater improvement in both anthropometric and biochemical status for the treatment group.	
Gustiya et al (24)	2020	intervention groups (20 respondents, control groups (20 respondents, and a total 40 sample	21 days in the Grabag working region (Grabag I & Grabag II Public Health Centre) in Magelang District, Central Java, Indonesia, from February to March 2020	Toddlers aged 12-60 with Z Score < 2 SD	Toddlers between the ages of 12 and 60 months who are in good health, have a Z Score of less than two standard deviations, live in the study region, and whose parents or guardians have signed an informed consent form consenting to their participation in the study	-	Moringa Oleifera leaf nanoparticles with a dose of 65 mg/day and supplementary feeding	Treatment Group: • The average albumin level prior to the intervention was 4.685 ± 0.232. • The average albumin level following the intervention was 4.963 ± 0.190. • There was a statistically significant increase in albumin levels post-intervention (p = 0.001, Paired T-Test). • The mean increase in albumin levels was 0.278 g/dL. • Control Group: • The average albumin level before the intervention was 4.538 ± 0.443. • The average albumin level after the intervention was 4.566 ± 0.436. • No statistically significant difference in albumin levels was observed before and after the intervention (p = 0.150, Paired T-Test).	the Health Research Ethics Commission Dr. Moewardi with Number 1.483/ XII/ HREC/ 2019

Table 1 (*Continued*)

Author	Year	Subject	Duration	Sample size (age)	Inclusion Criteria	Exclusion Criteria	Intervention	Results	The Human Ethics Committees
								• The difference in energy intake from baseline to endline in the control group was 20.8 ± 3.9 kcal, while in the treatment group it was 45.6 ± 8.6 kcal. For protein intake, the endline values were 9.5 ± 1 g in the control group and 16.6 ± 2.4 g in the treatment group. Changes in body weight in the control group increased from 11.7 ± 0.8 kg to 13.3 ± 1.1 kg, whereas the treatment group saw an increase from 11.7 ± 0.7 kg to 13.6 ± 1.0 kg. • The increase in albumin levels in the control group was 0.3 ± 0.1 g/dL, compared to 1.0 ± 0.2 g/dL in the treatment group.	
Widodo et al (25)	2015	Malnourished children 3-5 years	September 2013-January 2014 with a biscuit intervention period of 90 days (November 2013-January 2014).	total number of subjects 2 groups x 25 = 50	• Aged between 3 and 5 years. • Children who have poor nutritional status (stunting, underweight, or severe malnutrition). • Children registered in the local posyandu data. • Children whose parents have given their consent after an explanation of the research and filling out the informed consent.	-	3 year olds total 4 pieces (40 g) and for 4-5 year olds there are 6 pieces (60 g)	• The treatment group was 45.6±8.6 kcal, the difference between the baseline and endline in the control group for energy was 20.8±3.9 kcal, and the endline in the control group for protein was 9.5±1 g. • 16.6±2.4 g changes in body weight in the control group from 11.7±0.8 kg increased to 13.3±1.1 kg, the treatment group body weight from 11.7±0.7 kg increased to 13.6±1.0 kg. The treatment group's elevated albumin levels were 1.0±0.2 g/dL, while the control group's were 0.3±0.1 g/dL.	Health Research Ethics Commission of the Faculty of Medicine, Hasanuddin University, Makassar with No.1760/ HA.8.4.5.31/ PP36-KOMETIK/2013

					• Children who have undergone a clinical examination by a doctor to ensure that there are no congenital diseases that prevent participation in the study. • Children who have undergone initial blood sampling according to research procedures. • Children who have been randomized to receive intervention with treatment biscuits or control biscuits.				
Anton et al (26)		88 stunted children	The intervention group, consisting of 44 participants, was provided with supplementary food derived from rebon shrimp for a duration of 90 days, whereas the control group, also comprising 44 participants, was administered a placebo.	stunted children aged 24-60 months	Children aged 24 to 59 months, both male and female, with a height-for-age (HFA) z-score of less than -2 standard deviations, who are Indonesian citizens residing in Ma'rang Regency for a minimum of six months, and who are prepared to provide informed consent.	Children who were ill during the data collection period and those who had allergies to shrimp products.	The intervention group will be provided with supplementay food products derived from rebon shrimp, which will include items such as nuggets, fish sticks, and fried otak-otak, with a daily portion size of three pieces (75 grams per day). In contrast, the control group will be given a placebo consisting of low-protein flour.	• A statistically significant difference ($p<0.001$) in serum albumin levels was observed in the intervention group, whereas no statistically significant difference ($p=0.363$) was found in the control group. • The intervention group demonstrated an increase in albumin levels of 15.55 g/L, whereas the control group exhibited a tendency towards a decrease in serum albumin levels of -1.92 g/L among the children. • There was no notable difference in serum albumin levels between the two groups prior to the intervention ($p=0.180$). • The difference in serum albumin levels between the two groups was observed following the administration of the rebon product ($p<0.001$).	Research Ethics Committee (RECs) No. 271/ UN4.6.4.5.31/ pp36/2021

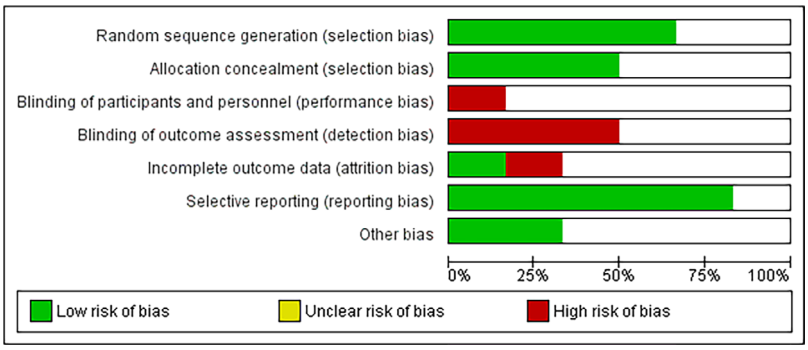

Figure 2. Risk of bias assessment plot

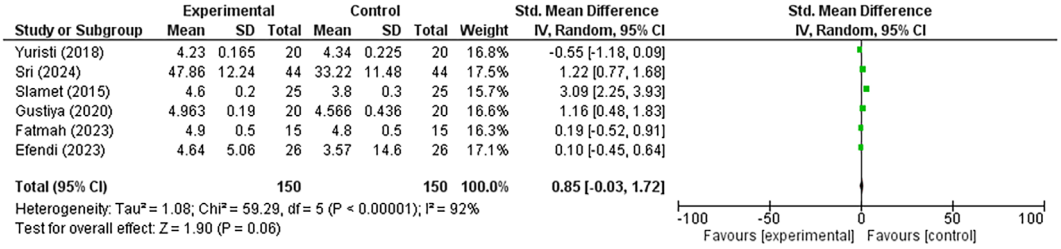

Figure 3. Forest plot of the total study sample and the Effect of High Protein Products Consumption on Albumin Serum.

compared to the control group, despite the presence of high heterogeneity. Most studies show significant results favoring the experimental group, with the exception of three studies that report non-significant results because their confidence intervals include zero: Yuristi (2018, CI: -1.18 to 0.09), Fatmah (2023, CI: -0.52 to 0.91), and Efendi (2023, CI: -0.45 to 0.64).

The funnel plot appears symmetrical, with data points clustered around the central line (SMD = 0), suggesting homogeneous results and no significant publication bias. Larger studies with smaller standard errors are at the top, while smaller studies with larger errors are at the bottom, forming an ideal funnel shape. Funnel plot analysis provided a visual indication of no major publication bias, which may reduce concerns about bias in the included studies, although it does not confirm their overall reliability. This symmetry implies that variations are likely due to random error rather than systematic bias, indicating reliable meta-analysis results and supporting homogeneity. These results are used for interpretation to strengthen the analysis of the selected articles, which is increasingly valid and stronger, as presented in Figure 4.

Discussion

Stunting is a chronic nutritional issue experienced by children due to prolonged insufficient nutrient intake, especially in the initial 1,000 days of life (27, 28). This condition is characterized by a child's height being significantly below the standard for their age, adversely affecting physical development, cognitive abilities, and overall quality of life (29). One key indicator used to assess the nutritional status of stunted children is serum albumin, the main protein in the blood that helps maintain fluid balance and transport nutrients (30). Low albumin levels often indicate severe malnutrition, and for stunted children, increasing adequate protein intake is crucial to improving this condition (31). High-protein products play a critical role in increasing serum albumin levels by providing essential amino acids required for protein synthesis (3). Albumin, which is produced by the liver, relies on sufficient protein intake for its formation (32). When the body receives adequate high-quality protein from dietary sources, the amino acids are utilized to support the synthesis of albumin (33). This increase in albumin levels is particularly important

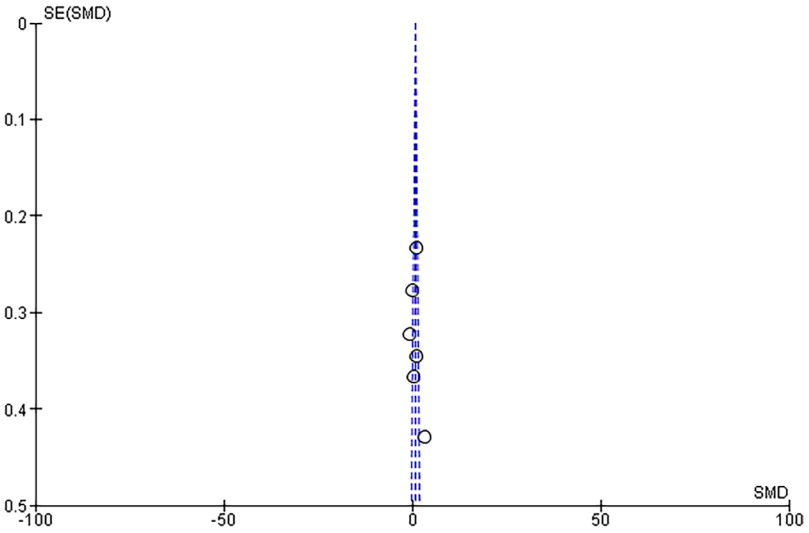

Figure 4. Result of funnel plot graphic analysis

for stunted children, as albumin helps maintain fluid balance, transport nutrients, and support immune function and tissue repair (34). Therefore, regular consumption of high-protein products can improve the nutritional status and overall health of children suffering from stunting (35). In Indonesia, addressing stunting requires increasing protein intake among children. The average per capita protein consumption is higher than the national average of 62.21 grammes per day, according to data from the National Socioeconomic Survey (Susenas) (36). Specifically, fish accounts for 9.58 grams, meat 4.79 grams, and eggs and milk only 3.37 grams per day (36). This gap is significant as animal protein is vital for child development and stunting prevention. The meta-analysis using RevMan 5.4 revealed significant heterogeneity among the included studies ($Chi^2 = 59.29$, $df = 5$, $p < 0.00001$, $I^2 = 92\%$). The substantial heterogeneity among the included studies ($I^2 = 92\%$) likely contributed to this inconsistency, suggesting that differences in study design, intervention type, and population characteristics may have influenced the outcomes. Future research with more standardized methodologies and larger sample sizes is needed to reduce heterogeneity and provide more conclusive evidence. However, three studies (Yuristi, 2018; Fatmah, 2023; Efendi, 2023) reported non-significant results, as their confidence intervals included zero. This highlights the need for standardizing intervention dosages and durations to achieve more consistent outcomes. High-protein product administration studies over periods from 7 days up to 12 weeks, using dosage ranges of 20-100 g, have also pointed out different effects depending on duration and dosage. In shorter-duration studies, such as 7-day studies, the increase in serum albumin may not be as highly evident, especially with lower doses of protein. This is because it takes quite a while for the body to start absorbing and metabolizing amino acids from protein for albumin synthesis. The higher the dosage, the greater the supply of amino acids for the support of protein synthesis, including albumin, over the given period (37). However, with larger doses, such as 100 g in a study, even a brief length of time can show really high effects because the increased intake of protein accelerates the anabolic course of the body's processes on protein. The meta-analysis using the Chi-square test showed that high-protein product administration has been associated with high serum albumin levels. Serum albumin levels did not significantly differ between primary school students who were stunted and those who were not, according to another study (38). Compared to healthy controls, children with protein-energy malnutrition (PEM) had significantly lower serum levels of total protein and albumin, most likely as a result of reduced protein consumption and production (39). Interestingly, severely stunted Nepali children from a remote village showed despite indicating modest morbidity, there were higher levels of the acute-phase protein alpha1-antichymotrypsin, which was inversely

correlated with plasma albumin levels (40). These findings highlight the complex relationship between protein intake, stunting, and serum protein levels in children. It can be learned from the analysis that the more frequent and higher the amount of high protein products given, that protein is very essential in supporting the synthesis of albumin within the body (41). The implications of the results, symmetrical funnel plot indicates no significant publication bias, supporting the reliability of the meta-analysis results. This strengthens the conclusion that high-protein interventions positively impact serum albumin levels in children with stunting (42). The funnel plot, therefore, shows consistency and dependability within the data used for the meta-analysis to ensure valid conclusions about the association between the intervention and the measured outcomes (43).

Conclusion

High-protein supplementation significantly enhances serum albumin levels among stunted children, thus playing a very important role in making up for nutritional deficiencies. Though there is marked heterogeneity among the studies (I^2 = 92%), the overall positive effect supports the importance of adequate and sustained protein intake, particularly from animal-based sources, in promoting albumin synthesis. Although this meta-analysis indicates a positive trend of high-protein interventions on serum albumin levels in stunted children, the high heterogeneity and wide confidence intervals highlight the need for cautious interpretation. Further high-quality clinical trials are required to strengthen the evidence base. The symmetrical funnel plot indicates minimal publication bias, reinforcing the reliability of these findings. To better these interventions, future efforts should focus on standardized protocols, sound methodologies, and access to quality protein for the vulnerable population to ensure better outcomes in stunting reduction and overall child health.

Study limitations

Although this meta-analysis is new, it has a number of limitations, such as limited quantities included studies, insufficient sample sizes, and non-uniformity in the high-protein products administered to subjects. Additionally, to the best of our knowledge, this is the first systematic observation and meta-analysis to examine the effect of administering high protein products on serum albumin to prevent stunting in stunted paediatric subjects.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Compliance with Ethical Guidelines: The protocol for this systhematic review and meta-analysis was registered at the PROSPERO database (Code: CRD42024576781).

Funding: The authors are grateful by PMDSU in Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, Republic of Indonesia, for the research grant with No. 359-076/UN7.D2.1/PP/VI/2025.

Author Contributions: NR, DNA: Conceptualization and study design; NR: Searching strategy and data extraction, Data interpretation; NR, AS, GA, DNA: Manuscript preparation; AS, GA, IJ, NR: Writing, review and editing; All authors: Final approval.

Acknowledgements: The authors extend their sincere gratitude to the PMDSU Program under the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia for its support and the Adjunct Professor Scheme in 2024 under the EQUITY Program.

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Received: 13 May 2025
Accepted: 26 September 2025
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