



Animal and Plant Proteins for Growth in Stunted Asian Children: A Systematic Literature Review

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Abstract

Asia bears more than half of the global burden of childhood stunting, yet evidence regarding the relative effectiveness of animal and plant proteins in promoting linear growth remains fragmented. This article synthesizes evidence on the effectiveness of animal- and plant-based protein interventions among stunted children and populations at high risk of stunting in Asia. A systematic literature review was conducted following the PRISMA 2020 guidelines. Literature searches were performed in PubMed, Scopus, and ScienceDirect, while study screening was managed using Covidence. Of 470 records identified, seven intervention studies published between 2020 and 2024 from Bangladesh, India, the Philippines, and Cambodia met the inclusion criteria and were narratively synthesized according to SWiM guidelines. The findings indicate that animal protein interventions generally improved length-for-age z-scores (LAZ) by 0.08–0.37, particularly when combined with micronutrient supplementation and nutrition education. Well-formulated plant protein interventions produced comparable, and in some cases superior, growth outcomes relative to animal-based interventions. However, the overall certainty of the evidence ranged from low to very low. These findings suggest that stunting-reduction strategies in Asia should integrate affordable animal-source proteins with high-quality plant proteins, alongside micronutrient support and nutrition education, to optimize child growth and nutritional outcomes.

INTRODUCTION

Stunting is a form of chronic undernutrition defined as a height- or length-for-age z-score (HAZ/LAZ) below -2 SD of the WHO Child Growth Standards. It has long-term consequences for cognitive development, productivity, and the risk of non-communicable diseases in adulthood (Victora et al., 2021). The 2025 edition of the UNICEF, WHO, and World Bank joint estimates reported that 150.2 million children under five, or 23.2% of children worldwide, were stunted in 2024, and more than half of them (51%) lived in Asia (UNICEF, 2025). Indonesia is a major contributor, with a stunting prevalence of 21.5% among children under five according to the 2023 Indonesian Health

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Survey (Indonesia, 2018). This figure remains far from the global target; therefore, identifying effective and affordable nutrition interventions remains a regional priority.

Biologically, linear growth requires an adequate supply of essential amino acids, particularly lysine, tryptophan, and branched-chain amino acids. These amino acids activate the mammalian target of rapamycin complex 1 (mTORC1) pathway and the secretion of insulin-like growth factor-1 (IGF-1), which regulate chondrocyte proliferation in the growth plate (Parikh et al., 2022). Children in low- and middle-income countries often consume sufficient total protein, yet their essential amino acid requirements are not met because their diets are dominated by cereals and have low diversity (Parikh et al., 2022; Samosir et al., 2023). Animal-source foods such as eggs, milk, fish, and meat have higher protein quality scores (DIAAS) and provide accompanying micronutrients such as zinc, heme iron, and vitamin B12. In contrast, plant proteins are generally deficient in lysine or methionine and contain antinutrients such as phytate and trypsin inhibitors that reduce digestibility, although conventional scoring may underestimate the quality of cooked and processed plant foods (Affrifah et al., 2023; Craddock et al., 2021).

Empirical evidence on animal-source protein remains inconsistent. A meta-analysis of randomized trials among children aged 6–24 months in low- and middle-income countries found that animal-source food supplementation improved LAZ with an effect size of 0.15 (95% CI: 0.02–0.27) (Asare et al., 2022), and a meta-analysis of egg interventions reported a 0.47 cm greater height gain than in control groups (Larson et al., 2023). However, individual trials vary widely; for example, a recent trial in South Africa found that one egg per day for six months did not improve linear growth (Ricci et al., 2024). Observational studies have also linked sustained animal-source food consumption with a lower risk of stunting, including longitudinal data from Nepal and Bangladesh (Khonje & Qaim, 2024; Zaharia et al., 2021). On the other hand, local plant proteins such as soybeans, tempeh, legumes, and moringa leaves are much cheaper and more accessible to poor households in Asia; thus, the advantages of animal protein must be weighed against affordability and sustainability (Keats et al., 2021).

The research gap arises from three issues. First, most frequently cited animal protein trials were conducted in Africa and Latin America, whereas dietary patterns, the price of animal protein, and the burden of enteric infection in Asia differ, so their results may not be transferable. Second, previous reviews generally assessed animal-source foods in general child populations without distinguishing children who were already stunted or at risk of stunting (Asare et al., 2022; Larson et al., 2023). Third, a direct comparison between animal and plant proteins in the Asian context has never been systematically synthesized. The novelty of this review lies in its geographical focus on Asia, its explicit comparison of both protein sources, and its assessment of study quality and certainty of evidence for studies published after 2020. The implications of this review are expected to inform the design of supplementary feeding programs (PMT) that are effective, economically realistic, and consistent with local food cultures in Asia, including Indonesia. Therefore, this review aimed to synthesize scientific evidence on the effectiveness of animal and plant protein provision on the growth of stunted children in Asia.

METHODS

This study used a systematic literature review design reported in accordance with the Preferred Reporting Items for Systematic Reviews and

Meta-Analyses (PRISMA) 2020 guideline (Aryasutha et al., 2025; Efendi et al., 2026; Engkizar et al., 2024, 2026; Sari et al., 2025; Yulfiarti et al., 2026). A protocol was developed in advance based on PRISMA-P 2015 and included the research question, eligibility criteria, search strategy, and synthesis plan. The main review question was: among stunted children or children in populations at high risk of stunting in Asia, how effective is animal protein provision compared with plant protein, placebo, or standard care on linear growth? The eligibility criteria were formulated using the PICOS framework, as presented in Table 1.

At the full-text review stage, the population criterion was amended. The initial protocol accepted only studies that recruited stunted children (HAZ/LAZ < -2 SD), but very few trials in Asia met this requirement. The criterion was therefore broadened to include stunted children, children at risk of stunting or undernutrition, and children from populations with a high prevalence of stunting. At the same time, nutrition packages containing protein-source foods as a main component were also accepted. This amendment was recorded in the protocol revision history and considered in the certainty-of-evidence assessment. The review stages are summarized in Figure 1.

Table 1. Study Eligibility Criteria (PICOS) after Amendment

Component	Inclusion criteria	Exclusion criteria
Population	Children aged 0–59 months (extendable to 10 years) who were stunted (HAZ/LAZ < -2 SD of the 2006 WHO standards), at risk of stunting or undernutrition, or from populations with a high prevalence of stunting, in Asian countries (UN geoscheme)	Children with severe chronic disease; severe wasting with RUTF as the focus; studies outside Asia
Intervention	Animal protein (eggs, milk, whey/casein, fish, meat, chicken liver) as a supplementary food, or main component of a nutrition package	Interventions without a protein-source food component
Comparison	Plant protein (soybean, legumes, coconut, moringa, spirulina), placebo, or standard care	Drugs, single micronutrients, or non-nutritional interventions
Outcome	Primary: change in HAZ/LAZ, length/height (cm), stunting prevalence. Secondary: WAZ, WHZ, MUAC, IGF-1, morbidity, adherence, adverse effects	No measured anthropometric outcome
Study design	Parallel or cluster RCTs, controlled quasi-experiments; intervention duration of at least 8 weeks	Observational studies without intervention, modelling, product development, protocols without results
Time & language	Published 1 January 2020 – 31 August 2026; English or Indonesian; full text available	Published before 2020; other languages; abstract only

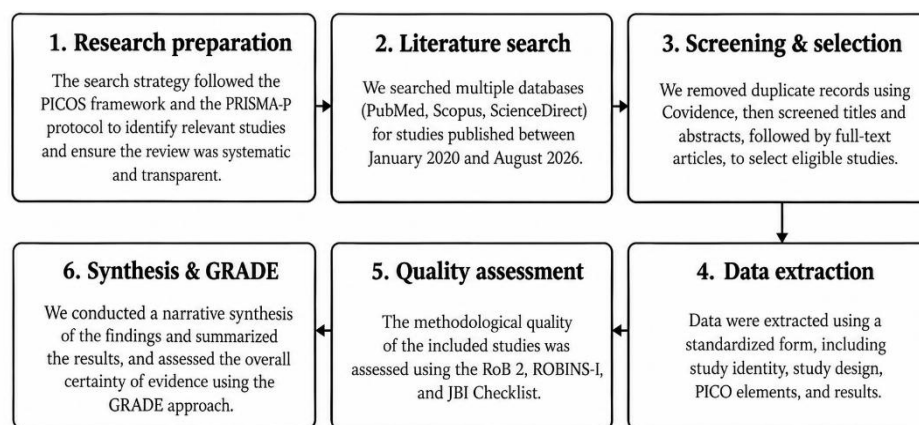


Fig 1. Stages of the Systematic Literature Review

Information sources and search strategy. The search was conducted in three databases: PubMed/MEDLINE, Scopus, and ScienceDirect. The search strategy was built from four concept blocks combined with the AND operator: child population (child, infant, toddler, preschool, under-five), stunting (stunting, linear growth, height-for-age, length-for-age, growth faltering), animal and plant protein (animal-source food, egg, milk, dairy, fish, whey, plant protein, soy, tempeh, legume, protein supplementation), and the Asian region (Asia, Indonesia, India, Bangladesh, Pakistan, Nepal, Vietnam, Philippines, Thailand, Cambodia, China, Myanmar, Sri Lanka, Laos, Malaysia). In PubMed, free-text terms were combined with MeSH terms such as Growth Disorders, Dietary Proteins, and Plant Proteins, Dietary. In Scopus, the TITLE-ABS-KEY field was used, whereas in ScienceDirect the search was split into three strings (A: animal protein, B: plant protein, C: protein supplementation) because of the limit of eight Boolean operators per field. The number of records per database is presented in Table 2.

Table 2. Literature Search Results by Database

Database	Search string	Number of records
PubMed/MEDLIN E	Four concept blocks (MeSH + free-text keywords)	22
Scopus	TITLE-ABS-KEY, four concept blocks	99
ScienceDirect	Search A (animal protein)	246
ScienceDirect	Search B (plant protein)	76
ScienceDirect	Search C (protein supplementation)	27
Total		470

Study selection. All records were imported into Covidence software for deduplication and screening. Screening was performed in two stages, namely title and abstract screening followed by full-text review against the PICOS criteria, by two reviewers independently. Disagreements were resolved through discussion or by involving a third reviewer, and every reason for exclusion at the full-text stage was recorded. The selection process is reported in a PRISMA 2020 flow diagram.

Data extraction. Data were extracted using a standardized form covering study identity (authors, year, country, funding source), design and duration, participant characteristics (number, age, stunting criteria), intervention (food type, protein dose, frequency, co-interventions), comparator, and outcomes (change in LAZ/HAZ, WAZ, WHZ, MUAC, biochemical markers, and adverse effects), together with effect sizes and their confidence intervals.

Quality assessment. Risk of bias was assessed according to study design: the Cochrane Risk of Bias 2 (RoB 2) tool for individually and cluster-randomized trials (Sterne et al., 2019), ROBINS-I for non-randomized intervention studies (Sterne et al., 2016), and the JBI Critical Appraisal Checklist as a complement for items not covered (Moola et al., 2020). The cumulative certainty of evidence for the main outcome was assessed using the GRADE approach (Higgins et al., 2019).

Data synthesis. A meta-analysis was planned if at least three studies with comparable populations, interventions, comparators, and outcomes were available. Because the included studies were highly heterogeneous in design, food type, comparator, and outcome reporting, the synthesis was conducted narratively following the Synthesis Without Meta-analysis (SWiM) guideline (Campbell et al., 2020). Studies were grouped into animal protein versus control and plant protein versus animal protein, and the direction of effect on linear growth was then summarized, taking into account study quality and country context.

RESULT AND DISCUSSION

Study selection results

The search of the three databases yielded 470 records, while searches of other sources yielded no additional records. A total of 100 records were removed before screening, consisting of 49 duplicates identified by Covidence and 51 records marked as ineligible by automation tools. Of the 370 records screened by title and abstract, 342 were excluded, leaving 28 articles for full-text review. All full texts were retrieved. Twenty-one articles were excluded because of an inappropriate study design ($n = 14$), population ($n = 4$), indication ($n = 2$), or outcome ($n = 1$). Articles excluded because of their design included a dietary modelling study, an observational cohort without a protein intervention (Parvin et al., 2022), a product development study (Katmawanti et al., 2021) and a trial protocol without results (Banjara et al., 2024), whereas an amino acid digestibility study was excluded because it did not measure anthropometric outcomes. Finally, seven studies were included in the review (Figure 2).



Fig 2. PRISMA 2020 Flow Diagram of Study Selection

Characteristics of included studies

The seven studies were published between 2020 and 2024 and all originated from South and Southeast Asia, namely Bangladesh ($n = 4$), India ($n = 1$), the Philippines ($n = 1$), and Cambodia ($n = 1$). No studies from East Asia, Central Asia, West Asia, or Indonesia met the criteria. The study designs comprised three cluster-randomized trials [Ara et al., \(2022\)](#); [Borg et al., \(2020\)](#); [Pasqualino et al., \(2024\)](#), two individually randomized trials [Agdeppa & Zamora, \(2022\)](#); [Tancja et al., \(2022\)](#), one follow-up analysis of a randomized trial [Mostafa et al., \(2024\)](#), and one intervention study with an external comparator [Mahfuz et al., \(2020\)](#). Participants were aged from 6 months to 8.4 years, with a total of approximately 6,000 children. Intervention durations ranged from 90 days to 12 months. Only three studies explicitly recruited stunted, at-risk, or undernourished children [Agdeppa & Zamora, \(2022\)](#); [Mahfuz et al., \(2020\)](#); [Mostafa et al., \(2024\)](#), whereas the other four were conducted in general populations with a high prevalence of stunting. By comparator, four studies compared animal protein with control or standard care, and three compared plant protein with animal protein. The characteristics of the studies are summarized in Table 3.

Table 3. Characteristics and Main Findings of the Included Studies (n= 7)

Study (country)	Design; sample	Intervention vs comparator; duration	Main growth findings
A. Animal protein versus control or standard care			
(Taneja et al., 2022) (India)	3-arm RCT; n = 1,548 infants aged 6 months	High-protein (5.6 g) or medium-protein (2.5 g) milk–cereal mix + MMN vs no supplement; 180 days	LAZ at 12 months higher with high protein vs no supplement (MD 0.08; 95% CI 0.01–0.15); no difference with medium protein
(Pasqualino et al., 2024) (Bangladesh)	Factorial cluster RCT; n = 2,337 infants (283 clusters)	One egg/day (both with nutrition education) vs control (age 6–12 months)	No difference in LAZ (β 0.05; CI –0.01 to 0.10) or stunting; weight (+0.07 kg) and WAZ (+0.06) increased
(Mostafa et al., 2024) (Bangladesh)	Intervention with external cohort comparator; n = 472 vs 174; days < –1	One egg + 150 mL cow's milk/day for 60 days vs MNP for 12–18 months	Δ LAZ +0.23 (CI 0.18–0.29); stunted subgroup +0.27; no allergic reactions
(Ara et al., 2022) (Bangladesh)	Cluster RCT (12 clusters); n = 412 mother–infant pairs	Vouchers for eggs, milk, semolina, sugar, oil + MNP counselling vs routine health communication; 12 months	LAZ +0.37 (CI 0.24–0.51); stunting risk reduced by 73% (OR 0.27; CI 0.13–0.58)
B. Plant protein versus animal protein			
(Agdeppa & Zamora, 2022) (Philippines)	Double-blind RCT; n = 444 undernourished/schoolchildren aged 6.0–8.4 years	Coconut skim milk vs coconut–cow's milk blend vs cow's milk; 200 mL/day; 95 days	WAZ and BAZ increased in all groups; stunting prevalence decreased significantly only with coconut milk
(Borg et al., 2020) (Cambodia)	4-arm cluster RCT; n = 485 infants aged 6–11 months	Local fish-based vs CSB++ (corn–soy) vs MNP vs control; 6 months	No difference in HAZ between fish RUSF, CSB++, and control; MUAC increased with RUSF (+0.04 cm)
(Mostafa et al., 2024) (Bangladesh)	2-year follow-up of an RCT; n = 124 moderately undernourished children aged 12–18 months	MDCF-2 (chickpea, soy, peanut, banana) vs standard RUSF (rice, lentil, milk powder); 3 months	Slower decline in LAZ (β 0.002/week; CI 0.001–0.003); plasma IGF-1 increased

Notes: BAZ = BMI-for-age z-score; CSB++ = corn-soy blend plus (containing a small amount of skimmed milk); HAZ/LAZ = height/length-

for-age z-score; CI = 95% confidence interval; MD = mean difference; MDCF-2 = microbiota-directed complementary food; MMN/MNP = multiple micronutrients/micronutrient powder; MUAC = mid-upper arm circumference; RUSF = ready-to-use supplementary food; WAZ = weight-for-age z-score. Source: compiled from the seven included articles.

Methodological quality of studies

The results of the quality assessment are presented in Table 4. Of the six randomized studies, two were judged to be at low risk of bias: the large, registered trial by [Taneja et al., \(2022\)](#) analyzed by intention-to-treat, and the double-blind trial by [Agdeppa & Zamora, \(2022\)](#). The other four studies raised some concerns because of an open-label design without blinding, a small number of clusters and retrospective registration [Ara et al., \(2022\)](#), missing complete anthropometric data for about a quarter of participants [Pasqualino et al., \(2024\)](#), randomization by site [Borg et al., \(2020\)](#), or a follow-up analysis in a subsample of the original trial ([Mostafa et al., 2024](#)). The study by [Mahfuz et al., \(2020\)](#) was at serious risk of bias because it compared the intervention group with a historical cohort from the same community without randomization.

Table 4. Methodological Quality Assessment of the Included Studies

Study	Tool	Domains of concern	Overall judgement
(Taneja et al., 2022)	RoB 2	No participant blinding; objective outcomes	Low risk
(Agdeppa & Zamora, 2022)	RoB 2	Short duration (95 days)	Low risk
(Pasqualino et al., 2024)	RoB 2 (cluster)	Missing outcome data ($\pm 23\%$)	Some concerns
(Ara et al., 2022)	RoB 2 (cluster)	12 clusters; retrospective registration; open-label	Some concerns
(Borg et al., 2020)	RoB 2 (cluster)	Randomization by site; variable adherence	Some concerns
(Mostafa et al., 2024)	RoB 2	Post-trial follow-up in a subsample	Some concerns
(Mahfuz et al., 2020)	ROBINS-I	Confounding; historical cohort comparator	Serious

Notes: RoB 2 = Cochrane Risk of Bias 2; ROBINS-I = Risk of Bias In Non-randomised Studies of Interventions.

Effect of animal protein versus control

Four studies compared animal protein provision with control or standard care, and three of them showed significant improvements in LAZ. The largest effect was found in the cluster trial by [Ara et al., \(2022\)](#), with an LAZ increase of 0.37 and a 73% reduction in the risk of stunting after 12 months. However, the intervention was a comprehensive package of egg and milk vouchers, micronutrient powder, and counselling on feeding and handwashing; thus, the contribution of animal protein cannot be separated from the other components. [Mahfuz et al., \(2020\)](#) reported an LAZ increase of 0.23 after 90 days of directly supervised egg and milk provision, with a larger effect in children who were already stunted (+0.27) than in those at risk of stunting (+0.19). Nevertheless, the non-randomized design with a historical comparator makes this estimate vulnerable to bias. [Taneja et al., \(2022\)](#) found that only the high-protein milk–cereal mix (5.6 g/day, 18% protein energy

ratio) improved LAZ, with a small effect (MD 0.08), whereas the medium-protein formula did not differ from the no-supplement group.

In contrast, providing one egg per day for six months to 2,337 infants in rural Bangladesh did not change LAZ or stunting prevalence, although weight and WAZ increased (Pasqualino et al., 2024). This pattern suggests that a single animal-source food tends to improve ponderal growth first, whereas improvements in linear growth appear more consistently in interventions that provide adequate protein doses or combine animal-source foods with micronutrients and education. The direction of effect across all studies is summarized in Table 5.

Table 5. Summary of the Direction of Effect on Linear Growth (SWiM Approach)

Comparison	Study	Direction of effect on LAZ/HAZ	Other outcomes
Animal-source food package + MMN + education vs standard care	(Ara et al., 2022)	▲ significant	Stunting ▼ 73%
Egg + milk + MNP (supervised) vs no intervention	(Mahfuz et al., 2020)	▲ significant*	No adverse effects
High-protein milk–cereal vs no supplement	(Taneja et al., 2022)	▲ small, significant	WAZ, WLZ, LILA ▲
Medium-protein milk–cereal vs no supplement	(Taneja et al., 2022)	◄► not significant	◄►
Egg alone vs control	(Pasqualino et al., 2024)	◄► not significant	Weight, WAZ ▲
Coconut milk vs cow's milk	(Agdeppa & Zamora, 2022)	◄► similar between groups	WAZ, BAZ ▲ in all groups
CSB++ vs fish-based RUSF	(Borg et al., 2020)	◄► similar	MUAC ▲ with RUSF
Legume-based MDCF-2 vs standard RUSF	(Mostafa et al., 2024)	▲ significant for MDCF-2 (rate)	IGF-1 ▲

Notes: ▲ = improvement; ▼ = reduction; ◄► = no significant difference; * = non-randomized design at serious risk of bias.

Comparison of plant and animal protein

Three studies compared plant protein with animal protein, and none showed an advantage of animal protein for linear growth. The most direct comparison came from the double-blind trial by (Agdeppa & Zamora, 2022) coconut skim milk, a coconut–cow's milk blend, and cow's milk all increased WAZ and BAZ among undernourished or stunted schoolchildren in the Philippines over 95 days, and a significant reduction in stunting prevalence occurred only in the coconut milk group. In Cambodia, a local fish-based RUSF did not differ from corn–soy-based CSB++ in HAZ, WAZ, or WHZ, and neither prevented the decline in HAZ compared with the control (Borg et al., 2020). Meanwhile, MDCF-2, composed of chickpea flour, soy, peanut, and green banana (Chen et al., 2021), slowed the decline in LAZ over two years of follow-up compared with a standard RUSF containing milk powder, accompanied by increases in plasma IGF-1 and growth-associated gut bacteria (Mostafa et al., 2024). These three studies suggest that well-formulated plant

proteins can provide benefits comparable to those of animal proteins, although the interventions were short and the populations varied.

Certainty of evidence

The certainty of evidence for each comparison is summarized in Table 6. The evidence for the effect of animal protein versus control on LAZ was rated as low certainty because of inconsistency in the direction of effect across studies, risk of bias in some studies, and indirectness, as not all participants were stunted. The evidence for plant versus animal protein was rated as very low because of the small number of studies, the high diversity of interventions and populations, and the short intervention durations.

Table 6. Summary of the Certainty of Evidence (GRADE) for Linear Growth Outcomes

Comparison	Number of studies (participant)	Reasons for downgrading	Certainty
Animal protein vs control/standard care	4 ($\approx$ 4,900)	Risk of bias, inconsistency, indirectness of population	⊕⊕○○ Low
Plant protein vs animal protein	3 ($\approx$ 1,050)	Risk of bias, imprecision, heterogeneity of interventions and populations	⊕○○○ Very low

Notes: the number of participants is the number analyzed or randomized in each study

This review found that animal protein has the potential to improve the linear growth of children in Asia, but its effects are small, inconsistent, and highly dependent on dose, quality, and delivery context. The magnitude of effect in the positive studies (LAZ 0.08–0.37) is consistent with the meta-analysis by [Asare et al., \(2022\)](#), which reported a pooled effect size of 0.15. However, the absence of an effect on linear growth in the egg trial in Bangladesh [Pasqualino et al., \(2024\)](#) resembles the null findings of a recent egg trial in South Africa [Ricci et al., \(2024\)](#) rather than the height gains pooled in the meta-analysis of egg interventions ([Larson et al., 2023](#)). This difference was likely influenced by better baseline nutritional status, a relatively low baseline stunting prevalence (18.5%), and the possibility that eggs displaced other foods in the child's diet, reducing the net additional intake.

The findings of [Taneja et al., \(2022\)](#) indicate a dose threshold: only the formula with an 18% protein energy ratio improved LAZ, whereas the 8% formula did not. This supports the view that adequacy of essential amino acids, rather than additional energy alone, is the determining factor for activation of the mTORC1 and IGF-1 pathways ([Parikh et al., 2022](#)). Meanwhile, the largest effect in the trial by [Ara et al., \(2022\)](#) was obtained from a package combining animal-source foods with micronutrients, feeding counselling, and handwashing. This result is consistent with the review by [Keats et al., \(2021\)](#) that nutrition-specific interventions are more effective when combined with improvements in caregiving practices and sanitation. Environments with a high burden of enteric infection, such as Bangladesh and Indonesia, can cause environmental enteric dysfunction that impairs nutrient absorption and lowers IGF-1 through systemic inflammation ([Htet et al., 2026](#)); therefore, nutritious food alone may not be sufficient for catch-up growth.

The finding that well-formulated plant proteins were not inferior to animal proteins opens relevant opportunities for Asia, where animal protein is

relatively expensive. Mechanistic evidence outside the included studies supports this: processing techniques such as soaking, germination, fermentation, and extrusion reduce antinutrients such as phytate, tannins, and trypsin inhibitors and improve legume protein digestibility ([Affrifah et al., 2023](#); [Senanayake et al., 2023](#)). Legume-based formulas designed to support the gut microbiota even provided growth benefits that persisted after the intervention ended ([Chen et al., 2021](#); [Mostafa et al., 2024](#)). These findings shift the focus from the question of "animal or plant" to how proteins are formulated, processed, and combined. For Indonesia, these results provide a basis for using local foods such as tempeh, mung beans, coconut, and moringa leaves in supplementary feeding programs. Such formulas need to be processed to reduce antinutrients, combined with affordable animal sources such as eggs or fish, and tested against growth outcomes. Local product development has so far reached only the acceptability testing stage ([Katmawanti et al., 2021](#)).

This review has several limitations. First, the population criterion was broadened after full-text review because only three studies specifically recruited stunted, at-risk, or undernourished children. Consequently, generalization to children who are already stunted should be made with caution, and amending the criteria after viewing the data may introduce bias into the review process. Second, heterogeneity in design, comparators, and outcome reporting precluded meta-analysis. Third, one study tested a multicomponent package [Ara et al., \(2022\)](#), so the effect of protein could not be isolated. Fourth, the search was limited to three databases and two languages; thus, studies from East Asia and local literature, including from Indonesia, may have been missed. Fifth, some of the supporting literature on animal protein was authored by the dairy industry [Parikh et al., \(2022\)](#), so potential conflicts of interest should be considered.

Future randomized trials should directly compare animal and plant proteins matched for energy and protein content, be conducted among children who are already stunted across various Asian subregions, last at least six months, and measure biochemical markers such as IGF-1. Ongoing trials, such as ENRICH in India [Banjara et al., \(2024\)](#), will add evidence on the effect of eggs at 9–18 months of age. Research based on Indonesian local foods, such as tempeh and fish, should also progress from product development to effectiveness trials.

CONCLUSION

This systematic literature review synthesized and compared evidence on the effectiveness of animal and plant proteins in supporting the growth of stunted children and those at high risk of stunting in Asia. The findings indicate that animal-source proteins can improve linear growth, particularly when provided in adequate amounts and combined with micronutrient supplementation and nutrition education. However, the growth benefits of animal proteins were not consistently superior to those of well-formulated plant-based interventions. Products such as coconut milk, corn-soy blends, and legume-based complementary foods designed to support gut microbiota demonstrated comparable, and in some cases superior, effects on growth outcomes.

The novelty of this review lies in its focused comparative synthesis of animal and plant protein interventions within the Asian stunting context, highlighting that intervention effectiveness depends not only on protein source but also on overall nutritional quality and program design. These findings

suggest that stunting reduction strategies in Asia, including supplementary feeding programs in Indonesia, should integrate affordable animal-source proteins with high-quality local plant proteins, alongside micronutrient support and caregiver nutrition education. Given the low to very low certainty of the available evidence, future randomized controlled trials directly comparing animal and plant protein interventions across diverse Asian settings are needed to strengthen the evidence base for nutrition policy and practice.

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DECLARATIONS

Author contribution

Rindy Manggalya Pambudi: data curation, writing-original draft preparation and editing, conceptualization, **Elviera Gamelia:** methodology, validation, visualization, **Eri Wahyuningsih:** supervision, software.

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REFERENCES

- Affrifah, N. S., Uebersax, M. A., & Amin, S. (2023). Nutritional significance, value-added applications, and consumer perceptions of food legumes: A review. *Legume Science*, 5(4), 192. <https://doi.org/10.1002/leg3.192>
- Agdeppa, I. A., & Zamora, J. A. T. (2022). The Effects of Coconut Skim Milk and Coco-Dairy Milk Blend on the Nutritional Status of Schoolchildren. *Journal of Nutrition and Metabolism*, 2022, 6793866. <https://doi.org/10.1155/2022/6793866>
- Ara, G., Sanin, K. I., Khanam, M., Sarker, M. S. A., Tofail, F., Nahar, B., Chowdhury, I. A., Boitchi, A. B., Gibson, S., Afsana, K., Askari, S., & Ahmed, T. (2022). A comprehensive intervention package improves the linear growth of children under 2-years-old in rural Bangladesh: a

- community-based cluster randomized controlled trial. *Scientific Reports*, 12(1), 21962. <https://doi.org/10.1038/s41598-022-26269-w>
- Aryasutha, R., Azizah Ria Kusriani, N., Nurul Ulya, J., & Syamsiah Septiani, N. (2025). Opportunities and Challenges for Islamic Education Teachers in Using Artificial Intelligence in Learning. *Muaddib.Intischolar.Id*, 2(1), 43. <https://muaddib.intischolar.id/index.php/muaddib/article/view/6>
- Asare, H., Rosi, A., Faber, M., Smuts, C. M., & Ricci, C. (2022). Animal-source foods as a suitable complementary food for improved physical growth in 6 to 24-month-old children in low- and middle-income countries: a systematic review and meta-analysis of randomised controlled trials. *British Journal of Nutrition*, 128(12), 2453–2463. <https://doi.org/10.1017/S0007114522000290>
- Banjara, S. K., Challa, S. R., Augustine, L. F., Dasi, T., Madhari, R., Fernandez Rao, S., Palika, R., Pullakhandam, R., Kalashikam, R. R., Kumar, R. N., Palepu, D. P., Chilumula, M., Selvaraj, K., Gopinath, P., Davies-Kershaw, H., Jobarteh, M. L., Haggarty, P., Heffernan, C., Ferguson, E., & Kulkarni, B. (2024). Eggs for Improving Nutrition, cognitive development and reducing linear growth retardation among Infants and young Children (ENRICH): Protocol of an egg supplementation trial among children aged 9-18 months in Hyderabad, India. *BMJ Paediatrics Open*, 8(Suppl 1), 1892. <https://doi.org/10.1136/bmjpo-2023-001892>
- Borg, B., Sok, D., Mhrshahi, S., Griffin, M., Chamnan, C., Berger, J., Laillou, A., Roos, N., & Wieringa, F. T. (2020). Effectiveness of a locally produced ready-to-use supplementary food in preventing growth faltering for children under 2 years in Cambodia: a cluster randomised controlled trial. *Maternal and Child Nutrition*, 16(1), 12896. <https://doi.org/10.1111/mcn.12896>
- Campbell, M., McKenzie, J. E., Sowden, A., Katikireddi, S. V., Brennan, S. E., Ellis, S., Hartmann-Boyce, J., Ryan, R., Shepperd, S., Thomas, J., Welch, V., & Thomson, H. (2020). Synthesis without meta-analysis (SWiM) in systematic reviews: Reporting guideline. *The BMJ*, 368, 6890. <https://doi.org/10.1136/bmj.l6890>
- Chen, R. Y., Mostafa, I., Hibberd, M. C., Das, S., Mahfuz, M., Naila, N. N., Islam, M. M., Huq, S., Alam, M. A., Zaman, M. U., Raman, A. S., Webber, D., Zhou, C., Sundaresan, V., Ahsan, K., Meier, M. F., Barratt, M. J., Ahmed, T., & Gordon, J. I. (2021). A Microbiota-Directed Food Intervention for Undernourished Children. *New England Journal of Medicine*, 384(16), 1517–1528. <https://doi.org/10.1056/nejmoa2023294>
- Craddock, J. C., Genoni, A., Strutt, E. F., & Goldman, D. M. (2021). Limitations with the Digestible Indispensable Amino Acid Score (DIAAS) with Special Attention to Plant-Based Diets: a Review. *Current Nutrition Reports*, 10(1), 93–98. <https://doi.org/10.1007/s13668-020-00348-8>
- Efendi, E., Jaafar, A., & Engkizar, E. (2026). Muslim Women's Leadership in Conflict Management in Higher Education. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, 11(2), 826–838. <https://doi.org/https://doi.org/10.24042/tadris.v11i2.30474>
- Engkizar, E., Jaafar, A., Hamzah, M. I., Syafril, S., Febriani, A., Oktavia, G., & Satrial, A. (2026). Quran Teachers' Skills as Pedagogical Foundations: Conceptual and Practical Insights into Nine Competencies. *Muaddib: Journal of Islamic Teaching and Learning*, 2(1), 22–38. <https://doi.org/10.67055/xt598c43>
- Engkizar, E., Jaafar, A., Sarianto, D., Ayad, N., Rahman, A., Febriani, A.,

- Oktavia, G., Puspita, R., & Rahman, I. (2024). Analysis of Quran Education Problems in Majority Muslim Countries. *International Journal of Islamic Studies Higher Education*, 3(1), 65–80. <https://doi.org/https://doi.org/10.24036/insight.v3i1.209>
- Higgins, J. P. T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. A. (2019). Cochrane handbook for systematic reviews of interventions. In M. J. & V. A. Welch (Eds.), *Cochrane Handbook for Systematic Reviews of Interventions* (pp. 1–694). <https://doi.org/10.1002/9781119536604>
- Htet, M. K., Nurfadilah, M., Angelin, T. C., Momo Kadia, B., Gabain, I. L., Ramsteijn, A. S., Davies-Kershaw, H., Calvo-Urbano, B., Webster, J. P., Walker, A. W., Ferguson, E. L., Allen, S., & Fahmida, U. (2026). Environmental enteric dysfunction influences linear growth of children through insulin-like growth factor-1: findings from the Indonesian Action Against Stunting Hub birth cohort. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 381(1950), 20250041. <https://doi.org/10.1098/rstb.2025.0041>
- Indonesia, K. K. R. (2018). Survei Kesehatan Indonesia 2023 dalam Angka. In *Kota Kediri Dalam Angka*. Badan Kebijakan Pembangunan Kesehatan.
- Katmawanti, S., Supriyadi, & Mariroh, F. (2021). Is instant porridge with a high calcium content based on Moringa oleifera as an alternative baby food to prevent stunting in Indonesia? *Journal of Public Health Research*, 10(2), 2233. <https://doi.org/10.4081/jphr.2021.2233>
- Keats, E. C., Das, J. K., Salam, R. A., Lassi, Z. S., Imdad, A., Black, R. E., & Bhutta, Z. A. (2021). Effective interventions to address maternal and child malnutrition: an update of the evidence. *The Lancet Child and Adolescent Health*, 5(5), 367–384. [https://doi.org/10.1016/S2352-4642\(20\)30274-1](https://doi.org/10.1016/S2352-4642(20)30274-1)
- Khonje, M. G., & Qaim, M. (2024). Animal-sourced foods improve child nutrition in Africa. *Proceedings of the National Academy of Sciences of the United States of America*, 121(50), 2319009121. <https://doi.org/10.1073/pnas.2319009121>
- Larson, E. A., Zhao, Z., Bader-Larsen, K. S., & Magkos, F. (2023). Egg consumption and growth in children: a meta-analysis of interventional trials. *Frontiers in Nutrition*, 10, 1278753. <https://doi.org/10.3389/fnut.2023.1278753>
- Mahfuz, M., Alam, M. A., Das, S., Fahim, S. M., Hossain, M. S., Petri, W. A., Ashorn, P., Ashorn, U., & Ahmed, T. (2020). Daily supplementation with egg, cow milk, and multiple micronutrients increases linear growth of young children with short stature. *Journal of Nutrition*, 150(2), 394–403. <https://doi.org/10.1093/jn/nxz253>
- Moola, S., Munn, Z., Tufanaru, C., Aromataris, E., Sears, K., Sfetcu, R., Currie, M., Qureshi, R., Mattis, P., Lisy, K., & Mu, P.-F. (2020). Chapter 7: Systematic reviews of etiology and risk. *JBIManual for Evidence Synthesis*. <https://doi.org/10.46658/jbimes-20-08>
- Mostafa, I., Hibberd, M. C., Hartman, S. J., Hafizur Rahman, M. H., Mahfuz, M., Hasan, S. M. T., Ashorn, P., Barratt, M. J., Ahmed, T., & Gordon, J. I. (2024). A microbiota-directed complementary food intervention in 12–18-month-old Bangladeshi children improves linear growth. *EBioMedicine*, 104, 105166. <https://doi.org/10.1016/j.ebiom.2024.105166>
- Parikh, P., Semba, R., Manary, M., Swaminathan, S., Udomkesmalee, E., Bos, R., Poh, B. K., Rojroongwasinkul, N., Geurts, J., Sekartini, R., & Nga,

- T. T. (2022). Animal source foods, rich in essential amino acids, are important for linear growth and development of young children in low- and middle-income countries. *Maternal and Child Nutrition*, 18(1), 13264. <https://doi.org/10.1111/mcn.13264>
- Parvin, T., Endres, K., Hasan, M. T., Uddin, I. M., Bhuyian, M. S. I., Zohura, F., Coglianese, N., Biswas, S. K., Alam, M., Faruque, A. S. G., Gittelsohn, J., Perin, J., & George, C. M. (2022). Low Fruit and Vegetable Consumption is Associated with Linear Growth Faltering among Children in Urban Bangladesh. *American Journal of Tropical Medicine and Hygiene*, 106(6), 1741–1746. <https://doi.org/10.4269/ajtmh.21-1124>
- Pasqualino, M. M., Shaikh, S., Hossain, M. I., Islam, M. T., Ali, H., Haque, R., Ayesha, K., Wu, L. S. F., Dyer, B., Hasan, K., Alland, K., Schulze, K. J., Johura, F. T., Alam, M., West, K. P., Ahmed, T., Labrique, A. B., & Palmer, A. C. (2024). An Egg Intervention Improves Ponderal But Not Linear Growth Among Infants 6–12 mo of Age in Rural Bangladesh. *Journal of Nutrition*, 154(7), 2290–2299. <https://doi.org/10.1016/j.tjnut.2024.05.006>
- Ricci, H., Faber, M., Ricci, C., Kruger, H. S., Malan, L., Nakiranda, R., Visser, M., & Smuts, C. M. (2024). Effects of egg as an early complementary food on growth of 6- to 9-month-old infants: a randomised controlled trial. *Public Health Nutrition*, 27(1), 1. <https://doi.org/10.1017/S1368980023002604>
- Samosir, O. B., Radjiman, D. S., & Aninditya, F. (2023). Food consumption diversity and nutritional status among children aged 6-23 months in Indonesia: The analysis of the results of the 2018 Basic Health Research. *PLoS ONE*, 18(3 March), 281426. <https://doi.org/10.1371/journal.pone.0281426>
- Sari, P. I., Tita, E. I., & Albizar, . A. (2025). Eight Concepts and Practices: Buying and Selling in Islam. *Multidisciplinary Journal of Thought and Research*, 1(2), 38–54. <https://mujoter.intischolar.id/index.php/mujoter/article/view/1>
- Senanayake, D., Torley, P. J., Chandrapala, J., & Terefe, N. S. (2023). Microbial Fermentation for Improving the Sensory, Nutritional and Functional Attributes of Legumes. *Fermentation*, 9(7), 635. <https://doi.org/10.3390/fermentation9070635>
- Sterne, J. A. C., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., Cates, C. J., Cheng, H. Y., Corbett, M. S., Eldridge, S. M., Emberson, J. R., Hernán, M. A., Hopewell, S., Hróbjartsson, A., Junqueira, D. R., Jüni, P., Kirkham, J. J., Lasserson, T., Li, T., ... Higgins, J. P. T. (2019). RoB 2: A revised tool for assessing risk of bias in randomised trials. *The BMJ*, 366, 4898. <https://doi.org/10.1136/bmj.l4898>
- Sterne, J. A., Hernán, M. A., Reeves, B. C., Savović, J., Berkman, N. D., Viswanathan, M., Henry, D., Altman, D. G., Ansari, M. T., Boutron, I., Carpenter, J. R., Chan, A. W., Churchill, R., Deeks, J. J., Hróbjartsson, A., Kirkham, J., Jüni, P., Loke, Y. K., Pigott, T. D., ... Higgins, J. P. (2016). ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ (Online)*, 355, 4919. <https://doi.org/10.1136/bmj.i4919>
- Taneja, S., Upadhyay, R. P., Chowdhury, R., Kurpad, A. V., Bhardwaj, H., Kumar, T., Dwarkanath, P., Bose, B., Devi, S., Kumar, G., Kaur, B., Bahl, R., & Bhandari, N. (2022). Impact of supplementation with milk-cereal mix during 6-12 months of age on growth at 12 months: a 3-arm randomized controlled trial in Delhi, India. *American Journal of Clinical*

- Nutrition*, 115(1), 83–93. <https://doi.org/10.1093/ajcn/nqab304>
- UNICEF, W. & W. B. G. (2025). Levels and trends in child malnutrition: UNICEF/WHO/World Bank Group joint child malnutrition estimates: key findings of the 2025 edition. In *WHO/World Bank Group Joint Child Malnutrition Estimates*. World Health Organization.
- Victora, C. G., Christian, P., Vdaletti, L. P., Gatica-Domínguez, G., Menon, P., & Black, R. E. (2021). Revisiting maternal and child undernutrition in low-income and middle-income countries: variable progress towards an unfinished agenda. *The Lancet*, 397(10282), 1388–1399. [https://doi.org/10.1016/S0140-6736\(21\)00394-9](https://doi.org/10.1016/S0140-6736(21)00394-9)
- Yulfiarti, K., Rifai, H., Mufid, F., Fauzi, A., Ningsih, E. D., Wiyana, I. E., & Fauzan, F. (2026). The Variations of Magnetic Susceptibility Values in Raw Mix I during the Cement Production Process. *Multidisciplinary Journal of Thought and Research*, 2(1), 1–13. <https://doi.org/10.67055/g5710029>
- Zaharia, S., Ghosh, S., Shrestha, R., Manohar, S., Thorne-Lyman, A. L., Bashaasha, B., Kabunga, N., Gurung, S., Namirembe, G., Appel, K. H., Liang, L., & Webb, P. (2021). Sustained intake of animal-sourced foods is associated with less stunting in young children. *Nature Food*, 2(4), 246–254. <https://doi.org/10.1038/s43016-021-00259-z>

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