Journal of Indonesian Specialized Nutrition | e-ISSN: 3032-3878
Vol. 04 No. 02, 2026

THE IMPORTANCE OF ANIMAL PROTEIN FULFILLMENT FOR OPTIMAL GROWTH OF UNDER-5 CHILDREN: MECHANISTIC INSIGHTS AND CLINICAL IMPLICATIONS

Rahayu Kania [1*], Dessy Pratiwi [2], Nurfadilah M. Rajab [3]

[1] *Yarsi Pratama University, Tangerang, Banten, Indonesia*
[2] *Indonesia Health Development Center, Jakarta, Indonesia*
[3] *Edukazi Indonesia Bergizi, Jakarta, Indonesia*

*Corresponding Author: rahayukania90@gmail.com

Abstract

Background: Protein plays a fundamental role in growth regulation through its structural, metabolic, and signaling functions. Increasing evidence indicates that the consumption of animal-source foods is associated with improved linear growth and a reduced risk of stunting during infancy and early childhood. This review aimed to evaluate the contribution of animal protein intake to linear growth among children under five years of age. **Methods:** A literature review was conducted to synthesize current evidence from studies indexed in PubMed and Scopus between 2016 and 2026. Eligible publications included observational studies, randomized controlled trials (RCTs), and review articles that examined the relationship between animal protein intake and indicators of linear growth in children younger than five years. **Results:** Animal-source proteins, including those derived from fish, eggs, milk, and meat, were consistently associated with favorable linear growth outcomes during the first five years of life. Evidence from randomized trials and meta-analyses demonstrated modest but significant improvements in length-for-age z-scores (LAZ), while cohort studies reported lower stunting prevalence among children with higher animal-source food consumption. Nevertheless, the magnitude of these effects varied according to contextual factors, including dietary adequacy, maternal nutritional status, infection burden, and environmental conditions. **Conclusion:** Regular consumption of modest amounts of animal-source foods can contribute to measurable improvements in linear growth, with pooled evidence indicating significant benefits across low- and middle-income countries. However, the effectiveness of animal protein interventions is optimized when integrated with strategies addressing underlying determinants of growth.

Keywords: Animal protein, Linear growth, First 1000 days, Child nutrition

Introduction

The first 1,000 days of life, spanning from conception to the second year after birth, represent a critical period of developmental plasticity during which nutrition and environmental exposures exert profound effects on lifelong health trajectories. This developmental window is characterized by rapid linear growth, organogenesis, immune maturation, neurodevelopment, and metabolic programming, all of which are highly sensitive to nutritional perturbations.[1,2] Importantly, evidence suggests that growth deficits acquired during this critical period are often only partially reversible, underscoring the importance of optimizing nutritional exposures during early life.[2,3]

Among the multiple determinants of child growth, adequate nutrition is recognized as one of the most fundamental and modifiable factors influencing linear growth velocity. While sufficient dietary energy intake is necessary to support growth, increasing evidence indicates that energy adequacy alone is insufficient to sustain optimal skeletal and tissue accretion.[4] Instead, growth depends heavily on the availability of high-quality dietary protein, indispensable amino acids, and bioavailable micronutrients required for anabolic processes.[5]

Protein plays a central physiological role in regulating growth through both structural and signaling functions. Adequate protein intake supports skeletal muscle accretion, extracellular matrix synthesis, cartilage formation, osteoblastic activity, tissue remodeling, and the production of hormones and enzymes essential for growth regulation.[6] Animal-source proteins are nutritionally distinct because they generally provide complete profiles of indispensable amino acids with high digestibility and superior anabolic potential compared with many plant-derived proteins.[7,8] Animal-source foods (ASF), including dairy products, eggs, fish, and meat, are also rich sources of highly bioavailable micronutrients critical for growth, such as iron, zinc, calcium, vitamin B12, choline, and long-chain omega-3 fatty acids, including docosahexaenoic acid (DHA).[9,10]

A growing body of epidemiological and interventional evidence has linked animal-source food consumption with improved linear growth outcomes and reduced risk of stunting during infancy and early childhood.[11] However, the evidence remains heterogeneous, with variability in study design, timing of exposure, socioeconomic context, and types of animal-source foods evaluated.[12] Consequently, substantial uncertainty persists regarding the mechanistic and clinical significance of animal protein intake in children.

Therefore, this review aims to examine the role of animal protein intake in supporting linear growth in children under five, with particular emphasis on protein quality, indispensable amino acid composition, anabolic signaling pathways, and current clinical and public health implications. By integrating mechanistic, nutritional, and epidemiological evidence, this manuscript seeks to clarify the biological rationale and translational relevance of animal-source protein consumption during early-life growth and development.

Methods

This study employed a narrative review approach to evaluate and synthesize the available evidence regarding the relationship between animal protein consumption and linear growth among children under five years of age. A systematic search of the literature was conducted in the PubMed and Scopus databases, covering publications from 2016 to June 2, 2026. The search strategy utilized the Boolean operator ["Animal protein" AND "Linear Growth"]. Retrieved records were screened through title, abstract, and full-text assessments following the removal of duplicate citations.

Studies were eligible for inclusion if they were review articles, observational studies, or randomized controlled trials (RCTs) examining the association between animal protein intake and indicators of linear growth in children under five years. Only full-text articles with direct relevance to the review objective were included. Conference abstracts, editorials, commentaries, and studies lacking open-access full-text availability were excluded. The selected articles (Figure 1) were subsequently appraised and synthesized narratively to provide a comprehensive overview of the current evidence on the contribution of animal-source protein to linear growth during early childhood.

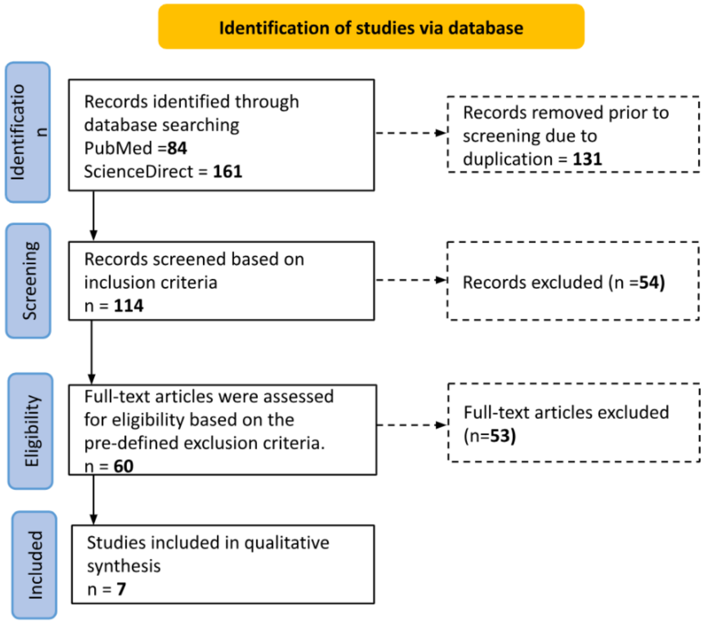

Figure 1. Flow chart of study selection

Results and Discussion

A total of seven studies published between 2019 and 2024 were included in this review. The studies were conducted in diverse settings, primarily in low-and middle-income countries (LMICs) across Africa and Asia, including Bangladesh, Malawi, Ethiopia, and Indonesia, while two studies synthesized evidence from multiple countries through systematic and narrative reviews. The study populations mainly comprised infants and young children during the first 1,000 days of life, particularly those aged 6–24 months, although some studies included children up to 36 months of age and broader pediatric populations under five years. Sample sizes varied considerably, ranging from relatively small intervention cohorts to large observational studies and multi-study evidence syntheses encompassing numerous populations across LMIC settings.

The included evidence represented a range of study designs, including one systematic review and meta-analysis of randomized controlled trials, Community-based nonrandomized comparative intervention study, one matched case–control study, two observational cross-sectional studies, and two narrative reviews of the literature. The intervention studies evaluated the effects of animal-source foods, including eggs, cow's milk, and mixed animal-source food interventions, on child growth outcomes, particularly linear growth and height gain. The observational studies examined associations between animal-source protein consumption and indicators of nutritional status, including height-for-age z-scores (HAZ) and stunting prevalence. The review articles synthesized evidence on the nutritional importance of livestock-derived foods and essential amino acids during the first 1,000 days of life and early childhood. Despite differences in study design and setting, all included studies investigated the contribution of animal-source food consumption to child growth and nutritional outcomes, providing complementary evidence on the potential role of animal protein in supporting linear growth and reducing the risk of stunting. The main findings of these studies are summarized below.

Animal-source proteins (fish, eggs, milk, meat) support linear growth during 5 years of life, with trials and a meta-analysis showing modest length-for-age z-score (LAZ) gains and cohort studies linking ASF consumption to lower stunting prevalence (Table 1). Effects are context dependent and often require complementary infection and maternal-nutrition measures.

Table 1. Summary of Findings

No.	Author (Year)	Study Design	Main Findings
1	Asare et al. (2022)	Systematic review and meta-analysis of randomized controlled trials (RCTs)	Animal-source foods provided during complementary feeding (6–24 months) were associated with improved physical growth outcomes, particularly linear growth. An increased effect on LAZ and WAZ was observed when the food supplementation was based on egg with effect size of 0.31 (95 % CI = −0.03, 0.64) and 0.36 (95 % CI = −0.03, 0.75), respectively.
2	Mahfuz et al. (2019)	Community-based nonrandomized comparative intervention study	Daily supplementation with egg, cow's milk, and multiple micronutrients significantly improved linear growth among young children with short stature. Compared with the comparison group,

No.	Author (Year)	Study Design	Main Findings
			adjusted difference-in-difference analysis revealed a change in LAZ +0.23 (95% CI: 0.18, 0.29; P < 0.05). In a subgroup analysis, the changes were +0.27 (95% CI: 0.18, 0.35; P < 0.05) in stunted (LAZ <2) children and +0.19 (95% CI: 0.12, 0.27; P< 0.05) in children at risk of stunting (LAZ -1 to -2).
3	Kaimila et al. (2019)	Cross-sectional observational study	Consumption of animal-source protein was positively associated with higher height-for-age z-scores (HAZ) among rural Malawian children aged 12–36 months. Children 12–36 months consuming more animal protein exhibited better linear growth (p = 0.047).
4	Tadesse et al. (2020)	Matched case-control study	Inadequate dietary diversity and limited consumption of nutrient-rich foods, including animal-source foods, were associated with increased risk of stunting (cAOR = 2.35; 95% CI: 1.21, 4.58)
5	Windiani & Adnyana (2024)	Cross-sectional study	A significant relationship between animal protein and stunting preventive measure was showed with consumption of growing-up milk (GUM), liver, and egg (p=<0.05). Further multivariate analysis revealed the strongest relation between the volume of consumed GUM (β=1.081, 95%CI=0.680-1.481, p=<0.01) and frequency of egg consumption (β=0.458, 95CI%=0.129-0.788, p=0.007) with stunting prevention.

No.	Author (Year)	Study Design	Main Findings
6	Parikh, Semba & Manary (2022)	Narrative review	Animal-source foods provide high-quality protein and essential amino acids critical for growth and development. Evidence suggests ASF intake supports linear growth and may help reduce stunting among children in LMICs.
7	Alonso et al. (2019)	Review article	Livestock-derived foods play an important nutritional role during the first 1,000 days of life by supplying high-quality protein, iron, zinc, vitamin B12, and other nutrients essential for growth, cognitive development, and prevention of undernutrition.

Growth Physiology in Early Childhood

Linear growth in early childhood is driven by endochondral ossification at the epiphyseal growth plate, a process regulated by the growth hormone (GH)–insulin-like growth factor-1 (IGF-1) axis. GH stimulates hepatic IGF-1 production, and circulating IGF-1 acts on growth plate chondrocytes to promote proliferation, hypertrophy, and matrix synthesis.[13] Insulin and free triiodothyronine also converge on the growth plate, and their circulating levels are tightly coupled to dietary protein intake, creating a direct nutritional gate on the endocrine growth machinery. When protein intake is insufficient, the GH-IGF-1 axis is downregulated even when GH secretion is normal, functionally decoupling the growth hormone signal from bone elongation.[14]

During periods of rapid growth in infancy and early childhood, protein deposition in lean tissues proceeds with exceptionally high efficiency.[15] This protein-stat model posits that protein intake is the most powerful macronutrient influence on the growth trajectory, acting through the insulin-IGF-1–free T3 cascade to sustain endochondral ossification. Any interruption from inadequate protein supply, recurrent infections, or environmental enteric dysfunction attenuates growth-plate activity and produces the cumulative length deficit that defines stunting.[16]

Protein Requirements During Growth

Protein requirements during the five-year period are among the highest per kilogram of body weight of any life stage, reflecting the rapid accretion of skeletal muscle, viscera, and bone matrix. The World Health Organization (WHO)/Food and Agriculture Organization (FAO) recommends approximately 1.5–1.8 g/kg/day for infants and young children. The therapeutic catch-up target is 2.82 g·kg−1·d−1 recommended for RUTF to achieve rapid catch-up weight gain in severe acute malnutrition. Protein quality threshold, such as Protein Digestibility Corrected Amino Acid Score (PDCAAS) of ≥90%, is considered adequate for follow-up formulas and therapeutic foods; lower scores require increasing protein quantity or improving digestibility.[17] In rural Ethiopian children aged 6–35 months, three-quarters were energy-deficient and stunted children had significantly lower daily energy and protein intakes than non-stunted peers, despite similar total grams of food consumed.[13]

The quantity of protein alone, however, does not guarantee adequate growth quality matters independently. In a Thai prospective cohort of 145 infants during complementary feeding, animal-source foods were the main protein source and showed a positive dose-response relationship with weight-for-age, weight-for-length, and body mass index (BMI) z-scores, whereas plant-based protein had no significant effect on any growth parameter. Notably, dairy protein had a greater impact on weight gain and growth-related hormones (IGF-1, IGFBP-3, insulin) than non-dairy animal proteins, while none of the protein sources were associated with linear growth in this population facing a double burden of malnutrition.[18] These findings underscore that both protein quantity and source-specific quality must be considered when designing complementary feeding recommendations.

Animal versus Plant Protein Bioavailability

Protein quality is conventionally assessed by the PDCAAS or the more recent Digestible Indispensable Amino Acid Score (DIAAS), both of which account for the amino acid profile and true ileal digestibility. Animal proteins typically score >100, indicating that all indispensable amino acids are present in adequate amounts and are highly bioavailable.[19] In contrast, most plant proteins are limited by one or more essential amino acids, cereals by lysine, legumes by methionine and contain anti-nutritional factors (e.g., phytates, tannins, trypsin inhibitors) that further reduce mineral and protein bioavailability. The DIAAS of plant protein commonly used in complementary feeding programs is lower, significantly below that of milk and other animal-source proteins.[7]

In the Malawian cohort studied by Kaimila et al., children in Limera consumed more fish than those in Masenjere (54% vs 35%, p = 0.009) and had higher intakes of bioavailable protein (26.0 vs 23.1 g/day, p = 0.018). Animal protein consumption was specifically associated with improved height-for-age z-scores in children aged 12–36 months (p = 0.047).[16] Importantly, total protein intake did not differ between communities only bioavailable (animal-derived) protein was higher, suggesting that protein quality rather than quantity was the discriminating nutritional factor for linear growth in this population. These observations align with the notion that even when total protein meets crude targets, poor amino acid digestibility and unbalanced profiles from plant-only diets may keep anabolic signaling sub-threshold for optimal growth.[5]

Evidence from Observational and Intervention Studies

A growing body of evidence from interventions supports the efficacy of animal-source proteins in improving linear growth during complementary feeding. In a randomized controlled trial in Zambia, Chipili et al. provided fish powder (7 g/day) or isocaloric sorghum powder to infants aged 6–7 months for 6 months. Fish powder increased LAZ by 1.26 (95% CI: 0.94–1.57) and weight-for-age z-scores (WAZ) by 0.95 (95% CI: 0.6–1.23) relative to the control group, with effects evident throughout the intervention period. A systematic review and meta-analysis of 14 randomized controlled trials across LMICs confirmed that animal-source food supplementation significantly improved LAZ (effect size 0.15; 95% CI: 0.02–0.27) and WAZ (0.20; 95% CI: 0.03–0.36) in children aged 6–24 months, with egg-based interventions showing the largest effects.[15] In other study of direct supplementation trial, daily provision of an egg plus 150 mL milk and multiple micronutrients to 12–18-month-old children with short stature increased LAZ by +0.23 (adjusted DID) over 90 days, with larger gains among already stunted children.[22] Case–control and cross-sectional studies in Ethiopia and Indonesia found that lack of meat intake and lower frequencies/volumes of milk and egg consumption were associated with higher odds of stunting in young children.[23,24]

Implications for Stunting Prevention

Strategically incorporating animal-source proteins into complementary feeding programs has the potential to address the amino acid deficiencies that underlie stunting. Higher intake of dairy products, eggs, fish, and meat has been associated with greater HAZ and improved growth trajectories in diverse populations. The Ethiopian data reported by Tessema et al. indicate that stunted children have lower daily energy intake and that serum tryptophan, protein intake, and energy intake are each independently associated with linear growth. Furthermore, the high prevalence of inflammation (35%) and intestinal parasites (48%) in that cohort suggests that even when protein is consumed, the presence of infection diverts amino acids away from growth toward acute-phase protein synthesis and immune activation, compounding the growth deficit.[13] Any effective stunting prevention strategy must therefore couple improved protein quality with infection control.

The observational evidence consistently aligns with intervention data: animal protein consumption was associated with improved HAZ in Malawian children, with fish consumption specifically differentiating communities with better growth outcomes.[16] In the Thai cohort, the distinctive impact of dairy protein on IGF-1 and weight gain, but not on linear growth, cautions against assuming that all animal-source foods equally promote height.[18] These data suggest that stunting prevention requires comprehensive approaches that improve the quality of dietary protein across multiple animal-source food groups, while addressing the non-nutritional determinants of linear growth inflammation, enteric dysfunction, and care practices.

Practical Recommendations

Based on current evidence, the daily inclusion of animal-source foods during the complementary feeding period (6–24 months) should be prioritized as a core strategy to support linear growth. Small quantities of animal protein, as little as 7 g/day of fish powder or 1 egg/day, have shown measurable effects on length gain in controlled settings, and these portions are feasible within most household food budgets when locally available species and culturally acceptable forms are used.[21] Programmatic efforts should focus on context-specific solutions: fish and eggs are widely available in many LMIC settings and are culturally acceptable as weaning foods, while dairy products (fresh, fermented, or fortified) provide high-quality protein for populations with access to them. Importantly, interventions should also address the absorptive and metabolic barriers, reducing inflammation through improved water, sanitation, and hygiene (WASH), and timely treatment of infections will maximize the growth benefit of improved protein intake.

Evidence suggests ASF intake supports linear growth and may help reduce stunting among children in LMICs.[25] Sustainability of livestock-derived foods plays an important nutritional role during the first 1,000 days of life by supplying high-quality protein, iron, zinc, vitamin B12, and other nutrients essential for growth, cognitive development, and prevention of undernutrition.[26] The corresponding expert consensus guidelines reinforced this, establishing that interprofessional collaboration teams must include nutritionists and dietitians with explicit mandates to promote animal-protein-containing complementary foods, given that 81% of expert panelists regarded such coordinated guidelines as very important.[27] This nutritional imperative is further corroborated by a scoping review which found that low maternal nutrition literacy specifically deficits in knowledge about animal-source food selection, preparation, and infant feeding consistently predicted stunting incidence across LMIC alike, affirming that translating protein-based dietary recommendations into household practice depends heavily on caregiver education.[28]

A clinical trial among 6–12-month-old infants with weight faltering further showed that combining nutritional advice with an oral nutritional supplement (ONS) a high-nutrient-density formula with a protein-to-energy ratio of 10% allowed 82.8% of the most severely faltering infants to recover above the growth threshold within one month, whereas nutritional advice alone achieved this in only 80% of the less-severe group, supporting the role of targeted protein-enriched supplementation in preventing the progression from weight faltering to overt stunting.[29]

From a health-economics perspective, a cost-utility analysis demonstrated that a 90-day intervention with a nutrient-dense formula (NDF) providing 400 kcal/day and enriched with protein, iron, and micronutrients was a cost-effective strategy for reducing stunting, wasting, and underweight prevalence in Indonesian children, providing the first data-driven economic argument for integrating high-protein supplementation into national health budgets.[30] Together, these sources indicate that animal protein and protein-dense formulas operate simultaneously at the level of clinical recovery, molecular growth regulation, household nutrition behaviour, and healthcare financing — making protein-centred strategies indispensable across every tier of stunting management, from community health promotion to primary care protocols.

The evidence included in this review has several notable strengths. First, it incorporates a diverse range of study designs, including a systematic review and meta-analysis of randomized controlled trials, community based trials, observational studies, and narrative reviews, allowing for the integration of both causal and real-world evidence. Second, the studies were conducted across multiple low- and middle-income countries, enhancing the relevance of the findings to populations where stunting and inadequate dietary quality remain major public health concerns. Third, several studies specifically focused on the critical complementary feeding period (6–24 months), a window during which nutritional interventions are most likely to influence linear growth and development. Collectively, the studies provide consistent evidence supporting the positive role of animal-source foods and animal-source protein in promoting child growth and reducing the risk of stunting.

However, several limitations should also be considered. The majority of primary studies were conducted in specific local settings within Africa and Asia, which may limit the generalizability of findings to other regions and populations. In addition, much of the evidence was derived from observational and cross-sectional studies, which can identify associations but cannot establish causality and remain susceptible to residual confounding from socioeconomic, environmental, and dietary factors. Furthermore, the included reviews and primary studies differed in their definitions and measurements of dietary intake and growth outcomes, contributing to methodological heterogeneity. Finally, relatively few randomized controlled trials were available, highlighting the need for additional well-designed longitudinal and intervention studies to strengthen the evidence base regarding the effects of animal-source protein consumption on child linear growth and stunting prevention.

Conclusion

The evidence across mechanistic, observational, and interventional studies establishes that animal-source proteins, through their dense and balanced essential amino acid profiles, particularly leucine, lysine, and tryptophan, directly activate the mTORC1 signaling cascade and sustain the GH–IGF-1 endocrine axis that drives endochondral ossification at the growth plate, a physiological advantage that plant-based proteins rarely match due to lower digestibility and limiting amino acid patterns. Modest daily additions of animal-source foods measurably improve linear growth with a significant pooled benefit across LMIC settings. However, animal protein supplementation is most impactful when baseline diets, concurrent environmental barriers, inflammation, enteric dysfunction, and recurrent infections are addressed, reflecting the multi-factorial etiology of linear growth. These findings carry clear practical implications: complementary feeding programs should prioritize daily inclusion of locally available, culturally acceptable animal-source foods guided by protein quality metrics such as PDCAAS, within integrated strategies that also control infection, improve dietary diversity, and address the absorptive and metabolic barriers that otherwise limit the growth benefit of improved protein intake.

Acknowledgment

The author gratefully appreciates all the constructive contributions and insights to improve the clarity and quality of this manuscript.

Conflict of Interest

The author declares there is no conflict of interest in this publication.

References

1. Schwarzenberg SJ, Georgieff MK; Committee on Nutrition. Advocacy for Improving Nutrition in the First 1000 Days to Support Childhood Development and Adult Health. Pediatrics. 2018;141(2):e20173716. https://doi.org/10.1542/peds.2017-3716
2. Victora CG, Christian P, Vidaletti LP, Gatica-Domínguez G, Menon P, Black RE. Revisiting maternal and child undernutrition in low-income and middle-income countries: variable

progress towards an unfinished agenda. Lancet. 2021;397(10282):1388-1399. https://doi.org/10.1016/S0140-6736(21)00394-9

3. Leroy JL, Frongillo EA. Perspective: What Does Stunting Really Mean? A Critical Review of the Evidence. Adv Nutr. 2019;10(2):196-204. https://doi.org/10.1093/advances/nmy101
4. Headey D, Hirvonen K, Hoddinott J. Animal Sourced Foods and Child Stunting. Am J Agric Econ. 2018;100(5):1302. https://doi.org/10.1093/ajae/aay053
5. Semba RD, Shardell M, Sakr Ashour FA, Moaddel R, Trehan I, Maleta KM, et al. Child Stunting is Associated with Low Circulating Essential Amino Acids. EBioMedicine. 2016;6:246-252. https://doi.org/10.1016/j.ebiom.2016.02.030
6. Millward DJ. Interactions between Growth of Muscle and Stature: Mechanisms Involved and Their Nutritional Sensitivity to Dietary Protein: The Protein-Stat Revisited. Nutrients. 2021;13(3):729. https://doi.org/10.3390/nu13030729
7. FAO. Dietary protein quality evaluation in human nutrition. FAO Food Nutr Pap. 2016;92:1-66.
8. Tessari P, Lante A, Mosca G. Essential amino acids: Master regulators of nutrition and environmental footprint? Sci Rep. 2016;6(1):26074. https://doi.org/10.1038/srep26074
9. Dror DK, Allen LH. Overview of Nutrients in Human Milk. Adv Nutr. 2018;9(Suppl 1):278S. https://doi.org/10.1093/advances/nmy022
10. Eaton JC, Dreker MR, Iannotti L, Lutter C, Kaganda J. Effectiveness of provision of animal-source foods for supporting optimal growth and development in children 6 to 59 months of age. Cochrane Database Syst Rev. 2019;2019(2):CD012818. https://doi.org/10.1002/14651858.CD012818.pub2
11. Shapiro MJ, Downs SM, Swartz HJ, Parker M, Quelhas D, Kreis K, et al. A Systematic Review Investigating the Relation Between Animal-Source Food Consumption and Stunting in Children Aged 6–60 Months in Low and Middle-Income Countries. Adv Nutr. 2019;10(5):827. https://doi.org/10.1093/advances/nmz018
12. Tadesse SE, Tariku A, Belachew T. Feeding practices of under-two children in Ethiopia: A systematic review and meta-analysis. PLoS One. 2026;21(2):e0342932. https://doi.org/10.1371/journal.pone.0342932

13. Tessema M, et al. Associations among High-Quality Protein and Energy Intake, Serum Transthyretin, Serum Amino Acids and Linear Growth of Children in Ethiopia. Nutrients. 2018;10(11):1776. https://doi.org/10.3390/nu10111776
14. Gat-Yablonski G, Phillip M. Nutritionally-Induced Catch-Up Growth. Nutrients. 2015;7(1):517. https://doi.org/10.3390/nu7010517
15. Asare H, Rosi A, Faber M, Smuts CM, Ricci C. 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. Br J Nutr. 2022;128(12):2453-2463. https://doi.org/10.1017/S0007114522000290
16. Kaimila Y, et al. Consumption of Animal-Source Protein is Associated with Improved Height-for-Age z Scores in Rural Malawian Children Aged 12–36 Months. Nutrients. 2019;11(2):480. https://doi.org/10.3390/nu11020480
17. Shivakumar N, Jackson AA, Courtney-Martin G, Elango R, Ghosh S, Hodgkinson S, et al. Protein Quality Assessment of Follow-up Formula for Young Children and Ready-to-Use Therapeutic Foods: Recommendations by the FAO Expert Working Group in 2017. J Nutr. 2020;150(2):195-201. https://doi.org/10.1093/jn/nxz250
18. Kittisakmontri K, Lanigan J, Wells JC, Manowong S, Kaewarree S, Fewtrell M. Quantity and Source of Protein during Complementary Feeding and Infant Growth: Evidence from a Population Facing Double Burden of Malnutrition. Nutrients. 2021;14(19):3948. https://doi.org/10.3390/nu14193948
19. Herreman L, Nommensen P, Pennings B, Laus MC. Comprehensive overview of the quality of plant- and animal-sourced proteins based on the digestible indispensable amino acid score. Food Sci Nutr. 2020;8(10):5379-5391. https://doi.org/10.1002/fsn3.1809
20. Chipili G, Van Graan A, Lombard CJ, Van Niekerk E. The Efficacy of Fish as an Early Complementary Food on the Linear Growth of Infants Aged 6–7 Months: A Randomised Controlled Trial. Nutrients. 2021;14(11):2191. https://doi.org/10.3390/nu14112191
21. Mahfuz M, Alam MA, Das S, Fahim SM, Hossain MS, Petri WA, et al. Daily Supplementation With Egg, Cow Milk, and Multiple Micronutrients Increases Linear

Growth of Young Children with Short Stature. J Nutr. 2020;150(2):394-403. https://doi.org/10.1093/jn/nxz253

22. Tadesse SE, Mekonnen TC, Adane M. Priorities for intervention of childhood stunting in northeastern Ethiopia: A matched case-control study. PLoS One. 2020;15(9):e0239255. https://doi.org/10.1371/journal.pone.0239255
23. Windiani IGAT, Adnyana IGANS. The relationship between animal protein consumption and stunting in children in Gianyar, Bali, Indonesia. Bali Med J. 2024;13(3):1413-1417. https://doi.org/10.15562/bmj.v13i3.5343
24. Miller V, Webb P, Micha R, et al. Defining diet quality: a synthesis of dietary quality metrics and their validity for the double burden of malnutrition. Lancet Planet Health. 2020;4(8):e352-e370. https://doi.org/10.1016/S2542-5196(20)30162-5
25. Parikh P, Semba R, Manary M, Swaminathan S, Udomkesmalee E, Bos R, et al. Animal source foods, rich in essential amino acids, are important for linear growth and development of young children in low- and middle-income countries. Matern Child Nutr. 2022;18(1):e13264. https://doi.org/10.1111/mcn.13264
26. Alonso S, Dominguez-Salas P, Grace D. The role of livestock products for nutrition in the first 1,000 days of life. Anim Front. 2019;9(4):24-31. https://doi.org/10.1093/af/vfz033
27. Sentika R, Setiawan T, Kusnadi, Rattu DJ, Yunita I, Basrowi RW, et al. Expert Consensus on Interprofessional Collaboration (IPC) Guidelines on Stunting Management in Indonesian Primary Healthcare (Puskesmas). 2024;17:e18749445352608. https://doi.org/10.2174/0118749445352608241119164446
28. Wahyuni FC, Karomah U, Basrowi RW, Sitorus NL, Lestari LA. The relationship between nutrition literacy and nutrition knowledge with the incidence of stunting: a scoping review. Amerta Nutr. 2024;7(3SP):71–85. https://doi.org/10.20473/amnt.v7i3SP.2023.71-85
29. Tanjung C, Fikri B, Prawitasari T, Massi N, Zainuddin AA, Juliaty A, et al. Comparative analysis of nutritional advice and a combined approach for addressing impending stunting in infants: a clinical trial. Nutrients. 2024;16(17):2832. https://doi.org/10.3390/nu16172832

30. Bahar M, Galistiani G, Eliyanti U. EE469 Cost-utility analysis of nutrient-dense supplementation in undernourished children in Indonesia. Value Health. 2024;27:S147–S148.