Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 9, 41-47
2025
Publisher: Learning Gate
DOI: 10.55214/2576-8484.v9i9.9768

Healthy snacks and their use in reducing anemia in Peruvian school-age children

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Abstract: The objective of this research is to analyze the use of healthy snacks fortified with iron and to evaluate their effectiveness as a strategy to reduce anemia. Anemia is a significant public health issue that affects a large number of children in Peru, particularly those of school age. It is characterized by a deficiency in the production of red blood cells, which can have serious consequences for both physical and cognitive development. The methodology focused on implementing programs for the development of fortified snacks, offering an alternative dietary option for school-age children. These programs applied fundamental concepts of food technology and included training initiatives for caregivers and food producers. The results obtained relate to the iron content (mg/100g), production weight (g), main ingredients, and type of snack. Evidence indicates that anemia among Peruvian children aged 1 to 59 months is primarily due to nutritional deficiencies, particularly protein deficiency, as well as family cultural practices and various demographic, sociocultural, and socioeconomic factors. The study concludes that the program's results facilitate active participation from parents, despite some differences in engagement levels. Notably, a significant level of participation in the feeding program was observed, demonstrating that parents are genuinely interested in the well-being of their children and are willing to support nutritional interventions.

Keywords: *Anemia, Food fortification, Healthy snacks.*

1. Introduction

The World Health Organization [WHO] [1] state that iron-deficiency anemia is a global health issue affecting millions of school-age children. Worldwide, it is estimated that 40% of children between 6 and 59 months, 37% of pregnant women, and 30% of women between 15 and 49 years of age suffer from anemia. Quesada [2] mentions that *The Lancet Global Health*, in collaboration with Harvard Medical School and the University of California, Santa Barbara, reports that 65% of the world population does not consume enough iron, which contributes to the prevalence of iron-deficiency anemia; Mithra, et al. [3] indicate that the experience in implementing iron and folic acid supplementation programs shows a significant reduction in anemia cases among adolescent girls. Alkassab-Córdova, et al. [4] report that, in 2017, the prevalence of anemia in Peruvian children between 1

History: Received: 16 June 2025; Revised: 7 August 2025; Accepted: 11 August 2025; Published: 1 September 2025
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and 5 years of age was moderate, influenced not only by nutritional factors but also by sociodemographic factors.

Anemia is a public health problem affecting a large number of children in Peru, especially those in the school-age population; a condition characterized by a deficiency in the production of red blood cells or hemoglobin levels in the blood, which can have serious consequences for the physical and cognitive development of children. It is therefore of vital importance to address effective strategies to combat anemia in the Peruvian school population. One such strategy is the promotion and use of healthy snacks, which are nutritious foods rich in iron and other essential nutrients for the prevention and reduction of anemia. Roche, et al. [5] indicate that there is a study highlighting the use of fortified snacks in school settings, where education and awareness about the importance of these nutrients have been observed to increase acceptance and consumption of these products. Reyes Narvaez, et al. [6] state that before the intervention, 145 children had been diagnosed with anemia, while after the intervention, only 46 children remained with the condition; likewise, the number of malnourished children dropped from 40 to 31 by the end of the intervention, having a positive impact on the reduction of anemia and malnutrition. Parabávidez [7] mentions that the main causes include: iron deficiency (the primary cause of anemia in Peruvian children, since iron, as a central component of hemoglobin, plays a crucial role in oxygen transport; its deficiency limits hemoglobin production, affecting the blood's ability to carry oxygen); deficiency of other micronutrients (folate and vitamin B12, which are cofactors in hemoglobin synthesis and essential for the production of healthy red blood cells; their deficiency can lead to the formation of immature and dysfunctional red blood cells, contributing to the development of anemia); as well as infectious and parasitic diseases, genetic disorders, among others, which may compromise red blood cell function and their ability to transport oxygen; and intestinal absorption issues (conditions affecting nutrient absorption in the intestine, such as celiac disease or Crohn's disease, can interfere with the absorption of iron and other micronutrients essential for erythropoiesis). Aggarwal, et al. [8] indicate that this begins with the lack of awareness among parents, compounded by poor nutritional practices, unhealthy eating habits, low dietary iron bioavailability, and infections. Acurio, et al. [9] state that it is necessary to seek nutritious food options that are also attractive to the market, especially for children and adolescents, who are the most challenging to engage. This research aims to explore and analyze the use of healthy snacks fortified with iron as a strategy to reduce anemia in Peruvian school-age children, addressing the importance of iron in the children's diet, its bioavailability in foods, and the nutritional composition of healthy snacks.

2. Materials and Methods

Methodology. This research is quantitative and experimental in nature. According to the Organization for Economic Co-operation and Development (OECD), it falls within the area of Food Science and Technology, specifically aimed at school-age children. The study focused on implementing programs for the development of snacks, which are intended as a dietary alternative for this age group. These programs applied fundamental concepts of food technology and training programs. The study adopted a quantitative approach and was both descriptive and experimental, involving training programs for both parents and school-age children. The research began in 2023 and concluded at the end of 2024.

Procedure. During this period, the research process included a literature review, experimental development, case analysis, data collection and analysis, discussion, and the formulation of conclusions and recommendations. Programs were designed to test children's diets, including anti-anemic evaluations, as well as physicochemical and microbiological analyses of the snacks, enabling the research objectives to be achieved. The main causes of anemia include iron and micronutrient deficiencies, infectious and parasitic diseases, genetic disorders, and intestinal absorption problems. Anti-anemia treatment should be administered once a year when the prevalence of soil-transmitted helminthiasis in a community exceeds 20%, and twice a year when it exceeds 50%. Early interventions targeting adolescent girls are essential to prevent iron-deficiency anemia, especially in areas with early marriages

Edelweiss Applied Science and Technology
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Vol. 9, No. 9: 41-47, 2025
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and high adolescent birth rates. To reliably obtain hemoglobin measurements, anemia diagnoses, and their classification by severity, the standards proposed by the World Health Organization were adopted. Anemia was categorized as severe, moderate, or mild for pregnant women and children aged 6 to 59 months. Daily iron intake requirements for three age groups are shown in Table 1.

Table 1.
Daily iron requirements for school-age children.

Age	Recommended Iron Intake (mg/day)
4-6 years	10 mg
7-10 years	12 mg
11-14 years	15 mg (women), 12 mg (men)

In academic settings, a decline in academic performance can be observed, along with a reduction in children's physical work capacity and cognitive function—factors that negatively affect their learning from the early school years. These issues have a direct impact on children's cognition, as changes in iron levels negatively affect neurological functioning Aggarwal, et al. [8]. Bedriñana and Peinado [10] point out that, in Peru, anemia is a critical issue rooted in socioeconomic and productive factors. This disease is associated with maternal and infant mortality, and it negatively affects children's emotional, cognitive, and motor development.

Table 2 presents regional data on the prevalence of anemia, the mother's educational level, and place of origin, which are significant indicators of health inequality in Peru [11].

Table 2.
Regional prevalence data of anemia in children grouped by region.

Region	Prevalence (%)
Coast	25.5
Highlands	38.7
Jungle	42.3
Metropolitan Lima	18.4

Note: Adapted from Al-kassab-Córdova, et al. [11].

Marangoni, et al. [12] highlight the importance of recognizing that the type of iron in food affects its absorption. Heme iron, found in meat, fish, and seafood, has high bioavailability (15–35%), whereas non-heme iron, present in cereals, legumes, and vegetables, has lower absorption rates (2–20%) and is influenced by factors such as vitamin C intake or inhibitors like phytates. Although the standard meal frequency is three times a day, some studies recommend eating four to five times daily to meet recommended daily energy intake. These additional meals include snacks, which may help increase nutrient intake (such as fiber and vitamins), though they can also contribute to digestive and metabolic overload. Shah, et al. [13] point out that these types of snacks are the most readily available in local shops, where children often choose products based on appealing packaging. However, these snacks often bear nutritional warning labels such as "High in Sodium" and "High in Saturated Fat," signaling that excessive consumption may be harmful to health. The role of healthy snacks in reducing anemia lies in their nutritional stability and richness. These products are considered ideal allies in the fight against malnutrition-related diseases. Therefore, snacks should be considered as a potential source of both micronutrients and macronutrients. Table 3 presents a summary of the main characteristics of several healthy snacks.

3. Results

Based on information related to iron content (mg/100), production weight (g), main ingredient, and type of snack, key benefits were identified in foods presented as quinoa bars, amaranth cookies, and broad bean chips. These benefits are shown in Table 3.

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Table 3.
Nutritional content and benefits of different types of healthy snacks.

Snack	Main ingredient	Iron content (mg/100)	Portion weight (g)	Key benefits
Quinoa bars	Fortified Quinoa	5.2	30	High in protein and fiber
Kiwicha cookies	Kiwicha and Amaranth	4.8	25	Rich in iron and calcium
Broad Bean Chips	Dried Broad Beans	6.1	35	Low in fat, high in protein

Chaudhary, et al. [14] state that promoting healthy eating habits in school settings has a significant impact on younger students. When children are exposed to interventions related to healthy eating both at school and at home, they are more likely to apply their nutritional knowledge in practical ways. These children tend to consume more fruits and vegetables, express a desire to prepare their meals more independently, adopt healthier eating patterns, and recognize school as the ideal environment to begin embracing healthier diets.

Through various interventions and campaigns promoting healthy nutrition, students learn how to eat properly, which helps them stay healthy internally and prevent diseases such as iron-deficiency anemia, diabetes, and obesity.

Okpiaifo, et al. [15] point out that, for a long time, the snack market has been dominated by unhealthy options, which are linked to adverse health outcomes. This creates the need to promote alternatives such as healthy snacks.

One such product is iron-enriched bread, which includes powdered bovine blood as a source of heme iron. Mansilla, et al. [16] note that, for programs to be implemented effectively in Peru and other countries, it is essential to consider strategies that include educational components and community-based monitoring, as these would greatly contribute to combating anemia in children from rural communities.

Iglesias Vázquez, et al. [17] mention that some of these interventions included mandatory sessions on nutritional and health education, aimed specifically at mothers or caregivers. Table 4 presents the various programs and interventions—implemented by either the government or private entities—that have significantly contributed to reducing anemia.

These programs often include snacks, whether as part of in-school meals or as take-home food items, which children can share with their families, thereby fostering nutrition and health education at home.

Table 4.
Intervention programs in Peru and other countries, including objectives, scope, and results.

Program	Country	Objective	Results
Chispitas	Peru	Reduce anemia in children through multi-micronutrient supplements	Moderate reduction in anemia in rural areas
ECDI	Peru	Improve child nutrition and anemia levels	Increased consumption of iron-rich foods
School Nutrition in Chile	Chile	Promote healthy eating in schoolchildren	Improved acceptance of fortified foods

Berky, et al. [18] emphasize that the outcomes and benefits of intervention programs are currently evolving, as new policies are being formulated to ensure these programs focus on health promotion and improving children's educational outcomes.

In Peru, public policies and strategic alliances on anemia—which causes irreversible cognitive and developmental deficits in children—led the government to declare anemia a primary public health issue in 2018 through the approval of a legislative initiative, thereby elevating it to an intersectoral priority.

Table 5 outlines the importance of both public and private entities, which act as strategic partners in this plan, as they help raise awareness and visibility of the issue.

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Table 5.
Related public policies, involved stakeholders, and their specific actions.

Policy/Strategy	Main Authority	Actions
Multi-Sectoral Plan to Combat Anemia	Peruvian Government	Distribution of fortified foods, educational campaigns
Nutritional Education in Schools	Ministry of Education	Teacher training and school feeding programs

Cotton, et al. [19] report that a training study was conducted involving teachers and school staff to assess the level of basic nutritional knowledge among primary school teachers. Unfortunately, the results were not as expected, as the teachers evaluated scored poorly on nutritional knowledge.

The effects of such instruction vary depending on factors such as the role of primary school teachers and nutrition education programs, which tend to have small to moderate effects on children's energy intake, followed by minor effects on fruit and vegetable consumption.

The smallest effect identified was the reduction in children's sugar intake as a result of teacher-led nutrition education programs. Nanayakkara, et al. [20] emphasize that teachers' confidence in their ability to teach food and nutrition is a crucial factor for effectively delivering such lessons in schools. Mahmood, et al. [21] state that the role of parents is fundamental in shaping their children's eating habits, particularly regarding snack consumption. As children grow older, they seek greater independence; however, during early childhood, parents have significant influence, as children tend to imitate what they observe at home.

4. Discussion

It was found that anemia in Peruvian children aged 1 to 59 months ranged from moderate to high, mainly due to nutritional and protein deficiencies, family cultural habits, and various demographic, sociocultural, and socioeconomic factors.

These findings align largely with those reported by Al-kassab-Córdova, et al. [4]. The main causes of anemia in Peru include iron deficiency in the diet, which affects oxygen transport to psychomotor components, this deficiency limits hemoglobin production. Additionally, the lack of cofactors such as folate and vitamin B_{12} leads to the formation of defective red blood cells, contributing to the development of anemia—confirming what was indicated by Parabávidez [7]. The effectiveness of healthy snacks in reducing anemia is attributed to the nutritional stability of these products and their ideal characteristics for addressing malnutrition-related diseases. Therefore, it is necessary to consider snacks as a potential source of beneficial factors to combat malnutrition, which agrees with the findings of Shah, et al. [13].

The results from the parent and school community participation program regarding school nutrition show that, despite differences, parents actively participated—each within their diverse contexts. There was significant engagement in the school feeding program, demonstrating genuine parental interest in their children's well-being. Active parental involvement contributes to the creation of a positive and healthy environment, benefiting both students and the school community by promoting healthy habits, improving communication, and fostering a culture of participation. To ensure consistent parental involvement, it is essential to implement policies that consider the realities of each family, including work schedules, transportation, and access to educational materials.

It is also important to recognize that parental participation depends on each family's individual circumstances. Anemia in Peruvian school-age children is a problem that demands comprehensive solutions, supported by both public and private entities, including innovations in the design of functional foods. In this context, healthy snacks represent a viable alternative to increase the intake of iron and other essential nutrients in this vulnerable population.

Technological processes such as extrusion and fortification allow for the production of snacks that are stable, safe, and high in nutritional value, facilitating their distribution in school programs and improving market acceptance. Nutrition education, the inclusion of fortified foods, and multisectoral collaboration are key to reducing the prevalence of anemia.

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Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

References

[1] Organización Mundial de la Salud, "Anemia," 2023. https://www.who.int/es/news-room/fact-sheets/detail/anaemia

[2] A. Quesada, "Micronutrient deficiencies are a global problem: 60% of the population doesn't get enough. EL PAÍS, September 13, 2024," 2024. https://elpais.com/proyecto-tendencias/2024-09-13/la-falta-de-consumo-de-micronutrientes-es-un-problema-global-el-60-de-la-poblacion-no-ingiere-los-suficientes.html

[3] P. Mithra *et al.*, "Interventions for addressing Anemia among children and adolescents: An overview of systematic reviews," *Frontiers in Pediatrics*, vol. 8, 2021. https://doi.org/10.3389/fped.2020.549549

[4] A. Al-kassab-Córdova, C. Méndez-Guerra, and P. Robles-Valcarcel, "Sociodemographic and nutritional factors associated with anemia in children aged 1 to 5 years in Peru," *Revista chilena de nutrición*, vol. 47, no. 6, pp. 925-932, 2020. http://dx.doi.org/10.4067/S0717-75182020000600925

[5] M. L. Roche *et al.*, "Adolescent girls' nutrition and prevention of anaemia: A school based multisectoral collaboration in Indonesia," *BMJ*, vol. 363, p. k4541, 2018. https://doi.org/10.1136/bmj.k4541

[6] S. E. Reyes Narvaez, A. M. Contreras Contreras, and M. S. Oyola Canto, "Anemia and childhood malnutrition in rural areas: Impact of a comprehensive community-level intervention," *Revista de Investigaciones Altoandinas*, vol. 21, pp. 205-214, 2019. http://dx.doi.org/10.18271/ria.2019.478

[7] S. Parabávidez, "Anemia: Symptoms, types, causes, and treatment. Metropolitan Polyclinic," 2022. https://policlinicametropolitana.org/

[8] A. Aggarwal, A. Aggarwal, S. Goyal, and S. Aggarwal, "Iron-deficiency anemia among adolescents: A global public health concern," *Int. J. Adv. Community Med*, vol. 3, no. 2, pp. 35-40, 2020. https://doi.org/10.33545/comed.2020.v3.i2a.148

[9] L. Acurio, D. Salazar, B. Castillo, C. Santiana, J. Martínez-Monzó, and M. Igual, "Characterization of second-generation snacks manufactured from Andean tubers and tuberous root flours," *Foods*, vol. 13, no. 1, p. 51, 2024. https://doi.org/10.3390/foods13010051

[10] J. I. C. Bedriñana and D. M. C. Peinado, "Prevalence of childhood anemia and its association with socioeconomic and productive factors in a high Andean community in Peru," *Revista española de nutrición comunitaria= Spanish Journal of Community Nutrition*, vol. 25, no. 3, p. 1, 2019.

[11] A. Al-kassab-Córdova *et al.*, "Inequalities in anemia among Peruvian children aged 6–59 months: A decomposition analysis," *Frontiers in Public Health*, vol. 11, 2023. https://doi.org/10.3389/fpubh.2023.1068083

[12] F. Marangoni *et al.*, "Snacking in nutrition and health," *International Journal of Food Sciences and Nutrition*, vol. 70, no. 8, pp. 909-923, 2019. https://doi.org/10.1080/09637486.2019.1595543

[13] F.-u.-H. Shah, M. K. Sharif, S. Bashir, and F. Ahsan, "Role of healthy extruded snacks to mitigate malnutrition," *Food Reviews International*, vol. 35, no. 4, pp. 299-323, 2019. https://doi.org/10.1080/87559129.2018.1542534

[14] A. Chaudhary, F. Sudzina, and B. E. Mikkelsen, "Promoting healthy eating among young people—a review of the evidence of the impact of school-based interventions," *Nutrients*, vol. 12, no. 9, p. 2894, 2020. https://doi.org/10.3390/nu12092894

[15] G. E. Okpiaifo, B. Dormoy-Smith, B. Kassas, and Z. Gao, "Perception and demand for healthy snacks/beverages among US consumers vary by product, health benefit, and color," *PLOS One*, vol. 18, no. 6, p. e0287232, 2023. https://doi.org/10.1371/journal.pone.0287232

[16] J. Mansilla *et al.*, "Model for improving anemia and child care in rural Peru," *Revista Panamericana de Salud Pública*, vol. 41, p. e112, 2018. https://doi.org/10.26633/RPSP.2017.112

[17] L. Iglesias Vázquez, E. Valera, M. Villalobos, M. Tous, and V. Arija, "Prevalence of Anemia in children from Latin America and the Caribbean and effectiveness of nutritional interventions: Systematic review and meta–analysis," *Nutrients*, vol. 11, no. 1, p. 183, 2019. https://doi.org/10.3390/nu11010183

[18] A. J. Berky, E. Robie, E. J. Ortiz, J. N. Meyer, H. Hsu-Kim, and W. K. Pan, "Evaluation of Peruvian government interventions to reduce childhood Anemia," *Ann Glob Health*, vol. 86, no. 1, p. 98, 2020. https://doi.org/10.5334/aogh.2896

[19] W. Cotton, D. Dudley, L. Peralta, and T. Werkhoven, "The effect of teacher-delivered nutrition education programs on elementary-aged students: An updated systematic review and meta-analysis," *Preventive Medicine Reports*, vol. 20, p. 101178, 2020. https://doi.org/10.1016/j.pmedr.2020.101178

[20] J. Nanayakkara, C. Margerison, and A. Worsley, "Ways to improve secondary school teachers' confidence in teaching food and nutrition subjects," *Education Inquiry*, vol. 15, no. 3, pp. 407-422, 2024. https://doi.org/10.1080/20004508.2022.2116865

[21] L. Mahmood, P. Flores-Barrantes, L. A. Moreno, Y. Manios, and E. M. Gonzalez-Gil, "The influence of parental dietary behaviors and practices on children's eating habits," *Nutrients*, vol. 13, no. 4, p. 1138, 2021. https://doi.org/10.3390/nu13041138

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ISSN: 2576-8484
Vol. 9, No. 9: 41-47, 2025
DOI: 10.55214/2576-8484.v9i9.9768