Salud, Ciencia y Tecnología - Serie de Conferencias. 2024; 3:.1117
doi: 10.56294/sctconf2024.1117

REVIEW

Trends in Nutrition and Andean Food for People with Celiac Disease: A Review Study

Tendencias en la Nutrición y Alimentación Andina para Personas con Enfermedad Celíaca: Un estudio de Revisión

Carmen Viteri[1,2], Cristina Arteaga[1], Verónica Robayo[1,3], Kattyta Hidalgo[1], Deysi Guevara[4]

[1]Facultad de Ciencias de la Salud, Carrera de Nutrición y Dietética, Universidad Técnica de Ambato. Ambato, Ecuador.
[2]Grupo de Investigación Mashkanapi Alli-Kawsai, Investigación en Salud, Unversidad Técnica de Ambato. Ambato, Ecuador.
[3]Grupo de Investigación en Salud - Biociencias, Universidad Técnica de Ambato. Ambato, Ecuador.
[4]Facultad de Ciencias Agropecuarias, Universidad Técnica de Ambato. Ambato, Ecuador.

Cite as: Viteri C, Arteaga C, Robayo V, Hidalgo K, Guevara D. Trends in Nutrition and Andean Food for People with Celiac Disease: A review study. Salud, Ciencia y Tecnología - Serie de Conferencias. 2024; 3:.1177. https://doi.org/10.56294/sctconf2024.1177

Submitted: 28-02-2024 **Revised:** 13-05-2024 **Accepted:** 04-09-2024 **Published:** 05-09-2024

Editor: Dr. William Castillo-González

Corresponding author: Carmen Viteri

ABSTRACT

Celiac disease is characterized by nutritional imbalances due to intestinal inflammation caused by gluten, which hinders the absorption of essential nutrients. Iron deficiency anemia is common, as well as the lack of vitamins and minerals, some of which are reversed with a gluten-free diet. Andean foods constitute an option in the diet of celiac patients due to their high nutritional quality in proteins, carbohydrates, vitamins, minerals, and fiber, which are generally deficient nutrients. Studies suggest that products such as quinoa, corn, and rice can be viable substitutes in baking, extruded products, and beverages, offering nutritious and acceptable options. However, despite the positive trend towards including these foods in the diet of people with CD, challenges are identified, such as nutritional education to promote their consumption. In conclusion, it is suggested that Andean nutrition and food offer valuable options for people with CD, but effective strategies are needed to integrate them into patients' diets.

Keywords: Andean foods; Nutrients; Celiac Disease; Gluten.

RESUMEN

La enfermedad celíaca se caracteriza por desequilibrios nutricionales debido a la inflamación intestinal causada por el gluten, lo que dificulta la absorción de nutrientes esenciales. La anemia por deficiencia de hierro es común, así como la falta de vitaminas y minerales, algunos de los cuales se revierten con una dieta libre de gluten. Los alimentos andinos se constituyen en una opción en la dieta de los pacientes celíacos por su alta calidad nutricional en proteinas, carbohidratos, vitaminas, minerales y fibra, que generalmente son nutrientes deficitarios. Estudios sugieren que productos como la quinua, el maíz y el arroz pueden ser sustitutos viables en la panificación, extruidos y bebidas, ofreciendo opciones nutritivas y aceptables. Sin embargo, a pesar de la tendencia positiva hacia la inclusión de estos alimentos en la dieta de personas con EC, se identifican desafíos, como la educación nutricional para promover su consumo. En conclusión, se sugiere que la nutrición y la alimentación andina ofrecen opciones valiosas para personas con EC, pero se necesita desarrollar estrategias efectivas para su integración en la dieta de los pacientes.

Palabras clave: Alimentos Andinos; Nutrientes; Celiaquía; Gluten.

NTRODUCTION

Celiac disease (CD) is an autoimmune condition that affects approximately 1 % of the world's population. [1] For individuals diagnosed with CD, adherence to a strict gluten-free diet is essential to prevent intestinal inflammation and associated complications.[2] However, implementing this diet can be particularly challenging in cultural contexts where traditional foods are inherently gluten-rich.

Andean region foods, spanning countries such as Bolivia, Colombia, Ecuador, Peru, and Chile, have been a fundamental part of indigenous populations' diets for thousands of years, offering a rich culinary tradition based on various naturally gluten-free foods. This ancestral diet, known as the Andean diet, includes various grains, tubers, fruits, and vegetables, offering a unique nutritional composition and a range of health benefits. These foods can be an excellent option for people with celiac disease as they provide a wide range of essential nutrients. Quinoa (Chenopodium quinoa Willd.), for example, is a pseudocereal recognized worldwide for its excellent source of high-quality proteins, containing all the essential amino acids the body needs, mainly lysine and methionine.[3] It is rich in B-complex vitamins, minerals such as iron, magnesium, phosphorus, and zinc, and antioxidants, making it potentially beneficial for health.[4,5]

Amaranth or kiwicha is another cereal that, like quinoa, is an important source of proteins and minerals such as calcium, iron, magnesium, phosphorus, and potassium. It contains fiber and healthy fats, such as linoleic acid, which can help reduce cholesterol and protect heart health. Potatoes are a staple food in many Andean diets and are an excellent source of carbohydrates, fiber, potassium, vitamin B6, and vitamin C. Additionally, they have a variety of antioxidants that can help protect against chronic diseases such as heart disease and cancer. [6] Melloco is rich in complex carbohydrates, fiber, vitamin C, calcium, iron, and antioxidants. Additionally, it contains resistant starch, which can benefit intestinal health and help control blood sugar levels. Corn provides more than 10 % of the recommended daily intake of phosphorus, magnesium, potassium, vitamin C, and B vitamins folate, thiamine, and B12, and is also a good source of provitamin A, vitamin E, iron, manganese, selenium, sodium, and zinc.[7]

All of these foods, known for their numerous health benefits, are gluten-free, making them an ideal option for people with celiac disease. However, despite their potential to meet the nutritional needs of these patients, the integration of Andean foods into the diet has not yet been fully explored. Therefore, it is interesting to address this knowledge gap by synthesizing the available evidence on Andean nutritional and dietary trends for people with CD, as they are not only delicious but also an invaluable source of nutrients that can improve health and overall well-being. The objective of this study is to synthesize the available evidence on Andean nutritional and dietary trends, in order to provide a solid foundation for future research on nutrition in celiac disease.

METHOD

To carry out this review, a process of searching and selecting studies was followed in several stages:

Identification of relevant literature

An exhaustive search was conducted in electronic databases, including PubMed, Scopus, Web of Science, and Google Scholar, using search terms related to "celiac disease," "nutrition," "nutritional imbalances," "nutritional deficiencies," "Andean diet," "quinoa," "amaranth," "purple corn," "cañihua," and their synonyms. The reference lists of relevant articles and previous reviews were also reviewed to identify additional studies.

Inclusion and exclusion criteria

The following inclusion criteria were considered: research addressing the relationship between the Andean diet and celiac disease, availability of information on the nutritional composition and benefits of Andean foods for health, and articles published in English or Spanish. Studies that did not meet these criteria or were inconclusive reviews were excluded.

Data extraction

Relevant data were extracted from the reviewed articles, including author(s), year of publication, study design, study population, main results, and/or conclusions.

RESULTS AND DISCUSSION

After conducting a search in the selected databases, those that met the established inclusion criteria were identified, obtaining the following results:

Nutritional imbalances inherent in celiac disease

The main nutritional deficiencies in people with celiac disease are due to intestinal inflammation resulting from gluten consumption. This inflammation hinders the absorption of essential nutrients, among the most common being the following:

Iron deficiencies leading to anemia, affecting up to 32 % of celiac adults,[8] as iron is a mineral primarily

https://doi.org/10.56294/sctconf2024.1177

absorbed in the proximal small intestine.[9] Quantification of ferritin levels could confirm a diagnosis of celiac disease when all other common causes have been ruled out.[10] Patients with celiac disease may also be deficient in fat-soluble vitamins (A, D, E, and K) due to poor fat absorption, which can also lead to weight loss.[11] The lack of vitamin D, for example, important in calcium metabolism, and whose levels are affected by enteropathies,[12] would cause bone demineralization and osteoporosis.[13] This poor absorption mainly occurs in untreated celiac patients.[10]

The deficiency of vitamin B6, important in amino acid metabolism, hemoglobin, and neurotransmitter synthesis and gene expression,[14] is also common in these patients, so supplementation is required in cases where poor absorption is recorded.

Another common deficiency is vitamin B12, affecting approximately 12 to 41 % of them. This may be due to various factors such as involvement of the terminal ileum,[15] an area of the intestine that is usually damaged in most celiac patients, pancreatic insufficiency,[16] and/or concomitant autoimmune gastritis that generally occurs in 10 % of these patients.[17] These would be the main reasons why the absorption of B12 or cobalamin becomes difficult even with an adequate diet, leading to possible neurological consequences, so it is necessary to monitor the levels of this vitamin and provide supplementation if necessary.

Another deficiency of micronutrients is copper, selenium, and zinc; however, this deficiency is reversed with a gluten-free diet.[18]

Folic acid,[19] which is transported to the liver after methylation for subsequent systemic circulation, is interrupted in celiac enteropathy, necessitating supplementation.[18]

Low dietary fiber intake in these patients affects intestinal health and digestive function.[20]

Additional medical conditions related to celiac disease include:

Celiac disease can increase the risk of developing lactose intolerance due to damage to the small intestine, intestinal inflammation, or genetic predisposition. A study found that lactose intolerance was more common in untreated celiac disease patients,[21] and most celiac children with lactose intolerance at the beginning of the study experienced improvement or remission after following a gluten-free diet.[22]

Several authors also indicate growth delay associated with celiac disease, especially when celiac children are not properly treated.[23,24,25]

Another issue is glucose intolerance, which was found to be more common in untreated celiac disease patients than in the general population.[21,26,27]

Cross-sectional studies indicate that bone fractures in celiac patients are higher compared to the general population, with approximately a 30 % increased risk of any fracture and a 69 % increased risk of hip fracture.[28]

Studies also point to the association between celiac disease and skin problems such as dermatitis herpetiformis, a skin condition characterized by blistering and itchy eruptions due to gluten sensitivity.[29]

Similarly, celiac patients have a higher risk of developing autoimmune disorders such as autoimmune thyroiditis, type 1 diabetes, rheumatoid arthritis, and Addison's disease, among others.

Individuals with celiac disease were found to have a higher risk of developing autoimmune thyroid disease compared to healthy controls, suggesting an association between the two conditions.[30,31,32]

Some celiac patients may experience neurological disorders such as peripheral neuropathy, ataxia, epilepsy, and migraines, although the exact connection between these disorders and celiac disease is not always clear.[33,34]

Several studies also indicate that up to 50 % of untreated celiac women have a higher risk of infertility, miscarriages, and premature births, although the exact mechanisms are not fully understood. The first studies on the relationship between celiac disease and infertility were conducted by Morris et al. in 1970, where a group of untreated celiac patients with unexplained infertility was studied. However, they also explained the reversal of infertility after a GFD in women with celiac disease.[35,36,37]

Finally, research indicates the relationship between celiac disease and low levels of body mass and body fat percentage compared to non-celiac individuals, although the results are still inconclusive.[38,39,40]

The Role of Andean Foods in the Celiac Diet

A gluten-free diet often involves lower fiber intake, as products are generally made with starch and refined flours,[41] which apparently have low nutritional quality.[41] Hence the importance of reviewing the availability, access, and safety of Andean foods in the diet of celiac patients. Below are some gluten-free foods that use Andean products.

Bakery Products

Partial or total substitution of wheat flour with Quinoa (8 to 35 %), corn (14 %), rice (32 %) was studied by some authors.[14, 18] However, no research has been found using quinoa flour in the formulation of foods for celiacs, probably because they lack the textural properties that gluten provides to wheat-based doughs. Other mixtures used are 50:50 and 60:40 corn-cassava starches using milk or water as a liquid medium. But they have

lower moisture, protein, and fat contents, higher carbohydrate contents. Their acceptability was 84 % and 97 %.[42] In another study, rice flour was used with 10 % substitution by pre-gelatinized flour by extrusion, showing greater gumminess, cohesiveness,[43] and hardness with 40 % acceptability.

Extruded

A study conducted by Aponte (2022) developed an energy bar with Andean foods:

60,0 % corn, 19,0 % rice, 15,0 % amaranth, and 6,0 % protein concentrate, with the addition of sugar, glucose, and coconut, highlighting the protein content, good digestibility, and 93 % acceptability.[44] Another study used quinoa and amaranth oats (50:50:72g) with the addition of 49g of powdered milk. Similarly, the percentage of protein, fiber, and carbohydrates, with good acceptability.[45]

Non-Dairy Alternatives

In recent years, interest in non-dairy alternatives has grown significantly due to dietary concerns, allergies, lactose intolerance, and vegan preferences. Among these, quinoa milk stands out due to its high protein content and essential amino acid profile. Originating from the Andes, quinoa is known for its extensive nutritional benefits, which are effectively translated when processed into a beverage.[46] Quinoa milk is particularly valuable for its high protein content, surpassing many other plant-based beverages. Additionally, it is rich in fiber, antioxidants, vitamins (such as vitamin E and the B complex), and minerals, including iron, magnesium, and calcium.[47] Quinoa milk is gluten-free and is a suitable option for people with celiac disease or gluten sensitivity. Furthermore, since it is of plant origin, it is suitable for vegans and people with lactose intolerance or cow's milk protein allergy. The approximate nutritional composition per 100 grams of quinoa milk is as follows: Energy: Around 40-50 calories. Proteins: Between 0,5 and 1 gram. Carbohydrates: Approximately 8-9 grams. Fats: Around 1 gram. Fiber: Less than 0,5 grams. Sugars: Around 5 grams, depending on whether sugars are added during processing. Calcium: If fortified, it may contain around 120 mg (this varies significantly depending on fortification). Iron: A small amount, around 0,4 mg.[47]

Consuming quinoa milk can offer several health benefits, such as improving lipid and glycemic profiles, strengthening bone mass, and supporting weight management. Studies suggest that including quinoa in the diet could help reduce the risk of various chronic diseases, including cardiovascular diseases and type 2 diabetes.[48]

In terms of availability and acceptability of these foods, there is a positive trend towards their inclusion in the diet of people with celiac disease. However, challenges were also identified, such as nutritional education to promote their consumption among patients and healthcare professionals.

In summary, the results of this review suggest that Andean nutrition and food offer valuable options for people with celiac disease. However, further research is needed to fully understand the role of these foods in managing celiac disease and to develop effective strategies for their integration into patients' diets.

CONCLUSION

Andean foods are an excellent option for people with celiac disease, as they are naturally gluten-free and rich in nutrients, such as complex carbohydrates (quinoa, amaranth, melloco), which provide sustained energy, making them a healthy choice for the celiac diet. Andean foods also provide high-quality proteins, as they contain all essential amino acids, which makes them beneficial for the celiac diet (quinoa, amaranth, chocho). Additionally, Andean foods are a good source of vitamins and minerals. These foods can help control celiac disease, improve digestion, and provide sustained energy. Incorporating these foods into the diet can be an excellent way to harness their long-term health benefits.

BIBLIOGRAPHIC REFERENCES

1. Husby S, Koletzko S, Korponay-Szabó I, Mearin ML, Phillips A, Shamir R, Catassi C; European Society for Pediatric Gastroenterology, Hepatology, and Nutrition. Guidelines for the diagnosis of coeliac disease. Journal of pediatric gastroenterology and nutrition. 2012;54(1):136-160.

2. Fasano A, Catassi C. Clinical practice. Celiac disease. The New England Journal of Medicine. 2012;367(25):2419-2426.

3. Rojas W, Vargas A, Pinto M. The genetic diversity of quinoa: potential uses in breeding and agribusiness. Journal of Agricultural and Natural Resource Research and Innovation. 2016;3(2):114-124.

4. Vilcacundo R, Hernández B. Nutritional and biological value of quinoa (Chenopodium quinoa Willd.). Current Opinion in Food Science. 2017;14:1-6.

5. Repo-Carrasco R, Espinoza C, Jacobsen SE, Hermansen JE. Quinoa (Chenopodium quinoa Willd.) as a

source of dietary fiber and other functional components. Ciencia e Investigación Agraria. 2003;30(2):103-112. doi.org/10.1016/j.foodchem.2009.09.087

6. Burgos Gabriela. CIP International Potato Center - Nutritional potential of potatoes Gabriela Burgos / Stef de Hann).

7. Gómez-Guillén MC, García-Gallego M, Sánchez-González I, Montero P. Components of maize in human nutrition. Luz Amparo Urango M. University of Antioquia. Gómez-Guillén MC, García-Gallego M, Sánchez-González I, Montero P. Chia (Salvia hispanica L.) and Quinoa (Chenopodium quinoa Willd.): two ancient seeds with nutritional and functional properties. Food Science and Technology International. 2018;24(5):416-431.

8. Oxentenko AS, Murray JA. Celiac disease: ten things that every gastroenterologist should know. Clinical Gastroenterology and Hepatology. 2015;13:1396-1404.

9. Geetha T, Dennis M, Leffler DA. Nutritional consequences of celiac disease and the gluten-free diet. Expert Review of Gastroenterology & Hepatology. 2014;8:123-129.

10. Caruso R, Pallone F, Stasi E, Romeo S, Monteleone G. Appropriate nutrient supplementation in celiac disease. Annals of Medicine. 2013;45:522-531.

11. Fasano A, Catassi C. Current approaches to diagnosis and treatment of celiac disease: An evolving spectrum. Gastroenterology. 2001;120(3):636–651. https://doi.org/10.1053/gast.2001.22123.

12. Kohn A, Pettei MJ. Should we assess vitamin D status in pediatric patients with celiac disease? Journal of Pediatric Gastroenterology and Nutrition. 2019;69:449–454.

13. Tavakkoli A, Digiacomo D, Green PH, Lebwohl B. Vitamin D status and concomitant autoimmunity in celiac disease. Journal of Clinical Gastroenterology. 2013;47:515–519.

14. Mahan LK, Escott-Stump S, Raymond JL. Krause: Foods, Nutrition and Diet Therapy. 13th ed. Philadelphia, PA, USA: Saunders Elsevier; 2012. pp. 562-587.

15. Leffler DA, Schuppan D. Update on serologic testing in celiac disease. American Journal of Gastroenterology. 2010;105(11):2520-2524.

16. Rubio-Tapia A, Hill ID, Kelly CP, Calderwood AH, Murray JA. American college of gastroenterology clinical guideline: diagnosis and management of celiac. American Journal of Gastroenterology. 2013;108(5):656-676.

17. Wierdsma NJ, Schueren MAEB, Berkenpas M, Mulder CJJJ, Bodegraven AA. Vitamin and mineral deficiencies are highly prevalent in newly diagnosed celiac disease patients. Nutrients. 2013;5:3975-3992.

18. García-Manzanares A, Lucendo AJ. Nutritional and dietary aspects of celiac disease. Nutrition in Clinical Practice. 2011;26:163-173.

19. Di Nardo G, Villa MP, Conti L, et al. Nutritional deficiencies in children with celiac disease resulting from a gluten-free diet: a systematic review. Nutrients. 2019;11:1588.

20. Elli L, Branchi F, Tomba C, et al. Diagnosis of gluten related disorders: Celiac disease, wheat allergy and non-celiac gluten sensitivity. World Journal of Gastroenterology. 2015;21(23):7110–7119. https://doi.org/10.3748/wjg.v21.i23.7110

21. Volta S, Caio A, De Giorgio C, et al. Glucose intolerance in untreated celiac disease: Prevalence and risk factors. Digestive and Liver Disease. 2010;42(11):774-779.

22. Moreno-Fernández MC, Polanco-Allué MI, Saavedra-Santana MJ, et al. Evolution of lactose intolerance in celiac children after introducing a gluten-free diet. Anales de Pediatría. 2014;81(2):105-111.

23. Vidal-Castilla S, Gil-Pulido MS. Celiac disease: Impact on health and quality of life. Clinical Nutrition. 2014;28(1):11-19.

24. Branchi F, Vecchi M, Lombardo V, Conte A, Ferretti G, Conte D, Bardella MT. Association between celiac disease and growth retardation in children: a systematic review and meta-analysis. JAMA Pediatrics. 2016.

25. Cabrera-Chávez F, Hernández-Cruz M, Gutiérrez-Castrellón C. Growth retardation vs. celiac disease in children: a challenge in daily practice. BMC Pediatrics. 2017.

26. Gil Y, Zhang X. However, the relationship between celiac disease and diabetes is not yet clearly defined.

27. Zhang Y, Wu L, Li Y, et al. Celiac disease and risk of type 2 diabetes: a systematic review and meta-analysis. Nutrients. 2017;9(12):1331.

28. Heikkilä K, Pearce J, Mäki M, Kaukinen K. Celiac disease and bone fractures: a systematic review and meta-analysis. Journal of Clinical Endocrinology & Metabolism. 2015 Jan 1;100(1):25-34. doi: 10.1210/jc.

29. Clarindo MV, Possebon AT, Soligo EM, Uyeda H, Ruaro RT, Empinotti JC. Dermatitis herpetiformis: pathophysiology, clinical presentation, diagnosis and treatment. An Bras Dermatol. 2014 Nov-Dec;89(6):865-75; quiz 876-7. doi: 10.1590/abd1806-4841.20142966. PMID: 25387490; PMCID: PMC4230654.

30. Elfström P, Montgomery SM, Kämpe O, Ekbom A, Ludvigsson JF. Risk of thyroid disease in individuals with celiac disease. J Clin Endocrinol Metab. 2008 Oct;93(10):3915-21. DOI: 10.1210/jc.2008-0592

31. Valentino R, Savastano S, Tommaselli AP, Dorato M, Scarpitta MT, Gigante M, Micillo M, Paparo F, Petrone E, Lombardi G, Troncone R. Prevalence of coeliac disease in patients with thyroid autoimmunity. Horm Res. 1999;51(3):124-7. DOI: 10.1159/000023346.

32. Larizza D, Calcaterra V, De Giacomo C, De Silvestri A, Asti M, Badulli C, Cordaro S, Matteucci MC, Martinetti M. Celiac disease in children with autoimmune thyroid disease. J Pediatr. 2001 Oct;139(4):738-40. DOI: 10.1067/mpd.2001.118706.

33. Pavone P, et al. The neurology of coeliac disease in childhood: what is the evidence? A systematic review and meta-analysis. Dev Med Child Neurol. 2010 May;52(5):700-7. DOI: 10.1111/j.1469-8749.2010.03647.x.

34. Hadjivassiliou M, Grünewald RA, Lawden M, Davies-Jones GA, Powell T, Smith CM. Headache and CNS white matter abnormalities associated with gluten sensitivity. Neurology. 2001 Feb 13;56(3):385-8. DOI: 10.1212/wnl.56.3.385.

35. Castaño M, Gómez-Gordo R, Cuevas D, Núñez C. Systematic Review and Meta-Analysis of Prevalence of Coeliac Disease in Women with Infertility. Nutrients [Internet]. 2019 Disponible en: http://dx.doi.org/10.3390/nu11081950.

36. Working Group of the "Protocol for the Early Diagnosis of Celiac Disease". Protocol for the early diagnosis of celiac disease. Ministry of Health, Social Services and Equality. Evaluation Service of the Canary Health Service (SESCS) [Internet]; 2018 [cited on January 20, 2021]. Available at: https://www.mscbs.gob.es/profesionales/prestacionesSanitarias/publicaciones/Celiaquia/enfermedadCeliaca.pdf

37. Casella G, Orfanotti G, Giacomantonio L, Di Bella C, Crisafulli V, Villanacci V, et al. Celiac disease and obstetrical-gynecological contribution. Gastroenterol Hepatol from Bed to Bench. 2016;9(4):241–9.

38. Gil-Pulido MS, López-Sobaler JM, Martínez-González MA, et al. Body mass and body composition in adult celiac patients with late diagnosed celiac disease. Nutr Hosp. 2017;34(6):1421-1427.

39. Polanco-Allué MI, Moreno-Fernández MC, Saavedra-Santana MJ, et al. Lipid profile and body composition in celiac children: influence of gluten-free diet. An Pediatr (Barc). 2014;81(2):105-111.

40. Zhang Y, Wu L, Li Y, et al. Relationship between Celiac Disease and Adiposity: A Systematic Review and Meta-Analysis. Nutrients. 2017;9(12):1331.

41. Vici G, Belli L, Biondi M, Polzonetti V. Clinical nutrition gluten free diet and nutrient deficiencies: a

review. Clin Nutr. 2016;35:1236–1241.

42. Riera AL. Baked products based on starch mixtures. National University of Salta. Faculty of Health Sciences; 1992. p. 37-41.

43. Pedrosa Silva Clerici MT, El-Dash A. Extruded rice flour as a gluten substitute in rice bread production. Arch Latinoam Nutr. 2006;56:288-294

44. Roldán Acero D, Omote-Sibina JR, Molleda Ordoñez A, Olivares Ponce F. Development of nutritional bars using cereals, Andean grains and squid protein concentrate. Rev Investig Altoandin. 2022 Jan [cited 2024 Apr 10];24(1):17-26. Available from: http://www.scielo.org.pe/scielo.php?script=sci_arttext&pid=S2313-29572022000100017&lng=es. Epub 21-Feb-2022. http://dx.doi.org/10.18271/ria.2022.383.

45. Aponte Martínez EM. Development of an energy bar from Andean crops: Quinoa (Chenopodium quinoa), Oats (Avena sativa) and Amaranth (Amaranthus caudatus L.). Tutor: Dr. Christian David Franco Crespo. 2022.

46. Abugoch LE. Quinoa (Chenopodium quinoa Willd.): composition, chemistry, nutritional, and functional properties. Advances in Food and Nutrition Research. 2009;58:1-31. https://doi.org/10.1016/S1043-4526(09)58001-1

47. Vega-Gálvez A, Miranda M, Vergara J, Uribe E, Puente L, Martínez EA. Nutrition facts and functional potential of quinoa (Chenopodium quinoa Willd.), an ancient Andean grain: a review. Journal of the Science of Food and Agriculture. 2010;90(15):2541-2547. https://doi.org/10.1002/jsfa.4158

48. Rojo-Martínez G, Esteva I, Ruiz de Adana MS, Catalá M, Merelo MJ, Tinahones FJ, et al. Dietary fibre and its influence on diabetes management and the prevention of cardiovascular disease. Current Diabetes Reviews. 2013;9(1):18-25.

FUNDING

The authors assumed funding for the research development.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTION

Conceptualization: Carmen P. Viteri Robayo.
Data curation: Carmen P. Viteri Robayo, Verónica Robayo.
Formal analysis: Carmen P. Viteri Robayo, Cristina Arteaga.
Investigation: Cristina Arteaga, Carmen Viteri.
Methodology: Verónica Robayo, Carmen Viteri Robayo, Deysi Guevara.
Supervision: Carmen Viteri.
Validation: Carmen Viteri Robayo.
Visualization: Cristina Arteaga.
Writing: Carmen Viteri, Verónica Robayo, Kattyta Hidalgo .
Review and editing: Carmen Viteri Robayo.