IMPROVING OF AMARANTH (*AMARANTHUS* SPP.) AND QUINOA (*CHENOPODIUM QUINOA*) BY GENETIC RESOURCES

ABSTRACT:

The modern human population is more mindful of their diet and choose foods carefully in order to maintain a healthy lifestyle and prevent illness. Thus, instead of sticking to their long-standing diets of ordinary cereals and basic foods, individuals are starting to choose more intelligent and nutrient-dense dietary choices. Because they are gluten-free, have no added sugar, and are somewhat higher in nutrients than typical cereals, pseudocereals—particularly quinoa and amaranth—are significant substitutes. Both Amaranthaceae crops are hardy, low-input plants that can withstand salt, stress, and drought. Therefore, these crops might be advantageous to emerging nations with limited agricultural resources and subsistence agriculture. But these are neglected orphan crops, and for a very long time, there has been no attempt to enhance them by lowering their saponin content. These crops also have a great degree of variety, but their genetic development towards high-yielding genotypes is sluggish. This is because traditional cereals are facing problems, and crop diversification is the preferred solution to address climate change. The most recent technological advancements that can speed up breeding to increase agricultural output and quality are far behind and move more slowly than the world's primary crops that are already well-established.

Keywords: Amaranthaceae crops, gluten-free, long-standing, nutrient-dense, pseudocereals

1. INTRODUCTION

Nowadays, there is a growing interest among health-conscious individuals in exploring better diet options and finding ways to include micronutrients into their meals beyond the traditional sources found in main cereal crops. Globally, people appreciate grain amaranth (Amaranthus spp.) for its decorative appeal, nutritive grain, and leaf vegetable uses **(Figure 1)**. The "Amaranth" is a popular plant since it is long-lived and resilient; the Greek term for "everlasting" describes the plant well. Many people across the globe rely on it as a key source of nutrition, including those living in Mexico. It serves several purposes, including as a crop for human consumption (grain and leaves) and, in certain regions, as a source of pasture for cattle (Hart and Vorster, 2006). Natural dyes, lubricants, and pharmaceuticals are some of its other uses. For those who have to avoid gluten in their diet, amaranth flour is a great option since it doesn't contain any gluten. The anti-cancerous properties of amaranth leaves make them an appropriate choice for cancer patients. These leaves inhibit the aberrant proliferation of cancer cells in the liver, breast, and colon (Hongyan et al., 2015).

Figure 1. Amaranta field

Furthermore, several items derived from amaranth grains have gained popularity in the market (Mlakar et al., 2009). Amaranth, a dicotyledonous plant, serves as an illustrative case that employs the C4 pathway for the process of photosynthesis. Consequently, it has potential as a model plant for genetic control investigations pertaining to photosynthesis (Joshi et al., 2018). This particular organism is classified as a saprophytic halophyte and has a high tolerance to salt, making it well-suited for subsistence agriculture (Barba et al., 2009).

Quinoa (Chenopodium quinoa Willd.) is a very nutritious grain crop that has had its origins in the Andean region of South America, as shown by Adolf et al. (2012). The cultivation of this kind may be traced back to previous periods in several nations, including the Andean region, Bolivia, Peru, and Chile **(Figure 2)**. Approximately 7,000 years ago, the first documentation of the process of domestication originated from Lake Titicaca, thereafter spreading from South America to other regions throughout the globe (Pearsall, 2008). The practice of cultivating the quinoa plant in Chile may be traced back to around 5,000 BC. Currently, there are around 250 distinct Chenopodium species documented globally (Rojas et al., 2015). Subsequently, it has served as a significant primary grain for the Inca civilization, referred to as "chisiya mama" or "Mother Grain" in their indigenous Quechua language. The classification of plants is determined based on their colour, form, and fruit (Vega-Galvez et al., 2010). Quinoa is known by many names within the same community in the Andean region. In the Aymara language, it is renowned for its multiple names, such as kinua, quinhua, and jupha, which are based on the different colors of its grains. Quinoa thrives on nutrient-deficient soil found in rainfed environments, has exceptional versatility in adapting to many agro-climatic conditions, and possesses untapped commercial prospects in India (Bhargava et al., 2007).

Figure 2. Quinoa plants

2. NUTRITIONAL VALUES:

Quinoa is a pseudo-cereal with protein, fat, fiber, vitamins, and minerals (Navruz-Varli and Sanlier 2016 Quinoa grains include antioxidants and biological components (Pellegrini et al., 2018). However, genotype composition varies greatly (Nowak et al., 2016). Two quinoa groups. Group A has more phytochemicals and polyunsaturated fats, whereas group B has more linolenic and long-chain fats. Food items may use both groups (Chen et al. 2019). Quinoa grain includes 32–60% carbohydrate, 10–18% protein, and 4.4%–8.8% fat. The ashes, mostly potassium and phosphorus, are 2.4% to 3.7%, and the fiber is 1.1–13.4%. Quinoa contains vitamin B and vitamin E, a fat-soluble antioxidant (Romano et al., 2020).

Quinoa grains are used in food after removing fractions rich in antinutritional compounds, such as saponins in the perianth and pericarp, which cause bitterness and damage the intestinal mucosa. Quinoa is rinsed with tap water, hand-rubbed, then dried to eliminate saponins. This procedure may need many cycles (Mhada et al., 2020).

Quinoa may replace rice, be boiled into infant cereal, or be eaten for breakfast. You may pop the seeds like popcorn. To make flour, sprout or process seeds. Salads need green sprouts (Valencia-Chamorro, 2003). The seed coat contains saponin, an antinutritional substance that protects the plant from insects and pests, which must be removed before eating quinoa (Filho et al., 2017). To make quinoa a global staple, we must process it to minimize saponin (Rao and Shahid, 2012). Boosting appetite is excellent. Eye infections and asthma may be treated with it (Reyad-ul-Ferdous et al., 2015).

Amaranth leaves are utilized as preventive food owing to their antioxidant and phytochemical qualities (Njonje, 2015). Boiling leaves to treat jaundice, rheumatic pain, and stomach troubles works wonderfully. Internal and exterior application of root paste has several benefits (Achigan-Dako et al., 2014). Amaranth root paste regulates vomiting in dysentery patients, while black pepper pastes treat rabies. The seeds may be eaten to halt internal bleeding, heavy menstruation, and diarrhoea. This poultice treats shattered bones externally. Cholera, piles, and snake bites may be treated using the entire Amaranth plant (Nawaz et al., 2009).

3. PLANT DESCRIPTOR

- **QUINOA:**

Quinoa is classified as a dicotyledonous annual plant that falls under the botanical family Amaranthaceae. The plant thrives in India, exhibiting several cultivars that reach a height of 1.5 m, possess numerous branches, and has a substantial leaf size (Tapia, 2000). The presence of unisexual female flowers is a notable attribute of quinoa, as seen in **Figure 3**. Quinoa exhibits three distinct panical shapes, namely amarantiform, intermediate, and glomerulate. The secondary axis gives rise to elongated glomeruli in amarantiform panicles, while the tertiary axis develops spherical glomeruli. In certain instances, a plant may exhibit both amarantiform and intermediate panical shapes, resulting in the formation of an intermediate inflorescence (Rojas et al., 2013).

Figure 3. Quinoa leaf and different verities of quinoa

According to Naik et al. (2020), several achene-type fruits are produced by each flower. The indehiscent fruits have a seed-like appearance as a result of the pericarp's hardening process. The achenes mature while the plant undergoes desiccation. Upon reaching maturity, the grains exhibit a diverse range of colors, including a multitude of tints **(see figure 4)**. There are four distinct shapes, namely lenticular, cylindrical, ellipsoid, and conical, as well as four corresponding sizes, namely extra-large, big, medium, and tiny. (Bolivian Institute of Normalization, 2007).

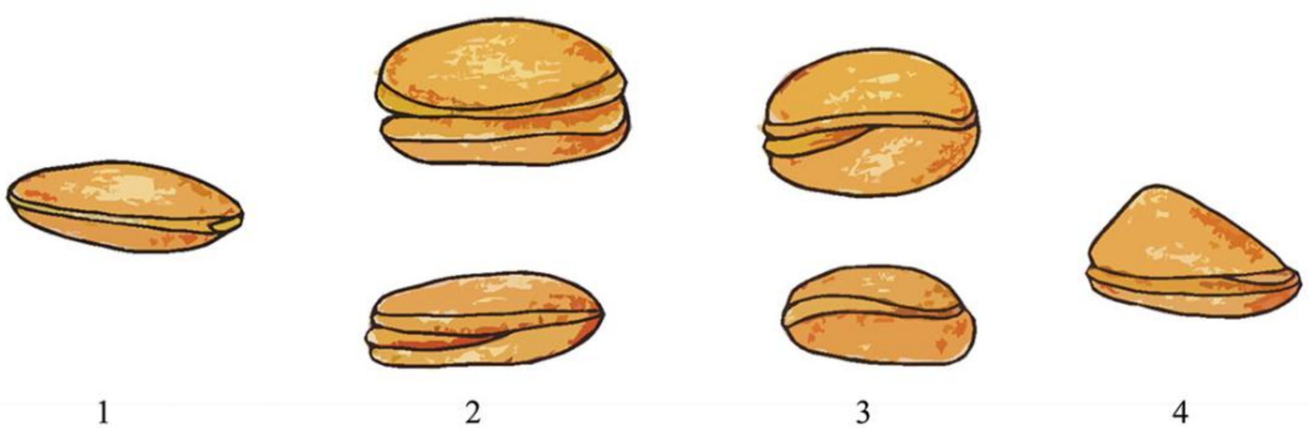

Figure 4. Quinoa grain forms include lenticular, cylindrical, ellipsoid, and conical.

The height of quinoa may exceed two meters, while its panicle-shaped inflorescences exhibit a diverse range of colors, spanning from yellow to purple. There are two distinct forms of panicles, which may be distinguished based on the shape and insertion of the glomeruli. Glomerulated glomeruli are characterized by their spherical shape and originate from tertiary axis, whereas amaranthiform glomeruli are characterized by their elongated shape and originate from secondary axis **(see Figure 5)**. There are instances when the plant exhibits both traits simultaneously, resulting in the formation of an intermediate inflorescence (Rojas and Pinto 2013).

Figure 5. Quinoa panicle morphologies include (1) glomerulated, (2) intermediate, and (3) amaranthiform.

Although there is significant diversity, quinoa is a single species that encompasses several variants. Typically, the plant in question is classified as herbaceous, exhibiting stems that are green, reddish, or purple in colour, and may or may not be branched (Kinupp&Lorenzi, 2014). **(see figure 6)**.

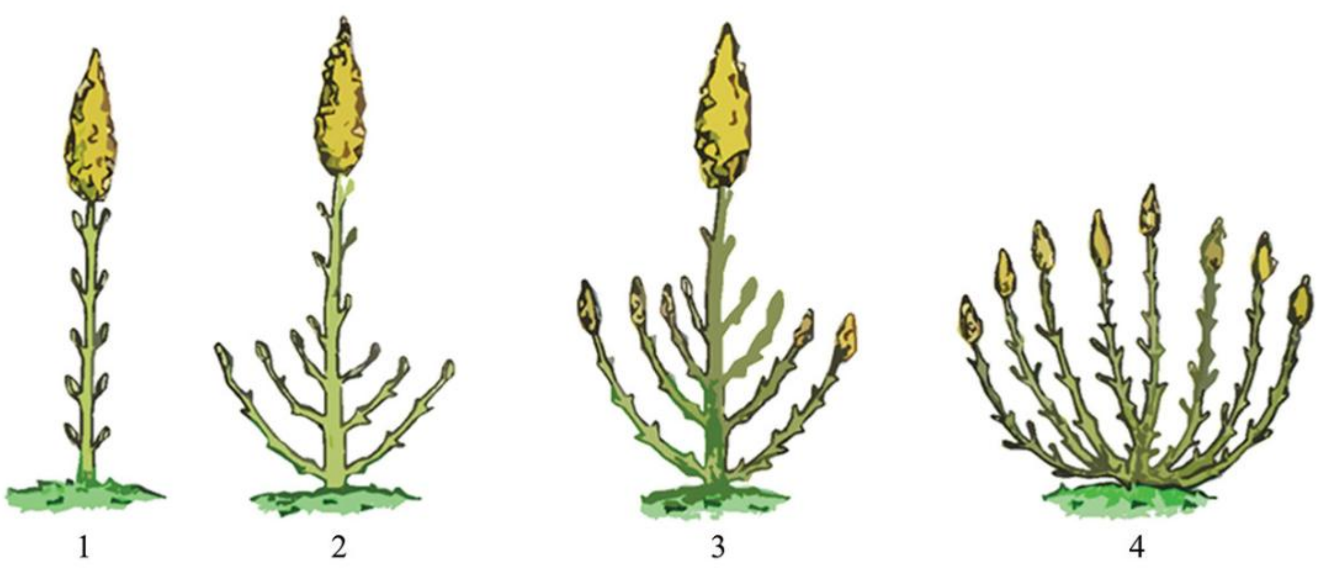

Figure 6. **Quinoa growth tendencies include: (1) simple, with no stems; (2) branched only up to the bottom portion of the plants; (3) stems up to the top third of a plant; and (4) completely branched.**

- **AMARANTA:**

  Amaranth is classified as a non-grass annual plant. It has a herbaceous stem that exhibits a height range of 30 to 210 cm. The stem is solid and exhibits a variety of colours. It has a petioled morphology, specifically an ovate shape. The leaves may be either hairy or non-hairy, with wavy edges and an alternating pattern of length ranging from 7.5 to 15 cm. Additionally, the leaves display a range of colors. The dimensions of the bloom exhibit a range of 1 to 2 cm across several hues, spanning from red to maroon (see Fig 7). The seeds have an oval form and come in three colors: white, red, and black. They have the ability to germinate when exposed to high levels of humidity (Akubugwo et al., 2007). Amaranth seeds possess a folded flange, reticulation cartridges that cover the spermoderm, and exhibit verucate processes (Spehar, 2003). Additionally, the fruits of amaranth plants possess a dehiscent pyxis. The plant has a lengthy, succulent, red or pink taproot system that is deep and well-developed, allowing it to thrive in water-stressed environments. Amaranth is a monoecious plant, with just a few species that are dioecious. Pollination may be facilitated using either wind or insect means. The coloration of amaranth leaves has a range from vibrant red to violet, with the maroon hue attributed to the pigments present in battalions (Hongyan and al., 2015).

  Amaranth displays a range of ploidy levels, and the analysis of pollen grain characteristics enables the identification of interspecific hybrids. Pollen grains of dioecious plants has several pores on their surface. According to the ploidy level of the plant, the size of pollen grains is contingent upon. A lower ploidy level is associated with a smaller size, whereas an increase in ploidy level is associated with a rise in size. Polyploids have a greater number of patterns in the exine compared to diploids (Franssen et al., 2001).

Figure 7 . Leaves and seeds of Amaranth

4. GENETICALLY IMPROVEMENT OF QUINOA:

Quinoa is a crop that naturally reproduces itself with very few opportunities for crossbreeding (17.36%). To ensure its purity, it may be sold in a controlled manner by covering the flowering stem with a paper bag (Silvestri and Gill, 2000. The primary goals of quinoa breeding were to achieve a compact plant structure with little branching, rapid development, a short growth cycle, early maturity, low saponin content, resistance to both abiotic and biotic stressors, and increased grain yields for commercial types. This was achieved using mass selection and hybridization, which will be used as direct tactics for future breeding. The presence of variety within the basic gene pool contributes to the characterization of Quinoa. The importance of breeding research for Quinoa stems from its great genetic diversity, broad agronomic flexibility, ability to tolerate many soil types, particularly saline soils, and its capacity to thrive in dynamically fluctuating conditions of humidity, elevation, and temperature. Additionally, Quinoa offers significant nutritional health advantages (Murphy et al., 2016). In order to meet the needs of farmers in different locations and agronomic systems, it is necessary to engage in global collaboration for quinoa. This collaboration might potentially serve as a foundation for enhancing plant breeding efforts in both developed and developing countries.

The phylogeny was revealed by the analysis of entire chloroplast (cp) DNA using next-generation sequencing, which involves the examination of whole plastid genome sequences, together with the use of molecular markers (Hong et al., 2017). However, this is not the case with SSR markers. Utilizing InDel (insertion/deletion) for whole-genome re-sequencing would provide valuable insights on population diversity and its influence on the development of desirable genotypes in quinoa (Zhang et al., 2017). Additionally, it may be used to re-sequence quinoa accessions.

TILLING (Targeting Induced Local Lesions in Genomes) is a novel genome editing technique that has shown remarkable efficacy and rapidity in the detection of induced mutations across several genes (Holme et al., 2019). Currently, extensive TILLING libraries often consist of over 3,000 extensively mutated quinoa individuals (Mestanza et al., 2018). The use of advanced genetic screens facilitates the creation and evaluation of much bigger collections obtained from populations that have been subjected to mutagenization (Wendt et al., 2019). Gene functional studies are conducted utilizing this gene silencing approach to provide insights into functional genomics. The research conducted by Da Silva et al. (2011) offers valuable insights into the genetics of anti-nutritional components found in Amaranth and Quinoa.

5. GENETICALLY IMPROVEMENT OF AMARANTH:

The crop known as amaranth exhibits self-pollination, with few occurrences of cross-pollination. Amaranth has monoecious characteristics. Over the course of 6–8 generations, a process of recurrent self-pollination and inside selection maintained homozygous, true-to-type lines. These lines were then used for hybrid production. In the process of hybridization, it is necessary to plant male and female parents at an appropriate distance from each other. The study included the implementation and advancement of emasculation techniques and controlled pollination methods. Chromosomal investigations were conducted to examine polyploids. The researchers (Vaidya, 1984) have discovered a significant level of variety in Indian germplasm. The present study investigated the manner of trait inheritance in the amaranth crop, focusing on several characteristics such as yield metrics.

Inheritance studies played a crucial role in enhancing hybrid production by identifying and choosing relevant traits that need further investigation. Gene markers are a straightforward methodology for investigating the heritability of favorable characteristics in order to cultivate superior cultivars. In previous research, Kulakow et al. (1985) conducted a comprehensive investigation of the inheritance of markers associated with several factors, including plant development, plant shape, seed characteristics, and blooming behaviour. A study was conducted in Japan to investigate the inheritance of nutritional facts, specifically focusing on the properties of starch and the perisperm layer of grain. The development of amaranth genotypes is influenced by the distinct agro-ecological areas' environment (Makobo and Shoko, 2010).

6. CONCLUSION:

Amaranth and quinoa are ultra-nutritious foods, especially beneficial for those with wheat or gluten sensitivities. In underdeveloped nations such as Africa, where malnutrition is prevalent, it might be included into the diet. These crops have the ability to thrive in challenging environments while requiring minimum resource utilization. Nevertheless, it is essential to address the anti-nutritional elements found in these crops, such as saponin in quinoa, by targeted breeding initiatives. The extensive range of genetic resources accessible for these crops should be effectively harnessed via the process of selection for specific features. Although these crops have reached their maximum potential as important crops, the breeding programmed aimed at improving them are insufficient to obtain the level of importance they deserve in the food sector. The high cost of advanced technology and infrastructure hinders their availability. However, we anticipate that genetic advancements through classical and molecular breeding techniques will change this situation by producing a crop that is rich in nutrients and exhibits exceptional performance. This crop has the potential to meet the growing demand for food in an evolving environment. Hence, the promotion and large-scale cultivation of region-specific varietals and agrotechnology would be crucial elements.

7. ETHICS APPROVAL

Not applicable

REFERENCES

Achigan-Dako, E. G., Sogbohossou, O. E., & Maundu, P. (2014). Current knowledge on Amaranthus spp.: research avenues for improved nutritional value and yield in leafy amaranths in sub-Saharan Africa. Euphytica, 197, 303-317.

Adolf, V. I., Shabala, S., Andersen, M. N., Razzaghi, F., & Jacobsen, S. E. (2012). Varietal differences of quinoa's tolerance to saline conditions. Plant and Soil, 357, 117-129.

Akubugwo, I. E., Obasi, N. A., Chinyere, G. C., &Ugbogu, A. E. (2007). Nutritional and chemical value of Amaranthushybridus L. leaves from Afikpo, Nigeria. African Journal of Biotechnology, 6(24).

Barba de la Rosa, A. B., Fomsgaard, I. S., Laursen, B., Mortensen, A. G., Olvera-Martínez, L., Silva-Sánchez, C., ... & De León-Rodríguez, A. (2009). Amaranth (Amaranthushypochondriacus) as an alternative crop for sustainable food production: Phenolic acids and flavonoids with potential impact on its nutraceutical quality. Journal of Cereal Science, 49(1), 117-121.

Bhargava A, Shukla S, Ohri D. Genome size variation in some cultivated and wild species of *Chenopodium* (Chenopodiaceae). *Caryologia.* (2007) 60:245–50. 10.1080/00087114.2007.10797943

Boukid, F., Folloni, S., Sforza, S., Vittadini, E., &Prandi, B. (2018). Current trends in ancient grains-based foodstuffs: insights into nutritional aspects and technological applications. Comprehensive Reviews in Food Science and Food Safety, 17(1), 123-136.

Chen, Y. S., Aluwi, N. A., Saunders, S. R., Ganjyal, G. M., & Medina-Meza, I. G. (2019). Metabolic fingerprinting unveils quinoa oil as a source of bioactive phytochemicals. Food Chemistry, 286, 592-599.

Da Silva, L. S., Taylor, J., & Taylor, J. R. (2011). Transgenic sorghum with altered kafirin synthesis: kafirin solubility, polymerization, and protein digestion. Journal of agricultural and food chemistry, 59(17), 9265-9270.

Franssen, A. S., Skinner, D. Z., Al-Khatib, K., & Horak, M. J. (2001). Pollen morphological differences in *Amaranthus* species and interspecific hybrids. *Weed Sci.* 49:732–7.

Hart, T., & Vorster, I. (2006). Indigenous knowledge on the South African landscape: potentials for agricultural development (No. 1). HSRC Press.

Holme, I. B., Gregersen, P. L., &Brinch-Pedersen, H. (2019). Induced genetic variation in crop plants by random or targeted mutagenesis: convergence and differences. Frontiers in Plant Science, 10, 488642.

Hong, S. Y., & Cho, K. S. (2017). Complete chloroplast genome sequences and comparative analysis of Chenopodium quinoa and C. album. Frontiers in Plant Science, 8, 283727.

Hongyan, L., Deng, Z., Liu, R., Zhu, H., Draves, J., Marcone, M., ... &Tsao, R. (2015). Characterization of phenolics, betacyanins and antioxidant activities of the seed, leaf, sprout, flower and stalk extracts of three Amaranthus species. Journal of Food Composition and Analysis, 37, 75-81.

IBNORCA, B. (2004). Instituto Boliviano de Normalización y Calidad. Ministerio de Servicios y ObrasPúblicas–Viceministerio de ServiciosBásicos NB, 512.

Joshi, D. C., Sood, S., Hosahatti, R., Kant, L., Pattanayak, A., Kumar, A., ... & Stetter, M. G. (2018). From zero to hero: the past, present and future of grain amaranth breeding. Theoretical and Applied Genetics, 131, 1807-1823.

Kinupp, V. F., Lorenzi, H., Cavalleiro, A. D. S., Souza, V. C., &Brochini, V. (2021). Plantasalimentíciasnãoconvencionais (PANC) no Brasil: guia de identificação, aspectosnutricionais e receitasilustradas.

Kulakow, P. A., Hauptli, H., & Jain, S. K. (1985). Genetics of grain amaranths: I. Mendelian analysis of six color characteristics. Journal of Heredity, 76(1), 27-30.

Kulakow, P., & Jain, S. (1987). Genetics of grain amaranths: 4. Variation and early generation response to selection in Amaranthuscruentus L. Theoretical and Applied Genetics, 74, 113-120.

Kumari, M., Zinta, G., Chauhan, R., Kumar, A., Singh, S., & Singh, S. (2023). Genetic resources and breeding approaches for improvement of amaranth (Amaranthus spp.) and quinoa (Chenopodium quinoa). Frontiers in Nutrition, 10.

Makobo, N. D., Shoko, M. D., &Mtaita, T. A. (2010). Nutrient content of Amaranth (Amaranthuscruentus L.) under different processing and preservation methods. World journal of Agricultural sciences, 6(6), 639-643.

Mestanza, C., Riegel, R., Vásquez, S. C., Veliz, D., Cruz-Rosero, N., Canchignia, H., & Silva, H. (2018). Discovery of mutations in Chenopodium quinoa Willd through EMS mutagenesis and mutation screening using pre-selection phenotypic data and next-generation sequencing. The Journal of Agricultural Science, 156(10), 1196-1204.

Mhada, M., Metougui, M. L., El Hazzam, K., El Kacimi, K., &Yasri, A. (2020). Variations of saponins, minerals and total phenolic compounds due to processing and cooking of quinoa (Chenopodium quinoa Willd.) seeds. Foods, 9(5), 660.

Murphy, K. M., Bazile, D., Kellogg, J., &Rahmanian, M. (2016). Development of a worldwide consortium on evolutionary participatory breeding in quinoa. Frontiers in plant science, 7, 184074.

Naik, S., Paramesh, R., Siddaraju, R., & Shankar, P. R. (2020). Studies on growth parameters in quinoa (Chenopodium quinoa Willd.). International Journal of Chemical Studies, 8(1), 393-7.

Navruz-Varli, S., &Sanlier, N. (2016). Nutritional and health benefits of quinoa (Chenopodium quinoa Willd.). Journal of cereal science, 69, 371-376.

Nawaz, A. H. M. M., Hossain, M., Karim, M., Khan, M., Jahan, R., &Rahmatullah, M. (2009). An ethnobotanical survey of Rajshahi district in Rajshahi division, Bangladesh. American Eurasian Journal of Sustainable Agriculture, 3(2), 143-150.

Njonje, W. A. (2015). Nutrients, Anti-Nutrients and Phytochemical Evaluation of Ten Amaranth Varieties at Two Growth Stages. Nairobi: Jomo Kenyatta University of Agriculture and Technology.

Nowak, V., Du, J., &Charrondière, U. R. (2016). Assessment of the nutritional composition of quinoa (Chenopodium quinoa Willd.). Food chemistry, 193, 47-54.

Pearsall, D. M. (2008). Plant domestication and the shift to agriculture in the Andes. In The handbook of South American archaeology (pp. 105-120). New York, NY: Springer New York.

Pellegrini, M., Lucas-Gonzales, R., Ricci, A., Fontecha, J., Fernández-López, J., Pérez-Álvarez, J. A., &Viuda-Martos, M. (2018). Chemical, fatty acid, polyphenolic profile, techno-functional and antioxidant properties of flours obtained from quinoa (Chenopodium quinoa Willd) seeds. Industrial crops and products, 111, 38-46.

Pirozi, M. R., Borges, J. T., HM, P. S. A., Chaves, J. B., & Coimbra, J. S. (2017). Quinoa: Nutritional, functional, and antinutritional aspects. Critical Reviews in Food Science and Nutrition, 57(8), 1618-1630.

Rao, N. K., &Shahid, M. (2012). Quinoa-A promising new crop for the Arabian Peninsula. Am. J. Agric. Environ. Sci, 12(10), 1350-1355.

Romano, N., Ureta, M. M., Guerrero-Sánchez, M., & Gómez-Zavaglia, A. (2020). Nutritional and technological properties of a quinoa (Chenopodium quinoa Willd.) spray-dried powdered extract. Food research international, 129, 108884.

Sharma, G., Prakash, D., Gupta, C., Prakash, D., & Sharma, G. (2014). Phytochemicals of nutraceutical importance: do they defend against diseases. Phytochemicals of nutraceutical importance, 1.

Silvestri, V., & Gil, F. (2000). Alogamia en quinua: tasa en Mendoza (Argentina). Revista de la facultad de CienciasAgrarias, 32(1).

Singh, D. (2019). Quinoa (Chenopodium Quinoa Willd). Scientific Publishers.

Spehar, C. R. (2003). Morphological differences between Amaranthuscruentus, cv. BRS Alegria, and the weed species A. hybridus, A. retroflexus, A. viridis and A. spinosus. Planta Daninha, 21, 481-485.

Tapia, M. E. (1997). Cultivosandinossubexplotados y suaporte a la alimentación.

Vaidya, K. R. (1984). Genetic variation in landrace populations of Indian amaranths.

Valencia-Chamorro, S. A. (2003). Quinoa. Encyclopedia of food sciences and nutrition, 4895-4902.

Vega-Gálvez, A., Miranda, M., Vergara, J., Uribe, E., Puente, L., & Martínez, E. A. (2010). Nutrition facts and functional potential of quinoa (Chenopodium quinoa willd.), an ancient Andean grain: a review. Journal of the Science of Food and Agriculture, 90(15), 2541-2547.

Wendt, T., Olsen, O., Knudsen, S., Thomsen, H. C., Skadhauge, B., Rasmussen, M. W., ... &Striebeck, A. (2024). U.S. Patent No. 11,884,972. Washington, DC: U.S. Patent and Trademark Office.

Zhang, T., Gu, M., Liu, Y., Lv, Y., Zhou, L., Lu, H., ... & Zhao, H. (2017). Development of novel InDel markers and genetic diversity in Chenopodium quinoa through whole-genome re-sequencing. BMC genomics, 18, 1-15.