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Quinoa (*Chenopodium quinoa* Willd.) production in Burkina Faso: Nutritional benefits and challenges of its use in the context of food and climate crises

Elie Wilfried Wendnongma BIEGO [1,*], Abdalla DAO [3], Kawtar FARIH [4], Serge Sonagnon KOUHOUNDE [1], Fidèle Wend-Bénédo TAPSOBA [2], Thomas J NDIG-YENOUBA [1] and Hagrétou SAWADOGO/LINGANI [2]

[1] *Université Aube Nouvelle, Département sciences et technologies, Laboratoire des sciences biologiques et appliquées, Ouagadougou, Burkina Faso.*
[2] *Département Technologie Alimentaire (DTA), Institut de Recherche en Sciences Appliquées et Technologies (IRSAT), Centre National de la Recherche Scientifique et Technologique (CNRST), Ouagadougou, Burkina Faso*
[3] *Institut de l'Environnement et de Recherches Agricoles (INERA), Bobo Dioulasso BP910, Burkina Faso.*
[4] *Hassan II Institute of Agronomy and Veterinary Medicine, Department of food Science and Nutrition, Morocco*

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Abstract

Burkina Faso is a developing country facing major challenges in terms of food and nutritional security. Agriculture is essentially rain-fed, and climatic hazards such as drought have a negative impact on the productivity of crops, namely, millet, sorghum, maize and rice. In this context, quinoa, introduced in Burkina Faso through the FAO in 2015, appears to be an interesting alternative for diversifying crops and improving the food and nutritional security of the population. The aim of this review is to highlight the nutritional potential, advantages and challenges facing quinoa cultivation in Burkina Faso. It also seeks to raise awareness of the opportunities offered by this alternative crop to improve food security and nutrition for the population in Burkina Faso. We reviewed previous works by several authors who revealed that quinoa is an important nutritional source. Different information was collected and synthesized to determine the correlation between the introduction of quinoa and its positive contribution to improving the food and economic situation in Burkina Faso. The literature shows that quinoa can be used as an alternative crop for diversification and food security due to its ability to adapt to climatic changes and can offer significant nutritional benefits. However, challenges related to cultivation and processing techniques, and low awareness of this crop among local consumers and agro-industry actors, may limit quinoa production and consumption in the country. This paper sheds light on the possibilities for quinoa processing, products and byproducts in Burkina Faso.

Keywords: Burkina Faso; Quinoa; Food Security; Nutritional; Economic Opportunity

1. Introduction

Food and nutritional security are major challenges for developing countries, particularly those in sub-Saharan Africa, where the prevalence of malnutrition is high. The diversification of crops and diets is essential to meet this challenge. For this purpose, cultivation of quinoa (*Chenopodium quinoa Willd.*) is increasingly seen as a promising alternative for dietary diversification and food and nutritional security.

Quinoa (*Chenopodium quinoa Willd.*) originates from the Andean region of Bolivia and Peru, where it has been cultivated for more than 5,000 years [1]. It has been introduced into many countries in Europe, North America, Asia and Africa [2]. It is a plant that adapts well to difficult agroclimatic conditions (high altitudes, nutrient-poor soils and temperature variations) and maintains its productivity on arid soils or those marked by high salinity[3]. According to some authors,

* Corresponding author: Elie Wilfried Wendnongma BIEGO

the global production of annual quinoa has grown steadily over the last ten years to over 100,000 tons [4], sparking growing interest in its agricultural and food potential. In West Africa, quinoa cultivation is still in its emerging stages. Since 2013, the FAO has ranked this pseudocereal among the most promising crops for humanity, considering it an option for solving the problem of nutrition, and is working with several African countries to introduce and promote its cultivation [5]**;** [6]**.**

In the Burkina Faso context, quinoa is still poorly known to the general public, although it was introduced in 2015 through the FAO project called "Technical Assistance to Strengthen the Quinoa Food System" for the benefit of seven West African countries, including Burkina Faso. On the agronomic front, preliminary studies conducted by the national agency in charge of agricultural research have shown that quinoa can be grown in real environments under different agroecological conditions in Burkina Faso [7]**.**

Malnutrition and dietary diversification remain critical concerns in Burkina Faso. According to a report on the state of population health in Burkina Faso in 2020, unbalanced dietary practices negatively affect the nutritional situation of children and women of childbearing age, resulting in high levels of various forms of malnutrition [8].

From 2009 to 2019, the prevalence of acute malnutrition decreased from 11.3 to 8.1%, that of chronic malnutrition decreased from 35.1 to 25.4%, and that of underweight decreased from 26 to 17.3% among children under 5 years of age [8]**.** The main determinants of acute malnutrition are the very low minimum dietary diversity of both children and mothers, insufficient quality of food intake and the introduction of inadequate complementary foods. Quinoa cultivation could offer an interesting solution for diversifying diets and improving food and nutritional security in the country. However, despite the growing interest in this plant in the region, little information is available on its agricultural and food potential in the Burkinabe context.

In this article, we present a literature review on quinoa, focusing on its potential for diversification and food and nutrition security in Burkina Faso. We begin by analyzing the botanical, agronomic and nutritional properties of quinoa, as well as its history and worldwide distribution. Next, we review the current state of quinoa production, processing, marketing and consumption in Burkina Faso, its advantages and limitations, and its socioeconomic issues. Finally, we discuss the challenges and prospects for the future of quinoa cultivation in Burkina Faso.

2. Methods

This review article was conducted following a methodology aimed at identifying, evaluating and synthesizing the most relevant information. The literature research focused on the scientific databases google scholar, pubmed, Researchgate, using specific keywords and term combinations. The selected articles were evaluated according to predefined quality criteria, including relevance, methodological rigor and validity of conclusions. The extracted data were then synthesized and critically analyzed in order to identify trends, gaps and future perspectives in the field.

3. Results

3.1. Quinoa production worldwide

Quinoa (*Chenopodium quinoa* Willd.) This dicotyledonous plant in the Chenopodiaceae family is native to the South American Andes, where it has been cultivated for over 5,000 years by the people of this region[3]. Traditional quinoa-producing countries include Bolivia, Peru, and Ecuador, where quinoa is considered an important subsistence crop. Approximately 8,000 years ago, the first humans began to tame flora and fauna, and quinoa was one of the first crops to be domesticated. It would play a key role not only in the livelihoods but also in the political and sociocultural systems of the Andean people [9].

Quinoa has become an important crop in many countries around the world, including South America, Europe, Asia and Africa. Owing to its exceptional nutritional value and undemanding cultivation, quinoa is considered a promising alternative for food diversification and food security in developing countries According to FAO in 2013. However, quinoa production remains concentrated in a small number of countries, posing challenges for marketing the product. In addition, the global demand for quinoa has led to rising prices, making it more difficult for poorer populations in regions where quinoa is traditionally consumed to feed themselves [10]**.**

Despite these challenges, quinoa's production and marketing potential remain important for food diversification and food and nutrition security in developing countries. In recent decades, quinoa cultivation has spread around the world,

particularly in Europe, North America and Asia, owing to its growing popularity as a healthy and nutritious food (Table 1). Today, quinoa is grown in more than 70 countries worldwide, with a global production of approximately 170,000 tons in 2018 as reported FAOSTAT for 2018.

Table 1 Summary table of cultivated areas and yields for three major global quinoa producers (FAOSTAT, 2018)

Country	**2009**		**2010**		**2011**		**2012**		**2013**	
	C.A	Yields	C.A	Yields	C.A	Yields	C.A	Yields	C.A	Yields
Bolivia	59924	34156	58496	36724	63307	40942,72	131192	50874,42	147312	63074,77
Peru	34026	39397	35313	41079	35475	41182	38495	44212,6	44868	52129
Ecuador	1100	800	2170	1832,84	2384	2073,14	2552	2322,6	2591	2514,64
Country	2014		2015		2016		2017		2018	
	C.A	Yields	C.A	Yields	C.A	Yields	C.A	Yields	C.A	Yields
Bolivia	113506	67711	121186	75449	118913	65548	110639	66792	111605	70762,64
Peru	68140	114725	69303	105666	64859	89413,59	61721	78657	65736	86828,13
Ecuador	4122	3711	7148	12707,22	2214	3903,15	882	1286	2048	2146

C. A: Cultivated area

3.2. Botanical description and agronomic characteristics

Quinoa (*Chenopodium quinoa*) belongs to the class *Magnoliopsidaceae*, order *Caryophyllaceae*, family *Amanrantaceae* and genus *Chenopodium*. *Chenopodium* is the most important genus in this family, with over 250 species worldwide. It is a dicotyledonous plant that is considered a pseudocereal owing to its high starch and protein contents [11]**.** It is sometimes called an oleaginous pseudograin due to its high lipid content [11], [12]**.**

The quinoa plant has a vigorous taproot that divides into secondary and tertiary roots. The length of these roots is generally proportional to the height of the plant. This deep, branched root system may explain quinoa's resistance to drought [1]**.**

The quinoa stem is cylindrical at the collar, becoming angular as it branches. The degree of branching is influenced by genetic and environmental factors. The height varies from 0.5 to 2 meters, depending on the variety and growing conditions. The stem epidermis can be green, with purple or red stripes, or even entirely red [1]**.** Quinoa leaves alternate along the stem. They have long, thin, grooved stalks.

The quinoa inflorescence is a panicle consisting of a main axis from which secondary and tertiary axes emerge. The flowers are small and incomplete, without petals. They display a wide range of colors that evolve as quinoa seeds mature[12].

The quinoa fruit is an achene covered by the pericarp, which separates easily when dry. It can be conical, cylindrical or ellipsoidal in shape. The seed is surrounded by a thin episperm that can be of various colors[12]. The quinoa varieties and agroecological zones in which they are grown influence plant morphology. Significant variations can be observed in terms of plant color, seed color, inflorescence type and adaptability to various environmental conditions. The quinoa plant adapts well to difficult climatic conditions, such as high altitudes, nutrient-poor soils and temperature variations. It is also resistant to drought and certain diseases, making it an attractive crop for farmers in arid and semiarid zones [3]**.**

3.3. Seed composition

The nutritional properties of quinoa began attracting the interest of researchers in 1990, although this plant has been known for thousands of years as a staple food among the Incas, under the name "mother grain". Quinoa offers nutritional advantages over cereals (millet, corn, rice, sorghum), as shown in Table 2.

Table 2 Overall quinoa seed composition (g/100 g)

	Carbohydrates	Dietary Fiber	Proteins	Fat	Ash
Cauda et al., (2013)	69.0	3.8	16.5	6.3	3.8
Wright et al., (2002)	74.7	10.5	16.7	5.5	3.2
Vega-Valgez (2010)	69.7	2.9	15.6	7.4	3.0
Sobota et al., (2019)	60.8	1.92	15,24	8.5	3.7

In general, high variations in nutrient contents of quinoa, such as protein (9.1–15.7 g), total fat (4.0–7.6 g) and dietary fiber (8.8–14.1 g), are observed per 100 g edible portion on a fresh weight basis [13]**.** According to other authors, the protein content in quinoa is higher than that in most other cereals and varies between 15,24% and 16,7% ([11];[2];[1];[14]). Quinoa protein contains all the essential amino acids and is gluten-free, making it attractive to individuals with celiac disease or other digestive disorders, such as gluten intolerance [4]**.**

The carbohydrate fraction of quinoa contains a significant amount of starch and dietary fiber ([15];[16])**.** The amount of fiber contained in quinoa grains is greater than that contained in wheat or rice and comparable to that contained in legumes. Quinoa provides very high-quality oligosaccharides, fibers, peptides, phenolic antioxidants and unsaturated fatty acids that can prevent cancer development or modify the activity of enzymes linked to inflammation([17][18][19])**.**

Recent studies have indicated that phenolic antioxidants present in pseudo cereals have several health benefits, such as prevention and reduction of oxidative stress; anticancer, antidiabetic, anti-inflammatory, and antihypertensive effects; and prevention of cardiovascular diseases [20]**.**

However, the pericarps of quinoa grain walls contain saponins, which are responsible for their bitterness, limiting their incorporation in various technological processes. [21] proposed technological treatments such as soaking, washing, hulling, blanching, fermentation and drying to significantly reduce these antinutritional compounds in the finished product**.**

3.3.1. Amino acids in quinoa proteins

Quinoa is known for its complete protein content, meaning that it contains all the essential amino acids (Table 3) in adequate quantities to meet the nutritional requirements of the human body, as reported by [4]. Despite the fact that this plant has higher total protein values than other cereals do, its nutritional balance of amino acids is particularly interesting. The relative lack of lysine in cereals is a major concern when these are the main sources of protein in a diet, according to [22]**).** It is an essential amino acid, meaning that the body cannot produce it and must be obtained from food. It is concentrated in the muscles and has many biological functions. Among other factors, it contributes to bone growth, the formation of collagen and antibodies, and the metabolism of carbohydrates. Quinoa is thus positioned as an alternative for populations struggling to access a protein source with diverse essential amino acids, as reported by some authors [23][24][14][25]**.**

Table 3 Essential amino acid profile (g 100 g-1 protein)

Amino Acids	Kozioł (1992)	Dini et al. (1992)	Repo-Carrasco et al. (2003)	Wright et al (2002)
His	3.2	2.0	2.7	3.1
Ile	4.4	7.4	3.4	3.3
Leu	6.6	7.5	6.1	5.8
Met + Cys	4.8	4.5	4.8	2.0
Phe + Tyr	7.3	7.5	6.2	6.2
Thr	3.8	3.5	3.4	2.5
Val	4.5	6.0	4.2	4.0
Lys	6.1	4.6	5.6	6.1
Trp	1.2	-	1.1	-

Legend: His: Histidine, Ile: Isoleucine, Leu: Leucine, Met + Cys: Methionine + Cysteine, Phe + Tyr: Phenylalanine + Tyrosine, Thr: Threonine, Val: Valine, Lys-Lysine, Trp: Tryptophan, (-): Trace.

3.3.2. Fatty acids in quinoa lipids

Quinoa has an average fat content of 6%. The fatty acid composition of quinoa is similar to that of corn, with a high proportion of mono- and polyunsaturated fatty acids (Table 4), particularly linoleic acid, as reported by [22]. Polyunsaturated fatty acids have health benefits, particularly for cardiovascular disease [4].

Table 4 Fatty acid composition of quinoa

	Fatty acids (% of total Lipids)		
References	Oleic	Linoleic	Linolenic
Koziol (1992)	23,3	53,1	6,2
Repro-Carrasco et al. (2003)	26,0	50,2	4,8
Ruales and Nair (2002)	24,8	52,3	3,9

3.3.3. Carbohydrates

The main energy source in the human diet is starch. Quinoa contains between 58.1 and 64.2% starch [15]. In addition, relatively high levels of maltose and D-xylose have been observed, while the amounts of glucose and fructose are low.

According to [4], the carbohydrates in quinoa have a beneficial hypoglycemic effect and may even inhibit the release of fatty acids.

Table 5 Carbohydrate composition of quinoa compared with those of rice and barley (Lilian and al, 2009)

Carbohydrates	**Quinoa**	**Rice**	**Barley**
Carbohydrates	73,6-74	79,2	77,7
Starch	52,2-69,2	2,8	-
Dietary fiber	7-9,7	-	15,6
Soluble fiber	6,8-8,4	-	-
Insoluble fiber	6,1	-	-
Soluble sugars	2,9	-	-

3.3.4. Vitamins

Quinoa contains a variety of vitamins, as shown in Table 6. Every 100 grams, it provides sufficient folate (vitamin B9) to meet the nutritional needs of children (70 µg/day for infants and 100 µg/day for children aged 1 to 3) and adults (330 µg for men and 300 µg for women) according to the recommended daily allowance. The amount of riboflavin (vitamin B2) present in quinoa, which is essential for energy metabolism, accounts for approximately 80% of children's needs and almost 40% of adults' needs, according to [4].

Table 6 Vitamin composition of quinoa, maize and rice (µg/g)

Vitamins	**Quinoa (Herbillon, 2009)**	**Rice (USDA, 2023)**	**Corn (USDA, 2023)**
Thiamine	0,345 mg	0,163 mg	0.155 mg
Riboflavin	0,316 mg	0,013 mg	0.055 mg
Niacin	1,52 mg	1,48 mg	1.77 mg
Vitamin B6	0,487 mg	0,093 mg	0.093 mg
Folates	184 µg	58 µg	g

3.3.5. Minerals

Quinoa is a good source of minerals such as magnesium, which is involved in nerve impulse transmission; phosphorus, which is essential for bone formation; and potassium, which is important for regulating heart rate and blood pressure, as noted by [4].

The values described in Table 7 show the variation in the mineral composition of quinoa, rice, maize and wheat. The calcium, iron, magnesium, phosphorus and potassium contents of quinoa are significantly greater than those of corn, rice and wheat. The zinc content is similar to that of wheat.

Table 7 Mineral content of quinoa and other foods (mg/100 g)

Minerals	**Quinoa**		**Corn**	**Rice**	**wheat**
	FAO (2015)	**Konishi (2004)**	**FAO (2015)**	**FAO (2015)**	**FAO (2015)**
Calcium	148,7	86.3	17,1	6,9	50,3
Iron	13,2	15	2,1	0,7	3,8
Magnesium	249,6	502	137,1	73,5	169,4
Phosphorus	383,7	411	292,6	137,8	467,7
Potassium	926,7	732	377,1	118,3	578,3
Zinc	4,4	4	2,9	0,6	4,7

3.4. Current state of quinoa production and consumption in Burkina Faso

In West Africa, Mali was the first country to conduct experimental work on this plant in 2007 [5]. In Burkina Faso, it was only in 2015 that the plant was introduced through the FAO project entitled "Technical assistance to strengthen the quinoa food system" for the benefit of seven West African countries, including Burkina Faso. Preliminary studies, carried out by INERA as part of this project, have shown that its cultivation and adoption are possible. [5]assessed the yield potential of six quinoa varieties and producers' perceptions of quinoa cultivation at 3 different sites, namely, in the Hauts-Bassins region at Soumousso (Figure 1) and Banakélédaga and in the Boucle du Mouhoun region at Lanfiéra. The results showed that quinoa can develop well in farming environments.

Figure 1 Quinoa field, Soumousso site (Biego, 2023)

Six varieties of quinoa, *Negra collana*, *Salcedo INIA*, *Amarilla marangani*, *Psankalla*, *Puno* and *Titicaca*, were evaluated for seed yield in Soumousso and Banakélédaga (Hauts-Bassins) (Figure 1) and in Lanfiéra (Boucle du Mouhoun). The

average yields of the varieties evaluated at the three sites revealed that *Puno* (1.97 t/ha), *Psankalla* (1.80 t/ha) and *Titicaca* (1.53 t/ha) performed well in the field. In Togo, the *Titicaca* and Puno varieties presented average yields of approximately 1.6 t/ha.

Table 8 Grain yield of varieties according to the production site (t/ha) in Burkina Faso

Variety	**Production Sites**			
	Soumousso	Banakélédaga	Lanfiera	Moyenne
Puno	1,85	2,70	1,37	1,97
Titicaca	1,17	2,06	1,37	1,53
Psankalla	0,98	1,54	2,88	1,80
Negra collana	0,26	0,22	0,35	0,27
Amarilla Marangani	-	0,44	0,16	0,3
Salcedo INIA	-	0,89	0,74	0,81

The growers at the three production sites involved in the study said they had no previous knowledge of quinoa. However, when examining quinoa plants and grains, they noted a certain resemblance to other plants, such as sesame (*Sesamum indicum*), amaranth (*Amaranthus*), chia (*Salvia hispanica*) and false sesame (*Ceratotheca sesamoides*). Quinoa grains were compared with those of millet (*Pennisetum glaucum*), sorghum (*Sorghum bicolor*), and fonio (*Digitaria exilis*). However, farmers welcomed the cultivation of quinoa because of its potential to correct nutritional deficiencies in their diets. They also reported that the crop is easy to manage and emphasized the taste quality of quinoa-based dishes. As a result, they are committed to integrating quinoa into their regular diet, which probably justifies its future adoption by growers in Burkina Faso[5]**.**

Quinoa consumption in Burkina Faso is currently very low or almost nonexistent, as the crop is still poorly understood in the country. However, the work of [5] has made it possible to initiate trials for transforming quinoa grains into local dishes (Table 9). During this activity, 30 women followed the demonstration and practiced the process of using quinoa in the preparation of various dishes, namely, "Gnongon", a local dish usually prepared with millet grains, Donut, biscuits and a drink "zoom-koom". The majority of participants found it easy to prepare these dishes with quinoa and now feel able to use this cereal in their daily cooking. A hedonic test was carried out to assess the taste of the different dishes. The results in the following table show that 70% of the women greatly appreciated the taste of these dishes[5]**.**

Table 9 Appreciation of quinoa-based dishes

Details	**Local food « Gnongon »**	**Local drink « zoom-koom »**	**Donut**	**Biscuit**	**Medium**
Very good	73,33%	60%	70%	76,66%	70%
Good	26,66%	30%	30%	23,33%	27,5%
Less good	0%	0%	0%	0%	0%
No opinion	0%	10%	0%	0%	2,5%

Quinoa is just being introduced in Burkina Faso and has yet to become part of the Burkinabè diet. However, if its cultivation is adopted by producers, the availability of grains will certainly encourage households and consumers to use it in the preparation of various local dishes and prepackaged finished products, which usually use cereals as raw materials (tô, porridge, couscous, dégue, gapal, zoom-koom, infant flours, cookies, cakes, etc.); quinoa should be able to adapt to cereal processing technologies.

4. Discussion

4.1. Market potential of quinoa

Quinoa has become an important crop in many countries around the world, including South America, Europe, Asia and Africa. Owing to its exceptional nutritional value and undemanding cultivation, quinoa is considered a promising alternative for food diversification and food security in developing countries. However, quinoa production remains concentrated in a small number of countries, posing challenges for marketing the product. In addition, the global demand for quinoa has led to rising prices, making it more difficult for poorer populations in regions where quinoa is traditionally consumed to feed themselves [10].

Despite these challenges, quinoa's production and marketing potential remain important for food diversification and food and nutrition security in developing countries. In West Africa, for example, it is almost unknown. However, it can be an emerging crop because of its high nutritional value, which can generate a financial impact in our context, from production to consumption, as well as export. This could contribute to the country's gross domestic product.

4.2. Quinoa use in postharvest processing

The immediate postharvest processing of quinoa includes drying or stacking, threshing, venting, and storing. Drying or stacking involves arranging the plants in stacks immediately after cutting and can be performed via different methods, including Arcos (stacking in crosses), Taucas (panicles ordered toward the same side), or Chucus (cone shaped mounds). Threshing consists of the separation of grains from the panicle [26].

Quinoa can be used to prepare sweet or savory dishes, such as soups, salads, stuffed vegetables, desserts, beverages, etc. A wide variety of culinary preparations can be made using quinoa, making most of the nutritional richness of this pseudocereal. Quinoa seeds can be used in a variety of culinary dishes, including as a substitute for rice, pasta, semolina or flour, in both traditional and modern recipes [10].

In addition to the seeds, quinoa leaves are edible and are used in traditional Andean cuisine to prepare dishes such as quinoa soup, the Andean "pilaf". Young quinoa shoots are also edible and used in salads [27].

4.3. Advantages, limitations and prospects for the development of quinoa cultivation in Burkina Faso

To improve agricultural productivity and support the livelihoods of disadvantaged farmers, particularly those dependent on poor-quality land and limited water resources, it is crucial to identify alternative crops that are both resistant to environmental stress and rich in nutrients.

Quinoa is therefore emerging as a prime alternative to the current food production challenges in Burkina Faso, as well as in many West African countries, particularly in the Sahel region. For this purpose, the development of quinoa cultivation in Burkina Faso offers several potential benefits:

First, quinoa cultivation can contribute to food diversification, offering a nutritious alternative to traditional crops such as millet, maize, sorghum and rice, particularly in developing countries where access to a diversified and balanced diet is limited [6]. Quinoa can be grown in arid areas with low fertility [3]. The regular consumption of quinoa can help reduce malnutrition.

Quinoa is also an interesting crop for agricultural diversification, particularly in arid and semiarid regions where traditional crops have low yields and are subject to climatic hazards ([3];[28]). Indeed, quinoa is a drought-resistant crop and can be grown in difficult conditions, making it suitable for areas where other crops cannot be grown successfully.

Finally, growing quinoa can also offer additional income opportunities for local farmers, particularly in regions where agricultural production is limited [29], [30]. Quinoa is currently grown during the dry season in Burkina Faso, which means that it can be produced anywhere in the country and will provide an activity for producers during the dry season, improving their economy and standard of living. Indeed, quinoa is a high value-added crop [29], often sold at a higher price than traditional crops such as millet and sorghum.

The work of Dao et al. in 2019, during agricultural experiments with 110 growers in Burkina Faso, provided insight into growers' perceptions of quinoa cultivation. In fact, 63% of growers found seedbed preparation easy, and 38% found it

similar to market gardening. Seeding was easy for 72% of the growers but difficult for 23%. Fifty-six percent (56%) of growers felt that the method and frequency of irrigation for quinoa were the same as those for vegetable crops, but 39% of growers felt that irrigation for quinoa was relatively easier. Staking and weed control were easy for 50% and 78% of the growers, respectively. In addition, 94% of the growers felt that watering twice a week was sufficient to meet the plant's needs. In addition, 6% of the farmers reported that irrigation once a week kept the crop free from water stress. Fifty percent (50%) of growers reported that quinoa harvesting was less painful. The quinoa grain emergence, plant development and yields obtained were well appreciated by growers.

4.4. Challenges and development prospects

Agricultural research and development play crucial roles in the successful adoption of quinoa. Scientists can help improve plant production techniques and increase plant resistance to disease and pests, as well as develop techniques for processing quinoa for food in a variety of forms. Research efforts can also focus on adapting plants to local environmental conditions and developing drought-resistant varieties.

To develop quinoa cultivation in Burkina Faso, the following steps are necessary:

- First, campaigns should be organized to introduce quinoa and raise awareness of its cultivation among producers, and growers should wish to start producing quinoa into associations/groups.
- Second, producers' capacity in quinoa cultivation techniques, as well as in good harvesting and postharvest treatment practices, should be developed.
- Third, local processing (formulations of quinoa-based dishes and products, training actors to adopt processing technologies, etc.) and marketing of quinoa products should be developed.
- Finally, we provide technical and financial support from the state: funding quinoa research to provide certified seeds, technical itineraries, appropriate fertilizers, pest control techniques and methods, etc.

5. Conclusion and future perspectives

This review addresses the issues of quinoa production, processing and marketing with a goal of achieving food security in Burkina Faso. The nutritional properties of quinoa, as well as its ability to grow under difficult conditions, are discussed. Although there are barriers and challenges such as resistance to change and high production costs, the potential benefits of introducing quinoa for food security in Burkina Faso are considerable.

The introduction of quinoa could lead to significant nutritional benefits for local communities and positive changes in agricultural practices. It could also have positive economic and social effects, such as job creation and improved long-term food security. However, further research is needed to better understand the potential impacts of quinoa introduction and to overcome the barriers and challenges associated with its adoption.

Ultimately, the introduction of quinoa into the Burkina Faso diet is an important opportunity to improve food security, but it requires careful planning and implementation, as well as a clear understanding of potential impacts. Future research could focus on assessing the nutritional and economic benefits of introducing quinoa, cultivation and processing techniques, and ways of overcoming potential barriers and challenges.

In the West African subregion, the demand for quinoa could grow as a result of its increasing popularity as a superfood. The outlook for quinoa is therefore favorable, provided that producers and local governments succeed in overcoming the challenges associated with its adoption.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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