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Amaranth Production and Consumption in Kenya: Constraints and Opportunities

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Abstract

Amaranth production and consumption have the potential to enhance the food and nutrition security in Kenya, where the overall food deficit is between 20 percent and 30 percent amidst rainfall and temperature variability. The crop is hardy and grows well under various agro ecological conditions. Its seeds and leaves are edible and nutrient-dense, providing vitamins A, C, iron, zinc, and magnesium among others. Amaranth is however, underexploited in Kenya. In order to tap the benefits derived from amaranth, several production and consumption-related challenges, including exclusive dependence on a few foods such as maize, wheat, and rice and their sifted derivatives that lack important micronutrients as well as consumers' negative perception of traditional crops need to be addressed. Traditional crops, amaranth included, are generally termed 'poor man's food'. Through a systematic literature review and observation method, this paper explores the various constraints (e.g., poor distribution of certified seeds) and opportunities (e.g., emerging niche market) of amaranth production as well as strategies of promoting consumption (e.g., sensitization) of the crop in Kenya. This paper demonstrates that amaranth has the potential to partly offer a solution to challenges of climate variability as well as food and nutrition insecurity in Kenya. Amaranth may be included in Kenya's diets directly, whether in fresh or processed form; as vegetable or grain; as an accompaniment or main dish; as a medicinal herb or fortificant; and indirectly as livestock feed. Promoting the manifold uses of amaranth through channels such as conferences, schools, and media will contribute to better livelihoods among Kenyans.

Keywords: Amaranth, climate variability, food insecurity, Kenya, under-exploited

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Introduction

Globally, the human population is projected to rise from the current 8 billion to around 8.5 billion, 9.7 billion and 10.4 billion in 2030, 2050 and 2100, respectively (United Nations Department of Economic and Social Affairs [UNDESA], Population Division, 2022). Sub-Saharan Africa (SSA) is expected to contribute more than half of the global population increase anticipated by 2050 (UNDESA, Population Division, 2022). The population increase means more food demand. For instance, global cereal and meat demand is projected to increase by 1.03 percent and 1.42 percent per year, respectively, and at 2.43 percent and 3.65 percent in SSA between 2000 and 2050 (Ringler et al., 2010). During the same period (2000 to 2050), international prices of rice, wheat, and maize are projected to increase by 48 percent, 36 percent, and 34 percent, respectively (Ringler et al., 2010).

Agriculture will continue as the leading supplier of the increasing food demand. As such, global crop production should double by 2050 to satisfy the demand for food (Ray et al., 2013). Increasing crop production is, nevertheless, being undertaken in an environment constrained by variability in rainfall and temperature associated with climate change, posing major challenges to the venture particularly in countries such as Kenya that mainly rely on rain-fed agriculture (Pathak et al., 2018). Variability in temperature and change of onset, intensity, duration and frequency of rain positively or negatively influence the optimal crop production (Patrick et al., 2020). For instance, projections point to low yields of wheat, sweet potato and maize while that of millet and sorghum will be high in SSA (Porter et al., 2014). Generally, there have been low yields of staple crops (maize, wheat, rice, and potatoes) in Kenya (Patrick et al., 2020).

Reduced staple crop yields partly contribute to food and nutrition insecurity in Kenya. Ten million, four million, and 1.5 million people in the country are food insecure, chronically food insecure, and continuously require food aid, respectively while 29 percent of children five years and below are stunted (Njora & Yilmaz, 2021). Kenya’s overall food deficit which is between 20 percent and 30 percent increases annually (Republic of Kenya, 2019). Besides, overreliance on maize, wheat, rice, and potatoes increases micronutrient deficiencies and related diseases because they lack vitamin A and zinc (Aworh, 2018; Zhao et al., 2022). Moreover, reliance on a narrow spectrum of foods poses the risk of losing agricultural biodiversity, which is helpful in countering malnutrition (Hunter et al., 2019).

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Low cereal production in SSA and Kenya in particular implies more food imports at higher prices to make up for the deficits. World trade in cereals is projected to increase in almost threefold from 253 million metric tonnes in 2000 to 646 million metric tonnes by 2050 (Ringler et al., 2010). SSA is expected to have a net cereal imports increase by a factor of 5 within 50 years (2000 to 2050) (Ringler et al., 2010). In Kenya, average cereal imports in Kcal/day per capita are projected to rise to 1103 in 2050 from 403 between 2001 and 2010 (Chouchane et al., 2018). Higher food prices will depress food demand on final buyers in the longer term, with a decline of 1.5 percent expected in SSA by 2050 (Ringler et al., 2010). The decline in food demand will increase malnutrition rates in an already food-insecure region (FAO & ECA, 2018).

Malnutrition in SSA is further compounded by low intake of vegetables and fruits (Brückner & Caglar, 2016; Muyonga et al., 2020). Worldwide, 3.9 million deaths in 2017 were attributed to low consumption of fruits and vegetables (WHO, 2019). World Health Organization and FAO recommend that at least 400 grams or five servings of 80 grams of fruits and vegetables be eaten daily to benefit from their vitamins, minerals, essential micronutrients, fibre, and proteins (Aworh, 2018). However, the consumption of fruits and vegetables in SSA is a third of the WHO/FAO recommendation (FAO, 2020). In Kenya, the mean daily consumption of fruits and vegetables among young adults (aged 19–30 years) is 3.6 servings (Nyanchoka et al., 2022). Of the vegetables eaten in Kenya, exotic types (e.g., cabbages) are famous compared to amaranth even though their nutrient composition is lower (Table 1) (Muthoni & Nyamongo, 2010; Muyonga et al., 2020). Inadequate consumption of fruits and vegetables exposes Kenyans to non-communicable diseases (Wekesah et al., 2018).

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Table 1: Mean Nutrient Composition (per 100g) of Amaranth Vegetables Compared to Cabbages and Spinach

Nutrient Composition	Amaranth	Cabbage	Spinach
Potassium (mg)	411	-	470
Iron (mg)	8.9	0.7	3.1
Protein (g)	4.6	1.7	3.2
Calories	42	26	-
Carbohydrates (g)	8.2	6.0	4.3
Fiber (g)	1.8	1.0	0.6
Ascorbic acid (Vitamin C) (mg)	64	54	51
Calcium (mg)	410	47	93
Phosphorus (mg)	103	40	-
Carotenoids (Vitamin A) (IU)	6,100	100	8,100
Thiamine (Vitamin B1) (mg)	0.05	0.04	-
Riboflavin (Vitamin B2) (mg)	0.42	0.1	-

Source: Extracted from Muthoni and Nyamongo (2010); Rastogi and Shukla (2013).

Note. – represents missing data

Climate variability, food and nutrition insecurity are a concern in Kenya. As such, the government of Kenya is actively involved in addressing these concerns through increasing large-scale production of maize, potatoes and rice in 700,000 new acres via irrigation (Republic of Kenya, 2019; Republic of Kenya, 2020). Besides irrigation, several adaptation measures that can reduce adverse effects of climate variability including crop diversification, intercropping, planting drought-resistant or tolerant varieties, water harvesting techniques, and food biofortification among others have been documented (Ochieng et al., 2016; Patrick et al., 2020).

This review focuses on one of the climate variability adaptation measures, amaranth production and consumption, yet an underexploited indigenous crop (Chepkoech et al., 2019, 2020; Krause et al., 2019). Amaranth exists in more than 70 species and 400 varieties and grow wildly worldwide, with only a few cultivated in various countries (Aderibigbe et al., 2022). The crop is a C_4 plant, making it efficient in using CO_2 under a wide range of temperatures (from 25 to 40°C), higher light intensity, and moisture stress environments (Mlakar et al., 2010). Therefore, while amaranth thrives at 25°C, it tolerates low (15°C) and high (40°C) temperatures (Ebert, et al., 2011). Although actual data on global production and consumption of amaranth is not available, the contribution of neglected, underexploited and

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underutilized domesticated and undomesticated crops to global food production is approximated to be between 115-120 billion US$ per annum (Singh et al., 2019). Amaranth is a resilient multifunctional plant providing cereals and leafy vegetables with high essential nutritional value (Riggins et al., 2021).

The study contributes to the achievement of Sustainable Development Goal (SDG) number two: End hunger, achieve food security and improved nutrition and promote sustainable agriculture amidst the challenges of low cereal production, high food prices and low intake of vegetables. This review documents the common amaranth varieties in several parts of Kenya, their inherent features, and their uses. It also explores the emerging opportunities and constraints of amaranth production and strategies for promoting sustainable production and consumption of the crop in the country. It then highlights some recommendations in an attempt to make a case for intensified promotion of the inclusion of amaranth in Kenya’s diets.

Method and Materials

This study involved a review of published literature on climate variability and amaranth production. The observation method (photographs were taken by author) was also used to enhance information on amaranth farming. The Google Scholar search engine was mainly used to access online literature. The search was limited to a time span ranging from 2010 to 2023 to give the researcher a historical perspective of amaranth production, consumption, constraints, and opportunities in Kenya. Using selected keywords, including ‘amaranth production’, ‘amaranth consumption’, and ‘climate variability and agriculture’, to confine the internet search to the topic at hand, literature that was open access was reviewed. Data collected through observation was incorporated in this paper to provide current information on what is happening in some parts of the country where amaranth is cultivated. A detailed review of rainfall and temperature variability effects on crops as well as amaranth production and consumption with more focus on Kenya is described systematically in the following sections.

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Results and Discussions

Production of Amaranth in Kenya

In Kenya, amaranth grows well under a wide range of agroecological conditions (Alemayehu et al., 2014). The crop grows in poor soils but is best in fertile ones (Ebert, et al., 2011; Kariithi et al., 2018). As such, amaranth is grown in various regions in Kenya, including Kisumu, Vihiga, Nyamira, Bomet, Bungoma, Kakamega, Kisii, Kiambu, Nakuru, Kajiado and Kilifi (Kinyuru et al., 2012; Krause et al., 2019; Ochieng et al., 2019; Nyonje et al., 2022). Although amaranth can thrive on large farms (Patrick et al., 2020), its cultivation in Kenya is mainly by small-scale farmers on small parcels such as kitchen gardens (Plate 1). Besides being cultivated, amaranth grows wildly as a weed (Dizyee et al., 2020; Nyonje et al., 2022).

Fig. 1: Amaranth Growing as a Weed in a Kitchen Garden

Source: Author, April 2023

Although the total number of amaranth species world over is still unknown (Aderibigbe et al., 2022), a few species (Figure 2) are common in Kenya (Muriuki et al., 2014). The species include *A. dubius*, *A. blitum*, *A. spinosus* (spiked) and *A. hybridus* (red amaranth) mainly grown as vegetables; *A. Cruentus* as grain; and *A. hypochondriacus* as grain and vegetable (Muriuki et al., 2014; Muthoni & Nyamongo, 2010). The varieties go by the following names in Kenya; *Mchicha* (Swahili), *Terere* (Kikuyu), *Ododo/Soisoi* (Luo), *Tsimboga/Livogoi* (Luhya), *Emboga/Emboga Nyerere/Dodo* (Kisii), *Chelwanda/Mborochik* (Kalenjin), and *Logatsi* (Mijikenda) among others (Nyonje et al., 2022). Muthoni and Nyamongo (2010) note that *A. hybridus and A. graecizans* are widespread in the country; *A. dubius* is dominant in the coastal region; *A. sparganiocephalus* in regions occupied by nomadic pastoralists (Maasai, Turkana, Samburu, Pokot); *A. lividus* in Kisii, Nyanza and western while A. *spinosus* mainly thrive at the Coast and Western Kenya.

Fig.2: Three Types of Amaranths Common in Kenya

Note: From right to left *A. dubius*, *A. blitum* and *A. hybridus*.
Source: Author, April 2023

Inherent Features of Amaranth

Generally, amaranth has intrinsic features including resistance to drought, tolerance to heavy rainfall and pests and diseases (Chepkoech et al., 2019, 2020). Amaranth can produce a crop

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of edible leaves within two weeks and can mature within 60 days of planting (Aderibigbe et al., 2022). The crop is mainly grown by smallholder farmers for family food and income needs (Kinyuru et al., 2012; Krause et al., 2019). It is cultivated solely or intercropped (Malaba et al., 2018). However, the inherent features vary across the various varieties of amaranth (Muriuki et al., 2014). For instance, compared to other varieties, *A. Cruentus* and *A. blitum* better adapt to poor soil conditions and low soil moisture levels while *A. dubius* is less susceptible to wet/stem rot (Ebert, et al., 2011; Rastogi & Shukla, 2013). The inherent features of amaranth and the rising market demand are attracting more farmers to venture into its production (Krause et al., 2019).

Amaranth is a nutrient-dense crop providing vitamin A, C, iron, calcium, zinc and magnesium, protein, dietary fibre, lipids, unsaturated fatty acids and bioactive compounds such as phytosterols, squalene, fagopyritols, saponins and polyphenols necessary for health body development (Uusiku et al., 2010; Chivenge et al., 2015; Mbhenyane, 2017; Kambabazi et al., 2021). It is, however, important to note that the composition of nutrients varies in different species (Muriuki et al., 2014). For instance, *A. dubius* is a superior source of calcium and iron, while *A. cruentus* has high protein and phytochemicals (Muriuki et al., 2014). *A. dubius* has higher zinc content than *A. cruentus* and *A. hypochondriacus* – making it essential breeding material for amaranth breeders, best preferred by farmers (Fekadu et al., 2020).

The protein found in amaranth is high in the amino acid lysine, which is the key component found in insufficient amounts in maize, wheat, and rice (Alemayehu et al., 2014). This implies that amaranth would act as a suitable complement in the diets of Kenyans. However, it should be noted that the nutrient levels in amaranth are influenced by the ecological environment (Croft et al., 2017; Fekadu et al., 2020).

Consumption of Amaranth in Kenya

Both amaranth leaves and grains are eaten in Kenya (Nampeera et al., 2019). There is a notable increase in the consumption of amaranth in Kenya currently than was the case two decades ago (Fekadu et al., 2020; Krause et al., 2019; Macharia-Mutie et al., 2011; Uusiku et al., 2010). Amaranth is commonly eaten by most rural communities due to its being inexpensive and easy availability rather than the nutritional value (Gido et al., 2017). In addition, positive beliefs concerning the crop such as amaranth boosting blood in the body and milk production

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for nursing mothers, enhancing eyesight, eliminating marasmus in children, being an appetizer, detoxifying, and relieving constipation and menstrual pain, do promote its consumption (Nyonje et al., 2022).

Amaranth is mainly cooked before eating through boiling, frying or both (Nyonje et al., 2022). The vegetables are prepared either on their own or in combination with other foods such as kale, beans, and meat. Mbhenyane (2017) observes that amaranth is mixed with other vegetables to act as a tenderizer, reduce bitterness, improve flavour, save time for cooking, and increase the food quantity. Amaranth is mainly eaten as an accompaniment for other foods such as rice, but in rare circumstances, it is taken as a main dish (Macharia-Mutie et al., 2011). Including amaranth in diets caters for diversification, essential in achieving nutrient demands in body development. While cooking amaranth vegetables enhances their palatability and digestibility, it destroys microorganisms, minimizes their antinutrient content, it may denature the nutrients (Aderibigbe et al., 2022; Lee et al., 2018). This calls for further research on the best cooking methods.

Despite the improved consumption, some impediments remain to amaranth's full acceptability in Kenya (Okoth et al., 2017) (Figure 3). Several factors work in synergy to inhibit the consumption and, by extension, the cultivation of amaranth. The factors include the consumption of exotic vegetables such as kales, sensory attributes of amaranth, its seasonal availability, consumer's awareness of its nutritional and medicinal benefits, etc. (Gido et al., 2017; Nyonje et al., 2022).

Pests and diseases, poor distribution of quality seed in various parts of the country, uprooting as a harvest technique, and low yields during dry seasons reduce the quality and quantity of the amaranth (Ochieng et al., 2019; Nampeera et al., 2019). During rainy seasons when vegetables are abundant, there are meagre sales coupled with very low prices (Nyonje et al., 2022). Because amaranth vegetables are highly perishable and farmers do not preserve them, they incur postharvest losses.

Emerging Opportunities

With Kenya becoming more vulnerable to climate variability, an increasing population size and transformation of agricultural land to built-up areas, crops that can withstand harsh climatic conditions, produce relatively high yields and thrive in small parcels of land such as

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amaranth (Figure 2) may be the feasible complements or alternatives (Bharucha & Pretty, 2010; Kariithi et al., 2018; Patrick et al., 2020; Onyango et al., 2013). Grain amaranth, being high yielding, fast growing, resistant to drought, and nutrient-dense has the potential to complement staple food crops in Kenya (Alemayehu et al., 2014). Furthermore, amaranth thrives with minimal effort even as weeds and can be intercropped with such crops as kales (Fig. 3) thus optimizing on land use as well as ensuring diet diversification (Malaba et al., 2018).

Kales

Amaranth

Fig. 3: Amaranth Growing as Weeds among Kales in a Kitchen Garden

Note. 'Amaranth weeds' are harvested as vegetables before weeding while a few are allowed to continue growing among the kales.

Source: Author, April 2023.

Four (i.e., *A. dubius*, *A. hybridus*, *A. blitum* and *A. cruentus*) of the amaranth varieties found in Kenya have been improved (Ochieng et al., 2019). The improved varieties have large leaves, enhanced palatability, and are more drought-tolerant (Ochieng et al., 2019). Improved amaranth seeds are mainly supplied by Kenya Seed Company (KSC) Ltd, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya Agricultural and Livestock Research Organization (KALRO) and East Africa Seed Company (Ochieng et al., 2019). Availability of improved amaranth seeds presents an opportunity for farmers to grow high-yielding and drought-resistant varieties.

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There is an emerging market niche of consumers who prioritize the nutritional value and safety of their foods in Kenya and beyond (Aderibigbe et al., 2022; Rojas-Rivas et al., 2019; Singh et al., 2019). In Kenya, the niche market comprises high-performance athletes, malnourished children, HIV/AIDS and diabetic patients, people suffering from coeliac disease and those allergic to gluten (Alemayehu et al., 2014; Kinyuru et al., 2012; Muyonga et al., 2014; Nyonje et al., 2022). Besides, there is a rise in demand by urban residents (Krause et al., 2019; Ngenoh et al., 2018). Internationally, developed nations such as Germany import amaranth grains for use in food industries (Aderibigbe et al., 2022). These markets present an opportunity for farmers to exploit.

Amaranth is a feasible fortificant due to its inherent features. Fortification of staple foods has the potential to alleviate micronutrient deficiency and malnutrition problems in Kenya (De Groote et al., 2020; Olson et al., 2021). Amaranth flour has been suggested as a fortificant for foods such as maize (Okoth et al., 2017; Singh & Punia, 2021). Amaranth as a fortificant may be appropriate for financially struggling farmers in Kenya who may find it expensive to buy fortified planting materials or mineral fertilizers (Chadare et al., 2019; Olson et al., 2021). Moreover, poor farmers may neither afford industrial fortified foods for their consumption nor point-of-use fortification which targets specific groups, usually a small percentage, leaving out many in the society (Chadare et al., 2019; Olson et al., 2021). The use of amaranth to fortify foods could enhance the food and nutrient security of lots of people, enhance the utilization of traditional diets as well as promote Kenyan-based food systems and biodiversity.

The manifold uses of amaranth need to be exploited (Figure 4). In an attempt to shed more light on the multiple uses of amaranth, this review was guided by multifunctionality theory. The theory determines the role of agriculture and its structural elements in the modern economy (O'Farrell, 2005). It purports that an economic activity may have multiple outputs including intended and unintended ones (O'Farrell, 2005; Zhichkin et al., 2022). The theory has been widely applied in the study of agriculture and rural development of developed nations such as Russia in advocating for government support of agriculture (Robinson, 2018; Zhichkin et al., 2022).

Although multifunctionality theory may not be wholly replicated in developing countries such as Kenya, it provides a basis for the ideas presented in Figure 4 on amaranth

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farming. Apart from being human food, it is also emerging that amaranth has medicinal value, is an important fodder for livestock, their stalks are used for firewood, it is part of greening the environment, and preserves biodiversity and cultures of Kenyan communities (Muriuki et al., 2014; Nyonje et al., 2022). However, more research is required in order to scientifically establish the medicinal value of amaranth.

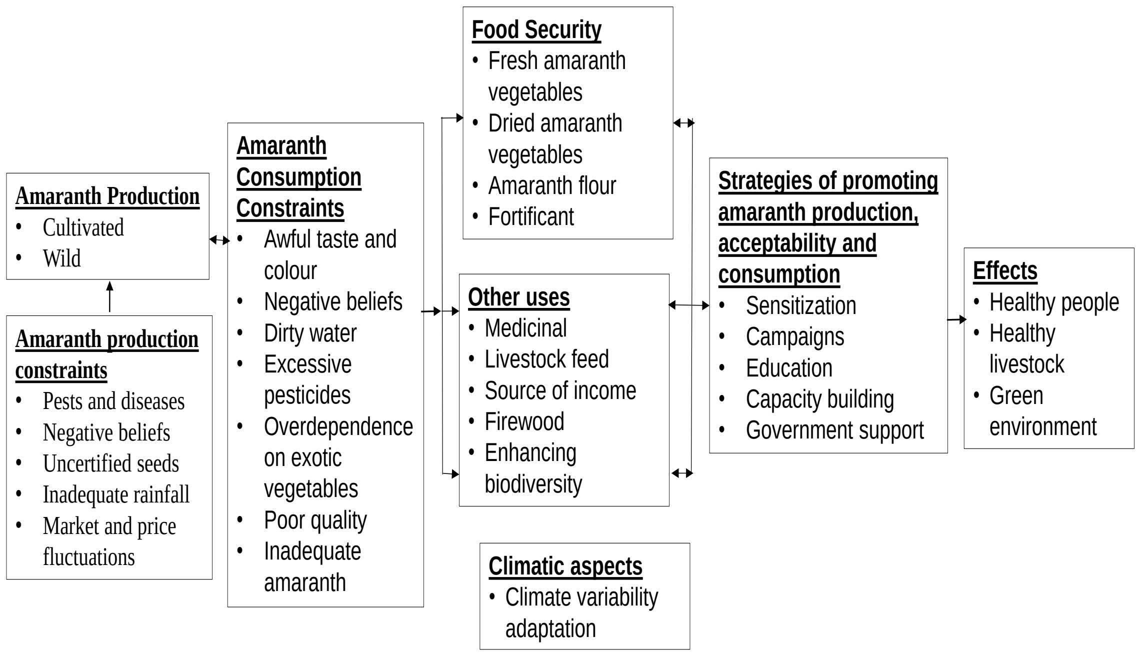

Fig. 4: A Conceptual Model Depicting the Manifold Uses, Production and Consumption Constraints, Strategies of Promoting Production, Acceptability and Consumption, and Effects of Amaranth

Note. A conceptual model developed by author from reviewed literature

Strategies for Promoting Acceptability of Amaranth

Acceptability of amaranth may be shaped by sensitization, education and capacity building. Activities (e.g., circulation of brochures, integrating awareness programmes on local or ethnic radio and television stations, well-coordinated market supply chains) geared towards raising awareness about the nutrient value of amaranth where producers, traders and consumers participate may be beneficial (Gido et al., 2017). Research indicate that such activities have in the past born fruits where ten years after such activities, almost half (45.2%) of participating households in Kenya had increased consumption of traditional leafy vegetables (Gotor & Irungu, 2010).

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Schools are avenues of creating awareness or application of interventions related to enhancing health diets (Hardcastle & Blake, 2016). School eating programmes do incorporate locally available foods in their diets (Bioversity International, 2019). Given the new Competent Based Curriculum (CBC), school-based interventions promoting the diverse importance of amaranth may be undertaken.

In order to achieve sustainability of what is learnt in school, the knowledge or skill should be transmitted to the parents or caregivers (Hardcastle & Blake, 2016). After all, some parents and caregivers are also the producers, buyers, and cooks of food at home. Besides, parents' dietary behaviour partly influences children's food intake (Mahmood et al., 2021; Monterrosa & Pelto, 2017; Scaglioni et al., 2018). Hardcastle and Blake (2016) and Mahmood et al. (2021) note that people seem to be socialized into particular types of eating when they are children and their childhood experiences may continue into adulthood. This observation implies that matters of health diets must go beyond production to encompass socio-psychological aspects.

Conclusion and Recommendations

The review demonstrates that amaranth has the potential to partly offer a solution to challenges of climate variability as well as food and nutrition insecurity in Kenya. Availability of amaranth in fresh or processed form, as vegetable or grain, as accompaniment or main dish, as medicinal herb or fortificant, as human food or livestock feed present opportunities of directly or indirectly having more of it on Kenyans' plates. However, Kenyans need to be incentivized to overcome common prejudices about amaranth and include it in their diets. Kenyans need to transition from production and consumption of a few staple crops and exotic vegetables to the underutilized nutrient-dense foods such as amaranth that thrive with minimal effort within a non-predictable climate variability environment making them readily available in most seasons of the year in many parts of the country. This will help transform Kenya into a greener and healthier country, contributing to the attainment of the SDG number two.

The study recommends an awareness campaign to all the stakeholders in the amaranth value chain including; farmers, traders, consumers, nutritionists, environmentalists, scientists, and policy makers, on the nutritional and biodiversity values of the crop. Concerted effort by

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all stakeholders in the amaranth value chain to implement the transition from a few staple foods and exotic vegetables to amaranth is encouraged.

The study also advocates for training on appropriate preparation and flavour promoting cooking methods of amaranth that minimally denature nutrients. There is also need to train farmers on the appropriate conservation techniques of surplus amaranth to reduce postharvest losses and ensure its availability during low production seasons.

This paper is mainly based on secondary data. An empirical study to determine the actual servings of amaranth consumed by Kenyans in both rural and urban areas is recommended.

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