

Sweetpotato, Functional Food in Africa

Subjects: **Food Science & Technology**

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Sweetpotato is regarded as a functional food because it contains bioactive compounds. Recently, sweetpotato has gained attention in sub-Saharan Africa (SSA), but research has focused on its use in alleviating micronutrient deficiencies such as vitamin A deficiency, particularly the orange-fleshed variety of sweetpotato. However, with the increased risks of non-communicable diseases plaguing developing countries, sweetpotato can be viewed in the light of a functional food. Sweetpotato has a potential of mitigating oxidative damage that leads to metabolic and other lifestyle-related diseases. Therefore, more research should focus on this aspect.

sweetpotato

functional food

plant bioactive compounds

phytochemicals

noncommunicable diseases

type 2 diabetes

sub-Saharan Africa

1. Introduction

Noncommunicable diseases (NCDs), especially in developing countries are on the increase ^[1] ([Figure 1](#)). In the last couple of decades, consumers worldwide are becoming increasingly aware of the importance of consuming meals that prevent diseases and promote health ^{[2][3]}. Undernutrition and infections are believed to decline with economic development and increased incomes. However, there are attendant changes in diet and lifestyles that have resulted in a shift from consumption of traditional foods to highly processed foods, sugar, and unhealthy fats, as well as lower intake of complex carbohydrates ^{[1][4]}. This is the situation in most developing countries ^[1]. These dietary changes are associated with greater prevalence of obesity and hypertension in the population. The consequence of this is an increased risk of NCDs such as stroke and cardiovascular diseases, inflammatory conditions, metabolic syndrome and diabetes, chronic respiratory diseases, chronic kidney diseases, and cancer, among others ^[5].

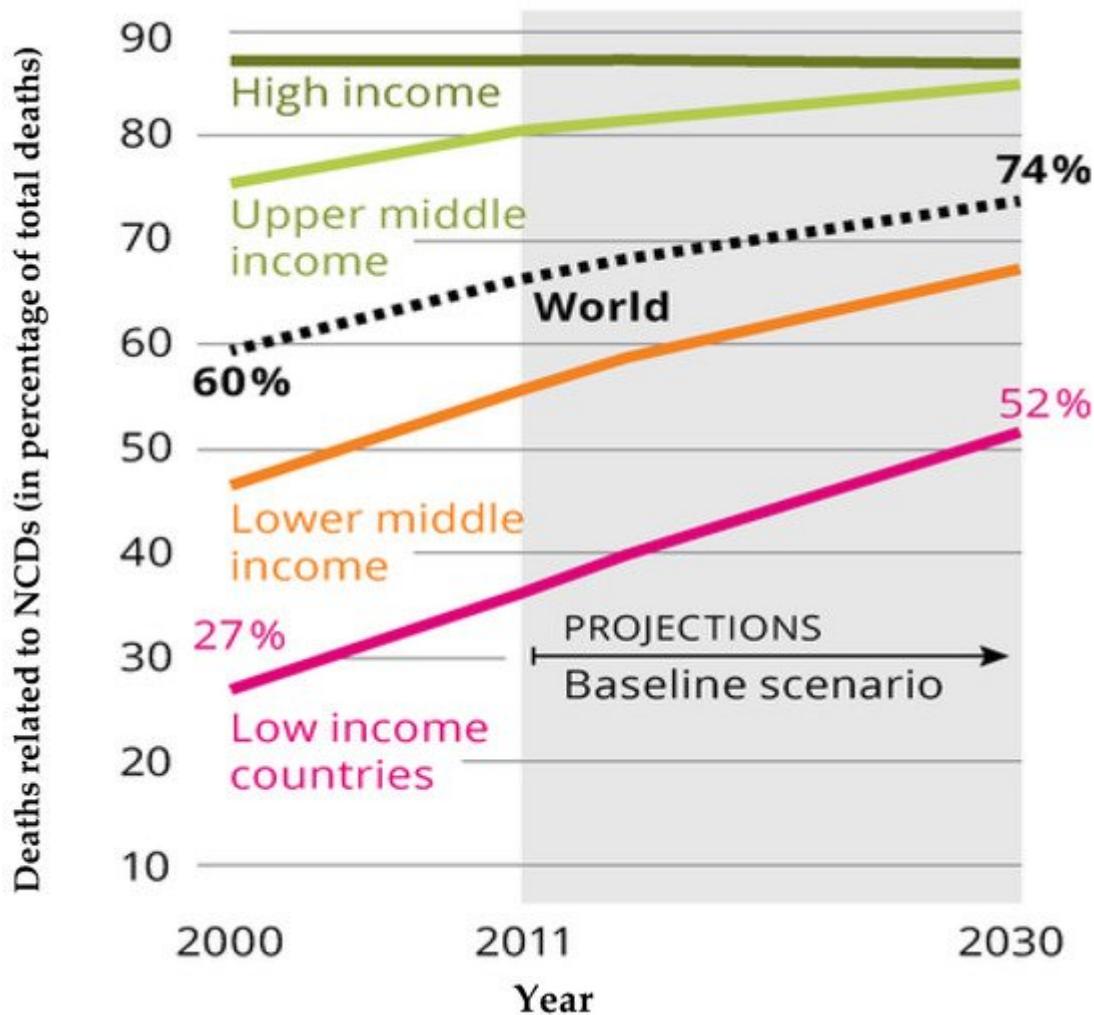


Figure 1. Future development of NCDs across world income regions. Source: European Environment Agency (2017). Downloaded from: <https://www.eea.europa.eu/data-and-maps/figures/the-shift-in-global-disease> [6].

In the light of the current global pandemic (COVID-19), the World Health Organization (WHO) has emphasized that people with NCDs are “among the most likely to become severely ill and die” from COVID-19 [7]. An optimal immune function that can prevent infections such as COVID-19 is dependent on, among other factors, adequate diet and proper nutrition [8]. Generally, an individual’s nutrition status, including consumption of functional foods, are known to promote proper functioning of the immune system [9].

The economic impact of the burden of NCDs is evident in increased personal and national healthcare costs, income losses, decreased productivity, and decreased life expectancy [5]. According to the WHO, in 2018, 71% of global deaths were due to NCDs [10]. It was reported that these NCDs had disproportionately higher rates in low- and middle-income countries, where over 85% of global “premature” deaths (deaths in population aged 30–69 years) due to NCDs occurred [10]. This situation, which poses a serious public health threat to developing countries [1], calls for attention.

Type 2 diabetes mellitus (T2DM), a chronic metabolic disorder, currently affects approximately 422 million people worldwide, with the majority living in low- and middle-income countries [11]. With T2DM having obesity as a highly

probable risk factor [12], it is one of the NCDs with an alarming increasing prevalence, especially in developing countries, due to the increased rates of obesity. Between 2013 and 2035, the Africa region, for example, is expected to have as high as a 109.1% increase in the number of T2DM cases [13].

In the past, public health interventions in SSA have focused on communicable diseases and maternal, neonatal, and nutritional disorders. However, NCDs in the region are a growing concern and are now key causes of morbidity and mortality [14]. Among the common, modifiable risk factors that underlie the major NCDs include unhealthy diet [1][10].

Instead of relying on pharmaceutical drugs, with their high costs and associated side effects, to manage the increasing NCD menace, food-based approaches would be a more practical and sustainable solution. Thus, dietary diversity and the regular consumption of cheap and readily available functional foods in SSA such as sweetpotato (*Ipomoea batatas* (L.) Lam, Convolvulaceae) could be encouraged. This could contribute to reducing the incidences of nutrition-related NCDs such as T2DM. Hence, research efforts that focus on these areas are a necessary step in all affected countries.

Sweetpotato, a starchy root crop, can be referred to as a “3-in-1” product, due to its integration of the qualities of cereals (high starch), fruits (high vitamin and pectin content), and vegetables (high vitamin and mineral content) [15]. Sweetpotato roots contain macronutrients such as starch, dietary fiber, and protein, in addition to a broad range of micronutrients including manganese, copper, potassium, iron, vitamin B complex, vitamin C, vitamin E, and provitamin A (as carotenoids, mostly in yellow and orange-fleshed varieties) [16][17][18]. The skin is usually brown, beige, red, or purple, while the flesh color may be white, cream, yellow, orange, or purple [19][20].

Globally, sweetpotato is the seventh most important staple, and in developing countries it ranks fifth, after rice, wheat, maize, and cassava [19]. Among the root and tuber crops cultivated globally, sweetpotato is the second after cassava [18]. As of 2019, the top four global producers of sweetpotato, ranking after China, were all SSA countries: Malawi, Nigeria, Tanzania, and Uganda [21]. Sweetpotato is drought-tolerant once established. It therefore has the potential of improving food and nutrition security, in the mostly rain-fed agriculture in the developing world, where droughts could severely affect yields of other staples such as cereals [22]. It was estimated that more than 2 billion people in Africa, Asia, and Latin America would depend on sweetpotato for food by 2020 [23]. In Uganda, for example, sweetpotato is the fourth most important staple and is grown by over 44% of farmers [24]. Further, it was estimated that by 2018, the biofortified orange-fleshed sweetpotato (OFSP) would have been adopted by over 292,000 Ugandan farming households who would be planting and eating it [24].

Sweetpotato roots are also regarded as a functional food, as they provide, in addition to nutrients, other physiological benefits [20]. They are rich sources of phytochemical compounds such as carotenoids, tocopherols, phenolic compounds, tannins, flavonoids, saponins, and anthocyanins, with their levels varying based on flesh color and variety [20][25]. These bioactive phytochemicals, either singly or collectively, exhibit antioxidant, cardioprotective, antidiabetic, hepatoprotective, neuroprotective, anti-inflammatory, and antimicrobial activities, as well as bowel-regulation properties [26]. The resulting effects are disease-fighting and immune-system-boosting,

which ultimately promote health and longevity [27]. The bioactive phytochemicals found in sweetpotato act as potential sources of antioxidants that can scavenge free radicals, and reduce or inhibit cellular damage and reduce metabolic oxidative stress, resulting in disease prevention and better health [17][26].

In recent years, biofortification programs carried out by several countries in SSA, such as Uganda, Malawi, Ghana, Mozambique, Kenya, and Ethiopia, have contributed to the release of new yellow, orange, and purple-fleshed sweetpotato varieties, but mainly OFSP for its provitamin A content [28][29][30][31]. In addition, these sweetpotato varieties may have other optimized traits such as enhanced disease tolerance and early maturity [29][32]. However, the great attention received by the biofortified sweetpotato has primarily been for the purpose of improving nutrition of low-income groups and vulnerable populations, such as children under five and women of child-bearing age [31][33][34].

OFSP, for example, has been highlighted as a choice crop for addressing vitamin A deficiency (VAD) due to its high level of carotenoids, especially β -carotene, the precursor of vitamin A [35][36][37][38]. OFSP has therefore been used in product formulations like complementary foods, crisps, and bread [39][40][41][42]. Generally, sweetpotato has great value in the food industry and has been used for baked foods, confectionaries, and beverages, among other uses [18][43].

Owing to its significant levels of bioactive phytochemicals, it is prudent for research focus on sweetpotato varieties in SSA to shift toward their potential use as functional food and how different processing methods affect the retention of the phytochemicals. In other parts of the world, research has investigated the potential of sweetpotato as functional food; however, such studies are scanty in SSA. Two recent studies in SSA investigated sweetpotato varieties for phytochemicals. The first compared inherent phytochemicals in leaves and storage roots of seven OFSP varieties from Kenya [44]. A second study followed up that evaluated the effect of boiling and frying on retention of some phytochemicals in Kenyan OFSP roots, as well as products from the roots [45]. However, more research is needed to compare not only OFSP varieties, but also other flesh colors. In addition, a broader range of cooking methods that are traditionally applied to sweetpotato in SSA before consumption could be evaluated. This would provide more information on how those methods affect phytochemical retention, and therefore offer recommendations to stakeholders such as farmers, processors, and consumers.

2. Sweetpotato Varieties, Their Distinctive Flesh Colors, and Levels of Bioactive Compounds

There are many varieties of sweetpotato known and cultivated around the world. These varieties come in different storage root skin and flesh colors, shapes, and sizes, and vary in taste and texture. The different varieties of sweetpotato are generally characterized by the skin and flesh color of the storage roots, as well as other agronomic traits such as leaf and stem morphology [46].

Recent research studies have supported the fact that the different varieties of sweetpotato contain different levels of bioactive phytochemical compounds, depending on genetic and environmental factors [47][48][49][50]. The major

phytochemicals that are generally present in sweetpotato are flavonoids, terpenoids, tannins, saponins, glycosides, alkaloids, carotenoids, steroids, and phenolic compounds [20][48]. These constituents may vary with varieties depending on flesh and skin color [51][52]. The staple root types in SSA, which are white- or cream-fleshed, are characterized by their high starch content [53]. Other flesh colors range from yellow to pale orange, deep orange, red, and purple. The orange-fleshed ones predominantly contain α -carotene, β -carotene, and β -5 cryptoxanthin [54]. They are usually characterized by their high β -carotene content, with a direct correlation between the intensity of the orange color and level of β -carotene [54].

Purple-fleshed sweetpotato (PFSP) contains higher levels of anthocyanins than other varieties [55]. The antioxidant activities of sweetpotato have mostly been attributed to their phenolic compounds, anthocyanin, and carotenoid contents [49][56]. Phenolic acids such as chlorogenic, isochlorogenic, caffeic, cinamic, and hydroxycinamic, generally present in all sweetpotato varieties, are also associated with their sensory qualities [57][58]. They are more abundant in PFSP and white-fleshed sweetpotato (WFSP) than in the other colored varieties [59].

Phytochemical screening of sweetpotato showed high percentages of reducing sugars and phenolic compounds in WFSP, while OFSP varieties contained higher levels of carotenoids, flavonoids, and total protein [50]. Another evaluation of the phytochemical diversity in sweetpotato roots of different flesh colors (orange, purple, and white) reported that carotenoid levels in OFSP were considerably higher, with β -carotene being predominant. In addition, phenolic acids and flavonoids were higher in PFSP compared to OFSP and WFSP [48].

In addition to variations in flesh color, another study suggested different genes were at work in the flesh versus skin of the sweetpotato, producing various concentrations of phytochemicals and antioxidants. A stronger antioxidant activity was reported in the peels of white and purple varieties when compared to the flesh samples [60]. This demonstrates that the skin of sweetpotato roots is also a rich source of antioxidative phytochemicals. Following this finding, more research is needed to establish if any significant differences exist between peeled and unpeeled sweetpotato roots that have undergone similar processing methods.

3. Sweetpotato Bioactive Compounds and Their Potential Health Benefits

Apart from sweetpotato roots being used as a staple food, earlier studies have shown that phytochemicals present in both the leaves and roots may be able to lower the potential health risks posed by free radicals [16][17][55][59]. [Table 1](#) provides a summary of the various health benefits associated with consumption of sweetpotato and the major bioactive compounds responsible for imparting those benefits.

Table 1. Health benefits associated with sweetpotato consumption.

Health Benefit	Bioactive Compound	Sweetpotato Flesh Color	References
Antioxidant capacity (scavenge free radicals)	Phenolic compounds, anthocyanins, carotenoids, tocopherols, flavonoids, ascorbic acid	White, cream, yellow, orange, purple	[44][55][59] [61][62][63]
Anticancer properties (colorectal, bladder, breast, pancreatic, lung, prostate)	Anthocyanins, ascorbic acid, carotenoids	Orange, purple	[64][65][66] [67][68]
Neuroprotection	Caffeoylquinic acid, anthocyanins	Purple	[69]
Reduction in systolic blood pressure	Anthocyanins	Purple	[70]
Hepatoprotective (improved liver function)	Anthocyanins, phenolic compounds	White, purple	[18][70]
Antimicrobial	Phenolic compounds, anthocyanins, flavonoids	White, cream, purple	[20][71][72] [73]
Antidiabetic (decrease blood sugar and lower insulin resistance)	Phenolic compounds, dietary fiber, resistant starch	White, cream, orange, purple	[74][75][76] [77][78][79]
Antiobesity	Anthocyanins, dietary fiber, resistant starch	White, purple	[80][81][82]
Anti-inflammatory	Anthocyanins, carotenoids, phenolic compounds, ascorbic acid	Yellow, orange, purple	[67][83]
Prebiotic and bowel regulation	Anthocyanins, carotenoids, dietary fiber, short-chain fatty acids	Orange, purple	[72][84]

Health Benefit	Bioactive Compound	Sweetpotato Flesh Color	References
Cardiovascular protection	Carotenoids, dietary fiber	Orange	[20][85]

vitamin A deficiency and providing a source of dietary antioxidants [54]. The relatively high anthocyanins and phenolic compounds in PFSP compared with other flesh colors, as stated earlier, possess antioxidant activities, and play a strong role in the prevention of degenerative illnesses such as cancer and cardiovascular diseases [46][62][63]. Studies have shown that PFSP has preventive properties against colorectal, breast, bladder, and pancreatic cancers [64][65][86][66], as well as elevated blood pressure [70].

4. Effects of Postharvest Processing and Cooking on Sweetpotato Bioactive Compounds

Domestic food-processing methods aim to make the final product more flavorful, tastier, more digestible, and microbiologically safer [87]. However, postharvest processing and heat treatments applied to foods, including sweetpotato roots prior to consumption, can cause changes in their chemical composition and impact the levels and bioavailability of their bioactive compounds [87]. **Table 2** summarizes the effect of different cooking methods on the retention of sweetpotato bioactive compounds.

Table 2. Effect of different cooking methods on the retention of sweetpotato bioactive compounds.

Bioactive Compound	Processing Method Applied	Sweetpotato Flesh Color	Effect on Retention	References
Phenolic compounds	Steaming	Orange	There were statistically nonsignificant increases in concentrations of both total phenolics and individual phenolic acids after cooking	[88]
Boiling, baking, frying, microwaving		Cream	Boiling decreased phenolic compounds concentration, while the other methods increased it	[89]
Boiling, steaming, baking, microwaving		Orange, purple	Except for boiling, all other cooking methods increased total phenolic content	[90]

Bioactive Compound	Processing Method Applied	Sweetpotato Flesh Color	Effect on Retention	References
Anthocyanins	Boiling, steaming, roasting, flour	Orange	Steaming, roasting, and flour processing decreased phenolic compounds, while boiling resulted in decreases in two of four varieties and increases in the other two	[91]
	Boiling, steaming, baking, microwaving	Purple	All cooking methods increased anthocyanin content, with microwaving being the highest	[90]
	Boiling, steaming, roasting	White, yellow, orange, purple	Anthocyanins were barely detected in white, yellow, and orange types. For the purple, all cooking methods decreased total anthocyanin content	[92]
	Steaming, baking	Purple	Steaming reduced total anthocyanin content by nearly half, while baking decreased it by 19%	[93]
Carotenoids	Boiling, steaming, baking, microwaving, deep frying, air frying, stir frying	Purple	Boiling increased total anthocyanin content, steaming and microwaving had no significant effect, but baking and all frying methods decreased it	[94]
	Boiling, baking, frying, microwaving	Cream	Boiling and frying increased total carotenoid concentrations, while baking and microwaving decreased it	[89]
	Boiling, steaming, roasting, flour	Orange	All methods decreased total carotenoid content, with flour processing exhibiting the greatest degradation	[91]

Bioactive Compound	Processing Method Applied	Sweetpotato Flesh Color	Effect on Retention	References
	Boiling, steaming, roasting	White, yellow, orange, purple	All cooking methods decreased total carotenoid content	[92]
	Induction boiling, conventional boiling, microwave steaming	Not specified	All methods decreased β -carotene content, with microwave steaming decreasing it the most	[95]
	Boiling, steaming, baking, deep frying	Orange	All methods generally decreased β -carotene content, with baking decreasing it the most	[96]
	Boiling, steaming, deep frying, drying (forced air convection, solar, open air)	Orange	All processing methods generally decreased β -carotene content, with solar drying retaining the most and steaming retaining the least	[97]
	Boiling, baking, frying, roasting	Not specified	The GI increased in the order boiling < frying < roasting < baking	[85]
Starch	Frying	Not specified	All fried samples had low to moderate GI	[98]
	Steaming, baking, microwaving, dehydrating	Orange	Dehydration resulted in the lowest GI, while all cooking methods resulted in a moderate GI	[99]

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5. Areas of Future Sweetpotato Research in Sub-Saharan Africa

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Sweetpotato as a Functional Food: Security in Global Health; Singh, R.B., Watson, R.R., Takahashi, T., Eds.; Elsevier Inc.: Cambridge, MA, USA, 2019; pp. 157–68. ISBN 9780128131480. [\[75\]](#) [\[78\]](#) [\[79\]](#) [\[100\]](#). However, not much research has focused on antidiabetic activities of sweetpotato varieties bred in SSA. Research on how cooked sweetpotato, the form mainly eaten in SSA, is warranted to find the evidence needed before recommendation to people with diabetes or insulin resistance to help control blood glucose. This diet therapy would be cheaper than conventional drugs and may have fewer side effects.

6. European Environment Agency. Future Development of NCDs across World Income Regions. Available online ([accessed on 7 May 2019](#)) suited for SSA and are therefore inexpensive and readily available. In addition, the transformation of sweetpotato roots into value-added marketable products is increasing.

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Asia and the United States. However, there is a knowledge gap between the theoretical bioactivity of these compounds and their actual influence on the body once ingested. There is no extensive research on their bioaccessibility after consumption, especially with respect to the effects of the food matrix and processing changes. Therefore, to fully understand the potential of sweetpotato varieties present in SSA as functional food, research is needed to explore the levels and bioaccessibility of their bioactive compounds, taking into consideration the various preparation and processing methods for maximum retention of these compounds.

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6. Conclusions

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In SSA especially, NCDs and metabolic disorders are steadily increasing, thereby prompting the need to fully understand how food-based approaches complement the current drug-based treatments. Although sweetpotato is an important food globally, it is only in recent years that research on this food crop has focused on its bioactive compounds, and hence its potential as a functional food. This review has shown that sweetpotato contains bioactive compounds such as carotenoids, polyphenols, dietary fiber, and RS. These compounds have been reported to play a role in modulating some metabolic processes, thereby imparting health benefits to humans. This review has further presented evidence on why sweetpotato can be regarded as a functional food and its preventive role against NCDs. However, there remains a gap to be addressed with regard to characterization of SSA sweetpotato varieties, how common processing methods employed by households in SSA affect the retention of their bioactive compounds, and the bioavailability of these compounds. These research efforts will provide holistic information on the functionality of sweetpotato in reducing NCDs among the individuals living in SSA.

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