Sweetpotato, Functional Food in Africa

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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.

Keywords: 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].

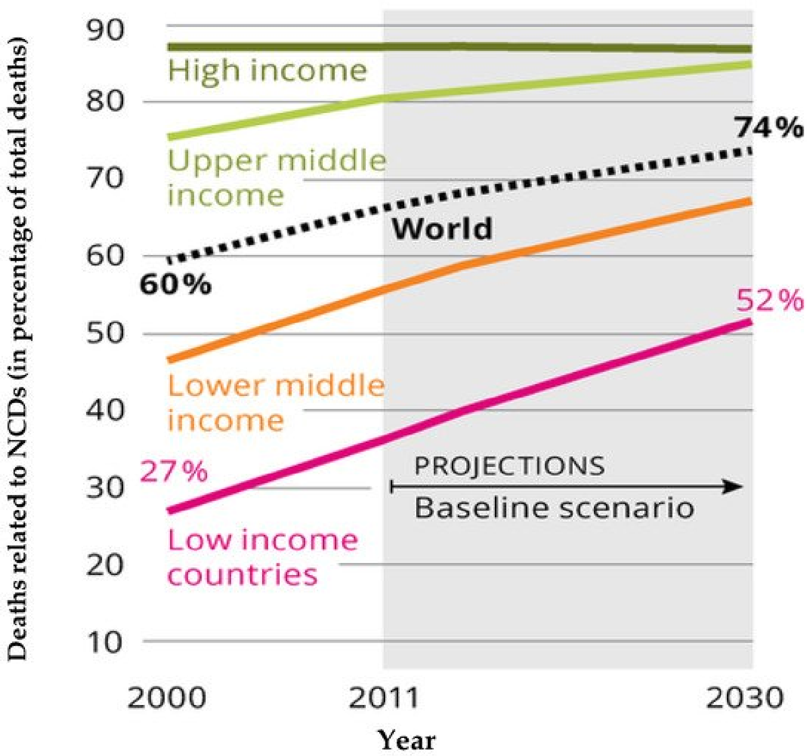

Figure 1. Future development of NCDs across world income regions. Source: European Environment Agency (2017). Downloaded from: https://www.eea.europa.eu/data-and-maps/figures/the-shift-in-global-disease [6].

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, cinammic, and hydroxycinammic, 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]
Cardiovascular protection	Carotenoids, dietary fiber	Orange	[20][85]

A red-fleshed sweetpotato cultivar grown in the Andean region, for example, has been reported to have higher antioxidant activity and phenolic content than a cultivar of blueberry, a fruit that is widely known to have high levels of antioxidants [61]. Carotenoids, mostly present in OFSP, also have potential antioxidant properties. In a study on OFSP varieties grown in Bangladesh, it was concluded that those varieties could serve a dual role of preventing 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]
	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]
Anthocyanins	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]
	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]

Bioactive Compound	Processing Method Applied	Sweetpotato Flesh Color	Effect on Retention	References
Carotenoids	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]
	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]
Starch	Boiling, baking, frying, roasting	Not specified	The GI increased in the order boiling < frying < roasting < baking	[85]
	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]

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

Sweetpotato, having bioactive phytochemicals as presented in this review, may have potential antidiabetic activity. Studies using extracts showed that sweetpotato exhibited potential antidiabetic activity [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.

The growing conditions of sweetpotato are aptly suited for SSA and are therefore inexpensive and readily available. In addition, the transformation of sweetpotato roots into value-added marketable products is increasing [18]. There is therefore the need for characterization of our varieties available for their bioactive components. From the literature, these bioactive compounds have been documented, especially in other parts of the world such as 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.

6. Conclusions

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.

References

1. Islam, S.M.S.; Purnat, T.D.; Phuong, N.T.A.; Mwingira, U.; Schacht, K.; Fröschl, G. Non-communicable diseases (NCDs) in developing countries: A symposium report. Glob. Health 2014, 10, 81.
2. Aguiar, L.M.; Geraldi, M.V.; Betim Cazarin, C.B.; Maróstica Junior, M.R. Functional food consumption and its physiological effects. In Bioactive Compounds-Health Benefits and Potential Applications; Campos, M.R.S., Ed.; Elsevier Inc.: Cambridge, MA, USA, 2019; pp. 205–225. ISBN 9780128147740.
3. Galanakis, C.M. Introduction to nutraceuticals and functional food components. In Nutraceutical and Functional Food Components; Galanakis, C., Ed.; Elsevier Inc.: London, UK, 2017; pp. 1–14. ISBN 9780128052570.
4. Rao, S.S.; Singh, R.B.; Takahashi, T.; Juneja, L.R.; Fedacko, J.; Shewale, A.R. Economic burden of noncommunicable diseases and economic cost of functional foods for prevention. In The Role of Functional Food Security in Global Health; Singh, R.B., Watson, R.R., Takahashi, T., Eds.; Elsevier Inc.: Cambridge, MA, USA, 2019; pp. 57–68. ISBN 9780128131480.
5. Isaza, A. Effects of western style foods on risk of noncommunicable diseases. In The Role of Functional Food Security in Global Health; Singh, R.B., Watson, R.R., Takahashi, T., Eds.; Elsevier Inc.: Cambridge, MA, USA, 2019; pp. 185–192. ISBN 9780128131480.
6. European Environment Agency. Future Development of NCDs across World Income Regions. Available online: (accessed on 7 May 2019).
7. WHO. Responding to Non-Communicable Diseases during and beyond the COVID-19 Pandemic: State of the Evidence on COVID-19 and Non-Communicable Diseases; WHO: Geneva, Switzerland, 2020.
8. Iddir, M.; Brito, A.; Dingeo, G.; Fernandez Del Campo, S.S.; Samouda, H.; La Frano, M.R.; Bohn, T. Strengthening the immune system and reducing inflammation and oxidative stress through diet and nutrition: Considerations during the covid-19 crisis. Nutrients 2020, 12, 1562.
9. Venter, C.; Eyerich, S.; Sarin, T.; Klatt, K.C. Nutrition and the immune system: A complicated tango. Nutrients 2020, 12, 818.
10. WHO. Noncommunicable Diseases-Key Facts. Available online: (accessed on 12 April 2021).
11. WHO. Diabetes-Key Facts. Available online: (accessed on 21 January 2021).
12. Maheshwari, A.; Saboo, B.; Singh, R.B.; Verma, N.; Vargova, V.; Pella, D.; Pella, D. Functional food security for prevention of diabetes mellitus. In The Role of Functional Food Security in Global Health; Singh, R.B., Watson, R.R., Takahashi, T., Eds.; Elsevier Inc.: Cambridge, MA, USA, 2019; pp. 157–166. ISBN 9780128131480.
13. Guariguata, L.; Whiting, D.R.; Hambleton, I.; Beagley, J.; Linnenkamp, U.; Shaw, J.E. Global estimates of diabetes prevalence for 2013 and projections for 2035. Diabetes Res. Clin. Pract. 2014, 103, 137–149.
14. Bigna, J.J.; Noubiap, J.J. The Rising burden of non-communicable diseases in Sub-Saharan Africa. Lancet Glob. Health 2019, 7, e1295–e1296.
15. Padmaja, G. Uses and nutritional data of sweetpotato. In The Sweetpotato; Loebenstein, G., Thottappilly, G., Eds.; Springer Netherlands: Dordrecht, The Netherlands, 2009; pp. 189–234. ISBN 978-1-4020-9474-3.

16. Bovell-Benjamin, A.C. Sweet potato: A review of its past, present, and future role in human nutrition. In Advances in Food and Nutrition Research; Taylor, S.L., Ed.; Elsevier Inc.: San Diego, CA, USA, 2007; Volume 52, pp. 1–59. ISBN 9780123737113.
17. Anbuselvi, S.; Muthumani, S. Phytochemical and antinutritional constituents of sweet potato. J. Chem. Pharm. Res. 2014, 6, 380–383.
18. El-Sheikha, A.F.; Ray, R.C. Potential impacts of bioprocessing of sweet potato: Review. Crit. Rev. Food Sci. Nutr. 2017, 57, 455–471.
19. Mohanraj, R. Sweet potato: Bioactive compounds and health benefits. In Bioactive Molecules in Food. Reference Series in Phytochemistry; Mérillon, J.M., Ramawat, K.G., Eds.; Springer International Publishing: Cham, Switzerland, 2018; pp. 1–16. ISBN 9783319545288.
20. Mohanraj, R.; Sivasankar, S. Sweet potato (ipomoea batatas [L.] lam)-a valuable medicinal food: A Review. J. Med. Food 2014, 17, 733–741.
21. Tridge Intelligence Data. Sweet Potato Global Production and Top Producing Countries. Available online: (accessed on 19 March 2021).
22. Motsa, N.M.; Modi, A.T.; Mabhaudhi, T. Sweet potato (Ipomoea batatas, L.) as a drought tolerant and food security crop. S. Afr. J. Sci. 2015, 111, 1–8.
23. Mu, T.; Sun, H.; Zhang, M.; Wang, C. Sweet Potato Processing Technology; Jones, G., Chan, K., Eds.; Academic Press, Elsevier Inc.: London, UK, 2017; ISBN 9780128128718.
24. USAID. Orange-Fleshed Sweet Potatoes: Improving Lives in Uganda. Available online: (accessed on 14 August 2018).
25. Woolfe, J. Sweet Potato: An Untapped Food Resource; Cambridge University Press: Cambridge, UK, 1992.
26. Panda, V.; Sonkamble, M. Phytochemical constituents and pharmacological activities of Ipomoea batatas L. (Lam)—A review. Int. J. Res. Phytochem. Pharmacol. 2012, 2, 25–34.
27. Shandilya, U.K. Functional foods and their benefits: An overview. J. Nutr. Health Food Eng. 2017, 7, 1–6.
28. Mwanga, R.O.M.; Odongo, B.; Niringiye, C.; Alajo, A.; Kigozi, B.; Makumbi, R.; Lugwana, E.; Namukula, J.; Mpembe, I.; Kapinga, R.; et al. 'NASPOT 7', 'NASPOT 8', 'NASPOT 9 O', 'NASPOT 10 O', and 'Dimbuka-Bukulula' sweetpotato. HortScience 2009, 44, 828–832.
29. Mwanga, R.O.M.; Kyalo, G.; Ssemakula, G.N.; Niringiye, C.; Yada, B.; Otema, M.A.; Namakula, J.; Alajo, A.; Kigozi, B.; Makumbi, R.N.M.; et al. 'NASPOT 12 O' and 'NASPOT 13 O' sweetpotato. HortScience 2016, 51, 291–295.
30. Musabyemungu, A.; Wasswa, P.; Alajo, A.; Chelagat, D.M.; Otema, M.A.; Rukundo, P.; Gibson, P.; Edema, R.; Pecota, K.V.; Yencho, G.C.; et al. Adaptability of a U.S. purple-fleshed sweetpotato breeding population in Uganda. Aust. J. Crop Sci. 2019, 13, 17–25.
31. Low, J.W.; Mwanga, R.O.M.; Andrade, M.; Carey, E.; Ball, A.-M. Tackling vitamin A deficiency with biofortified sweetpotato in Sub-Saharan Africa. Glob. Food Sec. 2017, 14, 23–30.
32. Okello, J.J.; Sindi, K.; Shikuku, K.; Mcewan, M.; Low, J.W. A study of household food security and adoption of biofortified crop varieties in Tanzania: The case of orange-fleshed sweetpotato. In International Development; InTechOpen: London, UK, 2017; pp. 19–36.
33. Jenkins, M.; Shanks, C.B.; Houghtaling, B. Orange-fleshed sweet potato: Successes and remaining challenges of the introduction of a nutritionally superior staple crop in Mozambique. Food Nutr. Bull. 2015, 36, 327–353.
34. Bouis, H.E.; Saltzman, A. Improving nutrition through biofortification: A review of evidence from HarvestPlus, 2003 through 2016. Glob. Food Sec. 2017, 12, 49–58.
35. Amagloh, F.K.; Hardacre, A.; Mutukumira, A.N.; Weber, J.L.; Brough, L.; Coad, J. A Household-level sweet potato-based infant food to complement vitamin A supplementation initiatives. Matern. Child Nutr. 2012, 8, 512–521.
36. Burri, B.J. Evaluating sweet potato as an intervention food to prevent vitamin A deficiency. Compr. Rev. Food Sci. Food Saf. 2011, 10, 118–130.
37. Islam, S.N.; Nusrat, T.; Begum, P.; Ahsan, M. Carotenoids and β-carotene in orange fleshed sweet potato: A possible solution to vitamin A deficiency. Food Chem. 2016, 199, 628–631.
38. Laurie, S.M.; Faber, M.; Claasen, N. Incorporating orange-fleshed sweet potato into the food system as a strategy for improved nutrition: The context of South Africa. Food Res. Int. 2018, 104, 77–85.
39. Adetola, O.Y.; Onabanjo, O.O.; Stark, A.H. The search for sustainable solutions: Producing a sweet potato based complementary food rich in vitamin A, Zinc and Iron for infants in developing countries. Sci. Afr. 2020, 8, e00363.

40. Bonsi, E.A.; Zabawa, R.; Mortley, D.; Bonsi, C.; Acheremu, K.; Amagloh, F.C.; Amagloh, F.K. Nutrient composition and consumer acceptability of bread made with orange sweet potato puree. Acta Hortic. 2016, 1128, 7–13.

41. Awuni, V.; Alhassan, M.W.; Amagloh, F.K. Orange-fleshed sweet potato (ipomoea batatas) composite bread as a significant source of dietary vitamin, A. Food Sci. Nutr. 2018, 6, 174–179.

42. Tumuhimbise, G.A.; Orishaba, J.; Atukwase, A.; Namutebi, A. Effect of salt on the sensory and keeping quality of orange fleshed sweetpotato crisps. Food Nutr. Sci. 2013, 4, 454–460.

43. Vithu, P.; Sanjaya, K.D.; Kalpana, R. Post-harvest processing and utilization of sweet potato: A review. Food Rev. Int. 2019, 35, 726–762.

44. Abong', G.O.; Muzhingi, T.; Okoth, M.W.; Ng'ang'a, F.; Ochieng, P.E.; Mbogo, D.M.; Malavi, D.; Akhwale, M.; Ghimire, S. Phytochemicals in leaves and roots of selected Kenyan orange fleshed sweet potato (OFSP) varieties. Int. J. Food Sci. 2020, 2020, 1–11.

45. Abong', G.O.; Muzhingi, T.; Okoth, M.W.; Ng'ang'a, F.; Ochieng, P.E.; Mbogo, D.M.; Malavi, D.; Akhwale, M.; Ghimire, S. Processing methods affect phytochemical contents in products prepared from orange-fleshed sweetpotato leaves and roots. Food Sci. Nutr. 2020, 9, 1070–1078.

46. Ayeleso, T.B.; Ramachela, K.; Mukwevho, E. A review of therapeutic potentials of sweet potato: Pharmacological activities and influence of the cultivar. Trop. J. Pharm. Res. 2017, 15, 2751.

47. Kourouma, V.; Mu, T.; Zhang, M.; Sun, H. Comparative study on chemical composition, polyphenols, flavonoids, carotenoids and antioxidant activities of various cultivars of sweet potato. Int. J. Food Sci. Technol. 2019, 55, 369–378.

48. Park, S.Y.; Lee, S.Y.; Yang, J.W.; Lee, J.S.; Oh, S.D.; Oh, S.; Lee, S.M.; Lim, M.H.; Park, S.K.; Jang, J.S.; et al. Comparative analysis of phytochemicals and polar metabolites from colored sweet potato (Ipomoea batatas, L.) tubers. Food Sci. Biotechnol. 2016, 25, 283–291.

49. Lebot, V.; Michalet, S.; Legendre, L. Identification and quantification of phenolic compounds responsible for the antioxidant activity of sweet potatoes with different flesh colours using high performance thin layer chromatography (HPTLC). J. Food Compos. Anal. 2016, 49, 94–101.

50. Shekhar, S.; Mishra, D.; Buragohain, A.K.; Chakraborty, S.; Chakraborty, N. Comparative analysis of phytochemicals and nutrient availability in two contrasting cultivars of sweet potato (Ipomoea batatas, L.). Food Chem. 2015, 173, 957–965.

51. de Albuquerque, T.M.R.; Sampaio, K.B.; de Souza, E.L. Sweet potato roots: Unrevealing an old food as a source of health promoting bioactive compounds–a review. Trends Food Sci. Technol. 2019, 85, 277–286.

52. Wang, S.; Nie, S.; Zhu, F. Chemical Constituents and Health Effects of Sweet Potato. Food Res. Int. 2016, 89, 90–116.

53. Tumwegamire, S.; Kapinga, R.; Rubaihayo, P.R.; LaBonte, D.R.; Grüneberg, W.J.; Burgos, G.; Felde, T.z.; Carpio, R.; Pawelzik, E.; Mwanga, R.O.M. Evaluation of dry matter, protein, starch, sucrose, β-Carotene, Iron, Zinc, Calcium, and magnesium in East African sweetpotato [Ipomoea batatas (L.) Lam] germplasm. HortScience 2011, 46, 348–357.

54. Alam, M.; Rana, Z.; Islam, S. Comparison of the proximate composition, total carotenoids and total polyphenol content of nine orange-fleshed sweet potato varieties grown in Bangladesh. Foods 2016, 5, 64.

55. Teow, C.C.; Truong, V.-D.; McFeeters, R.F.; Thompson, R.L.; Pecota, K.V.; Yencho, G.C. Antioxidant activities, phenolic and β-carotene contents of sweet potato genotypes with varying flesh colours. Food Chem. 2007, 103, 829–838.

56. Sun, Y.; Pan, Z.; Yang, C.; Jia, Z.; Guo, X. Comparative assessment of phenolic profiles, cellular antioxidant and antiproliferative activities in ten varieties of sweet potato (ipomoea batatas) storage roots. Molecules 2019, 24, 4476.

57. Musilová, J.; Bystrická, J.; Árvay, J.; Harangozo, Ľ. Polyphenols and phenolic acids in sweet potato (Ipomoea batatas, L.) roots. Potravin. Slovak J. Food Sci. 2017, 11, 82–87.

58. Rumbaoa, R.G.O.; Cornago, D.F.; Geronimo, I.M. Phenolic content and antioxidant capacity of Philippine sweet potato (ipomoea batatas) varieties. Food Chem. 2009, 113, 1133–1138.

59. Padda, M.S.; Picha, D.H. Quantification of phenolic acids and antioxidant activity in sweetpotato genotypes. Sci. Hortic. 2008, 119, 17–20.

60. Salawu, S.O.; Udi, E.; Akindahunsi, A.A.; Boligon, A.A.; Athayde, M.L. Antioxidant potential, phenolic profile and nutrient composition of flesh and peels from Nigerian white and purple skinned sweet potato (Ipomea batatas, L.). Asian J. Plant Sci. Res. 2015, 5, 14–23.

61. Cevallos-Casals, B.A.; Cisneros-Zevallos, L. Stoichiometric and kinetic studies of phenolic antioxidants from Andean purple corn and red-fleshed sweetpotato. J. Agric. Food Chem. 2003, 51, 3313–3319.

62. Ge, J.; Hu, Y.; Wang, H.; Huang, Y.; Zhang, P.; Liao, Z.; Chen, M. Profiling of anthocyanins in transgenic purple-fleshed sweetpotatoes by HPLC-MS/MS. J. Sci. Food Agric. 2017, 97, 4995–5003.

63. Steed, L.E.; Truong, V.-D. Anthocyanin content, antioxidant activity, and selected physical properties of flowable purple-fleshed sweetpotato purees. J. Food Sci. 2008, 73, S215–S221.

64. Asadi, K.; Ferguson, L.R.; Philpott, M.; Karunasinghe, N. Cancer-preventive properties of an anthocyanin-enriched sweet potato in the APC MIN mouse model. J. Cancer Prev. 2017, 22, 135–146.

65. Donaldson, M.S. Nutrition and cancer: A review of the evidence for an anti-cancer diet. Nutr. J. 2004, 3, 1–21.

66. Xu, J.; Su, X.; Lim, S.; Griffin, J.; Carey, E.; Katz, B.; Tomich, J.; Smith, J.S.; Wang, W. Characterisation and stability of anthocyanins in purple-fleshed sweet potato P40. Food Chem. 2015, 186, 90–96.

67. Sugata, M.; Lin, C.-Y.; Shih, Y.-C. Anti-inflammatory and anticancer activities of Taiwanese purple-fleshed sweet potatoes (Ipomoea batatas, L. Lam) extracts. Biomed Res. Int. 2015, 2015, 1–10.

68. Li, W.-L.; Yu, H.-Y.; Zhang, X.-J.; Ke, M.; Hong, T. Purple sweet potato anthocyanin exerts antitumor effect in bladder cancer. Oncol. Rep. 2018, 40, 73–82.

69. Sasaki, K.; Han, J.; Shimozono, H.; Villareal, M.O.; Isoda, H. Caffeoylquinic acid-rich purple sweet potato extract, with or without anthocyanin, imparts neuroprotection and contributes to the improvement of spatial learning and memory of samp8 mouse. J. Agric. Food Chem. 2013, 61, 5037–5045.

70. Oki, T.; Kano, M.; Watanabe, O.; Goto, K.; Boelsma, E.; Ishikawa, F.; Suda, I. Effect of consuming a purple-fleshed sweet potato beverage on health-related biomarkers and safety parameters in Caucasian subjects with elevated levels of blood pressure and liver function biomarkers: A 4-week, open-label, non-comparative trial. Biosci. Microbiota Food Health 2016, 35, 129–136.

71. D'Archivio, M.; Filesi, C.; Varì, R.; Scazzocchio, B.; Masella, R. Bioavailability of the polyphenols: Status and controversies. Int. J. Mol. Sci. 2010, 11, 1321–1342.

72. Zhang, X.; Yang, Y.; Wu, Z.; Weng, P. The modulatory effect of anthocyanins from purple sweet potato on human intestinal microbiota in vitro. J. Agric. Food Chem. 2016, 64, 2582–2590.

73. Boo, H.O.; Hwang, S.J.; Bae, C.S.; Park, S.H.; Heo, B.G.; Gorinstein, S. Extraction and characterization of some natural plant pigments. Ind. Crops Prod. 2012, 40, 129–135.

74. Zhang, Z.-F.; Lu, J.; Zheng, Y.-L.; Wu, D.-M.; Hu, B.; Shan, Q.; Cheng, W.; Li, M.-Q.; Sun, Y.-Y. Purple sweet potato color attenuates hepatic insulin resistance via blocking oxidative stress and endoplasmic reticulum stress in high-fat-diet-treated mice. J. Nutr. Biochem. 2013, 24, 1008–1018.

75. Mahadita, G.W.; Jawi, M.; Suastika, K. Purple sweet potato tuber extract lowers mallondialdehyde and improves glycemic control in subjects with Type 2 diabetes mellitus. Glob. Adv. Res. J. Med. Med. Sci. 2016, 5, 208–213.

76. Chen, Y.-Y.; Lai, M.-H.; Yu, T.-C.; Liu, J.-F. Low glycemic index sweet potato starch improves the postprandial glycemic response of STZ/nicotinamide-induced hyperglycemic rats by upregulating the proteins involved in insulin signaling. Curr. Top. Nutraceutical Res. 2012, 10, 179–185.

77. Chen, Y.-Y.; Lai, M.-H.; Hung, H.-Y.; Liu, J.-F. Sweet potato [Ipomoea batatas (L.) Lam. "Tainong 57"] starch improves insulin sensitivity in high-fructose diet-fed rats by ameliorating adipocytokine levels, pro-inflammatory status, and insulin signaling. J. Nutr. Sci. Vitaminol. 2013, 59, 272–280.

78. Akhtar, N.; Akram, M.; Daniyal, M.; Ahmad, S. Evaluation of antidiabetic activity of Ipomoea batatas, L. extract in alloxan-induced diabetic rats. Int. J. Immunopathol. Pharmacol. 2018, 32.

79. Ayeleso, T.B.; Ramachela, K.; Mukwevho, E. Aqueous-methanol extracts of orange-fleshed sweet potato (Ipomoea batatas) ameliorate oxidative stress and modulate Type 2 diabetes associated genes in insulin resistant C2C12 cells. Molecules 2018, 23, 2058.

80. Ju, R.; Zheng, S.; Luo, H.; Wang, C.; Duan, L.; Sheng, Y.; Zhao, C.; Xu, W.; Huang, K. Purple sweet potato attenuate weight gain in high fat diet induced obese mice. J. Food Sci. 2017, 82, 787–793.

81. Shih, C.-K.; Chen, C.-M.; Hsiao, T.-J.; Liu, C.-W.; Li, S.-C. White sweet potato as meal replacement for overweight white-collar workers: A randomized controlled trial. Nutrients 2019, 11, 165.

82. Zhang, Y.; Niu, F.; Sun, J.; Xu, F.; Yue, R. Purple sweet potato (Ipomoea batatas, L.) color alleviates high-fat-diet-induced obesity in SD rat by mediating leptin's effect and attenuating oxidative stress. Food Sci. Biotechnol. 2015, 24, 1523–1532.

83. Grace, M.H.; Yousef, G.G.; Gustafson, S.J.; Truong, V.-D.; Yencho, G.C.; Lila, M.A. Phytochemical changes in phenolics, anthocyanins, ascorbic acid, and carotenoids associated with sweetpotato storage and impacts on bioactive properties. Food Chem. 2014, 145, 717–724.

84. Muchiri, M.N.; Mccartney, A.L. In vitro investigation of orange fleshed sweet potato prebiotic potential and its implication on human gut health. Funct. Foods Health Dis. 2017, 7, 833–848.

85. Bahado-Singh, P.S.; Riley, C.K.; Wheatley, A.O.; Lowe, H.I.C. Relationship between processing method and the glycemic indices of ten sweet potato (Ipomoea batatas) cultivars commonly consumed in Jamaica. J. Nutr. Metab. 2011, 2011, 1–6.
86. Kapinova, A.; Stefanicka, P.; Kubatka, P.; Zubor, P.; Uramova, S.; Kello, M.; Mojzis, J.; Blahutova, D.; Qaradakhi, T.; Zulli, A.; et al. Are plant-based functional foods better choice against cancer than single phytochemicals? A critical review of current breast cancer research. Biomed. Pharmacother. 2017, 96, 1465–1477.
87. Ruiz-Rodriguez, A.; Marín, F.R.; Ocaña, A.; Soler-Rivas, C. Effect of domestic processing on bioactive compounds. Phytochem. Rev. 2008, 7, 345–384.
88. Truong, V.-D.; McFeeters, R.F.; Thompson, R.T.; Dean, L.L.; Shofran, B. Phenolic acid content and composition in leaves and roots of common commercial sweetpotato (Ipomea batatas, L.) cultivars in the United States. J. Food Sci. 2007, 72, C343–C349.
89. Ogliari, R.; Soares, J.M.; Teixeira, F.; Schwarz, K.; Da Silva, K.A.; Schiessel, D.L.; Novello, D. Chemical, nutritional and sensory characterization of sweet potato submitted to different cooking methods. Int. J. Res. Granthaalayah 2020, 8, 147–156.
90. Musilova, J.; Lidikova, J.; Vollmannova, A.; Frankova, H.; Urminska, D.; Bojnanska, T.; Toth, T. Influence of heat treatments on the content of bioactive substances and antioxidant properties of sweet potato (Ipomoea batatas, L.) tubers. J. Food Qual. 2020, 2020, 1–10.
91. Donado-Pestana, C.M.; Salgado, J.M.; de Oliveira Rios, A.; dos Santos, P.R.; Jablonski, A. Stability of carotenoids, total phenolics and in vitro antioxidant capacity in the thermal processing of orange-fleshed sweet potato (Ipomoea batatas L.) cultivars grown in Brazil. Plant Foods Hum. Nutr. 2012, 67, 262–270.
92. Tang, Y.; Cai, W.; Xu, B. Profiles of phenolics, carotenoids and antioxidative capacities of thermal processed white, yellow, orange and purple sweet potatoes grown in Guilin, China. Food Sci. Hum. Wellness 2015, 4, 123–132.
93. Kim, H.W.; Kim, J.B.; Cho, S.M.; Chung, M.N.; Lee, Y.M.; Chu, S.M.; Che, J.H.; Kim, S.N.; Kim, S.Y.; Cho, Y.S.; et al. Anthocyanin changes in the Korean purple-fleshed sweet potato, Shinzami, as affected by steaming and baking. Food Chem. 2012, 130, 966–972.
94. Liao, M.; Zou, B.; Chen, J.; Yao, Z.; Huang, L.; Luo, Z.; Wang, Z. Effect of domestic cooking methods on the anthocyanins and antioxidant activity of deeply purple-fleshed sweetpotato GZ9. Heliyon 2019, 5, e01515.
95. Nunn, M.D.; Giraud, D.W.; Parkhurst, A.M.; Hamouz, F.L.; Driskell, J.A. Effects of cooking methods on sensory qualities and carotenoid retention in selected vegetables. J. Food Qual. 2006, 29, 445–457.
96. Tumuhimbise, G.A.; Namutebi, A.; Muyonga, J.H. Microstructure and in vitro beta carotene bioaccessibility of heat processed orange fleshed sweet potato. Plant Foods Hum. Nutr. 2009, 64, 312–318.
97. Bengtsson, A.; Namutebi, A.; Alminger, M.L.; Svanberg, U. Effects of various traditional processing methods on the all-trans-β-carotene content of orange-fleshed sweet potato. J. Food Compos. Anal. 2008, 21, 134–143.
98. Odenigbo, A.; Rahimi, J.; Ngadi, M.; Amer, S.; Mustafa, A. Starch digestibility and predicted glycemic index of fried sweet potato cultivars. Funct. Foods Health Dis. 2012, 2, 280.
99. Allen, J.C.; Corbitt, A.D.; Maloney, K.P.; Butt, M.S.; Truong, V.-D. Glycemic index of sweet potato as affected by cooking methods. Open Nutr. J. 2012, 6, 1–11.
100. Ludvik, B.H.; Mahdjoobian, K.; Waldhaeusi, W.; Hofer, A.; Prager, R.; Kautzky-Willer, A.; Pacini, G. The effect of Ipomoea batatas (Caiapo) on glucose metabolism and serum cholesterol in patients with Type 2 diabetes-a randomized study. Diabetes Care 2002, 25, 239–248.