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Selected Superfoods and Their Derived Superdiets

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<http://dx.doi.org/10.5772/67239>

Abstract

Despite the reported decline in undernourishment in developing regions from 23.3% to 12.9% within 25 years, sub-Saharan Africa is the most malnourished region in the world, and the situation could get even worse depending on how the continent's love affairs with the few popular foods play out. The irony is that there are millions of nutrient-rich edible plants, insects and animals within tropical Africa, but due to modernization, only 3% of these foods are utilized within diets. Through a comprehensive literature review, this chapter will explore eight of the most feasible superfoods with an objective of using a systems approach to further look into their derived superdiets. Superfoods are naturally occurring plant or animal-based foods dense in nutrients, antioxidants and healthy fats, whilst superdiets are defined as feasible dishes prepared based on selected superfoods, incorporating other food ingredients and using appropriate processing and cooking techniques. The selected superfoods will include amaranth, teff, fonio, moringa leaves, baobab fruit, tamarind and hibiscus leaves. With the dense vitamins, minerals, healthy fats and antioxidants, these superfoods and more importantly their derived dishes have great potential in boosting the immune system, reducing risk of chronic diseases and promoting a healthy and productive population.

Keywords: superfoods, superdiets, moringa, hibiscus, tamarind, amaranth, teff, fonio, baobab

1. Introduction

The number of hungry people in the world has dropped to 795 million from 1 billion in 1990/1992 to the latest state of food insecurity in the world as reported in 2015 [1]. In addition, in the developing regions, the prevalence of undernourishment declined to 12.9% of the population, down from 23.3% a quarter century ago [1]. Despite the progress, sub-Saharan Africa is the region with the highest prevalence of undernourishment in the world, and the

situation could get better—or worse—depending on how the continent’s love affairs with some of its increasingly popular foods play out [2]. The irony is that there are millions of edible plants, insects and animals, and just like the Amazon, tropical Africa is still hiding most of the food items considered to be superfoods. Although superfood is a term originally used just as an advertisement and marketing tool, a superfood can be defined as a nutrient-dense, antioxidant-rich, natural-food product that is minimally processed and bioavailable in numerous, potent nutritive constituents. Consumption of superfoods increases energy and vitality, regulates cholesterol and blood pressure and may help to prevent or fight cancer and other diseases [3]. Superfoods are generally beneficial for health and well-being. Basing on the above definitions, there is a big range of foods considered to be superfoods, but for this chapter, focus will be on those mainly available within Africa and with higher potential of integration within existing food and diet systems. The objective is to downplay on the ‘superfood’ and emphasize more on ‘super diets’, where the emphasis is on a healthy balanced diet. The foods that will be explored include moringa leaves, hibiscus, amaranth, baobab fruit, tamarind, teff and fonio.

2. Selected superfoods

2.1. Amaranth

Botanically referred to as *Amaranthus*, this crop was cultivated by the Aztecs 8000 years ago and is still a native crop in Peru. The ancient history of amaranth can be traced to Mexico and the Yucatan Peninsula. The name for amaranth comes from a Greek word *amarantos* meaning ‘one that does not wither’ or ‘never fades’; this is true as amaranth’s bushy flowers retain their vibrancy even after harvesting and drying. In addition, some varieties of ornamental amaranth do not produce the fancy flowers but produce flashy foliage, sprouting leaves [4]. *Amaranthus* are now grown in Africa, India, China, Russia, throughout South America and North America. Amaranth is tall about 6 feet, has broad leaves with colours ranging from deep blood red to light green with purple veins and has around 60 different species [4], several of which are cultivated as leaf vegetables, grains or ornamental plants [5]. It is commonly known as pigweed (English), hanekam (Afrikaans), thepe (Sesotho), imbuya (isiZulu), mchicha (Swahili), terere (Gikuyu, Meru and Embu of Kenya), doodo (Luganda), shoko (Yoruba) [5] and lengalenga (Democratic Republic of Congo and Burundi) [6]. Both the amaranth leaves and seeds are useful in terms of human health [5]. Whether you choose to consume amaranth as a leaf vegetable, a cereal grain or grain flour, considering the versatility and high concentration of antioxidants and nutrients, amaranth is one of the most of valuable health foods that you may have never heard of [5].

2.1.1. Vegetable/leafy amaranth

Vegetable amaranths are probably the most widely eaten boiled or steamed greens throughout Africa’s humid lowlands. They secure the food supply for millions. The leaves and stems make excellent boiled or steamed vegetables as stew or sauce; they have a soft texture, mild

flavour and no trace of bitterness [7]. As already indicated, raw vegetables have higher nutrient levels than cooked vegetables, but it is also obvious that not all vegetables can be consumed raw. Amaranth leaves are one of those vegetables that have to be cooked. It is therefore important that when cooking the amaranth, the cooking time should not exceed 5 min, and in the case water is used, it should be used in minimal quantities and not discarded as most nutrients leach into the water. If the amaranth is being cooked together with other food items that require longer cooking time such as legumes and meats, it should be added to the food just a few minutes before the meal is ready. Therefore, following appropriate cooking methods, amaranth leaves have great nutrition value.

Cooked amaranth leaves are packed with antioxidants and an excellent source of several nutrients especially vitamins and minerals [8]. According to the FAO West African food composition table, 100 g of boiled leafy amaranth contains 4.6 g protein, 380 mg calcium, 4.9 mg iron, 58 mg magnesium, 54 mg potassium, 42 mcg folate, 19 mg vitamin C, 0.25 mg vitamin E and 228 mcg RAE of vitamin A [9]. There are very few leafy vegetables with high levels of calcium, and therefore amaranth is an absolute superfood in terms of boosting bone strength and preventing osteoporosis, thus extending your 'active life' well into old age. The significant level of carotenoids and vitamin A in amaranth leaves is a major boost for eye health, as these antioxidants can prevent macular degeneration and slow or stop the development of cataracts [10]. By lowering oxidative stress in the ocular system, amaranth keeps your vision healthy and strong. In addition, vitamin A plays a major role in boosting the immune system, thus reducing the likelihood of contracting infections and the severity if contracted. The type of vitamin E in this leafy vegetable is tocotrienols, a type which helps in reducing bad cholesterol (low density lipoprotein-LDL) levels in the body and prevents coronary heart diseases [10]. The high levels of potassium and magnesium are crucial for maintaining proper electrolyte balance in the body, and the presence of significant amounts of dietary fibre aids in the management and prevention of hypertension [10]. The antioxidant property of vitamin E, vitamin C and lysine in addition to other essential nutrients makes it possible for these leaves to fight against harmful free radicals and prevent the formation of malignant cells responsible for cancer [10]. Basing on the important role that folate plays especially in preventing neural tube defects in newborns, including amaranth vegetables to your diet would help protect your newest addition to the family.

2.1.1.1. Amaranth-based diets

Amaranth leaves come in different colour shades ranging from dark green and reddish green to deep red and purple, but the most popular variety in Africa especially East Africa is the dark green leafy type. Although there is no standard recipe of cooking amaranth, the basic ingredients include amaranth leaves and small parts of the stem, cooking oil, tomatoes, onions and salt. Depending on the culture and economic ability, other ingredients that could be added include meat, small fish, groundnuts, African eggplant, green pepper, garlic or red beans.

The most popular use of amaranth vegetable is as a vegetable sauce accompanying starchy staples such as steamed/boiled/stewed banana; 'ugali' (African polenta or cornmeal mush)

also called sima, sembe, kaunga, dona, banku, kenkey pup, posho, fufu; rice; and potatoes or sweet potatoes. As detailed in **Table 1**, it can also be cooked together with other food items to form a complete meal. In Burundi, amaranth is cooked together with beans and bananas and sometimes small fish locally called 'dagala' added. This provides a very nutritious meal able to meet a good range of both macro- and micronutrient needs.

| Dish name | Ingredients | Cooking procedure |
|---|---|--|
| Basic amaranth sauce | <ul style="list-style-type: none"> -Two bunches of amaranth leaves and small parts of the stem washed and drained (three to four cups) -One medium onion (chopped) -One tbsp of cooking oil -One medium tomato (chopped) -Water -Salt to taste -Seasoning (optional) | <ul style="list-style-type: none"> Add oil to a hot pan and immediately add the onions. Saute until translucent; do not let them turn brown Add the leaves and stir to prevent them from burning Cook covered on low heat for 3 min Add the chopped tomatoes and cook covered for 1 min Add seasoning of your choice Serve hot with starch accompaniment such as banana, 'ugali' potatoes, rice, etc. |
| Amaranth in groundnut sauce | <ul style="list-style-type: none"> -One onion, chopped -Two tbsp oil -Three tomatoes, cubed -1 kg amaranth, washed and chopped -Three tbsp groundnut paste -¼ tsp salt -Water <p>NB: one can either use flour made from grinding uncooked groundnuts or paste made from slightly roasted groundnuts)</p> | <ul style="list-style-type: none"> -Add oil to a hot pan and immediately add the onions. Saute until translucent; do not let them turn brown -Add the leaves and stir to prevent them from burning -Cook covered on low heat for 2 min -Meanwhile mix the groundnut powder in warm water, and stir into a smooth paste and keep aside -Add the chopped tomatoes to the amaranth and cook covered for 1 min -Stir the tomatoes in the vegetables and add the smooth groundnut paste into the amaranth, add some little water, keep stirring, season with salt, and cook covered on low heat for 5 more minutes -Serve with main dish of choice |
| Beans, cooking banana and amaranth leaves | <ul style="list-style-type: none"> -One cup dried red kidney beans -Five green cooking bananas -One bunch of amaranth leaves with small part of stems, washed and drained -One tbsp vegetable oil -Medium onion, thinly sliced -Two tomatoes slices into cubes -One tsp salt to taste -Hot chilli powder (optional) | <ul style="list-style-type: none"> -Soak the beans for 6–8 hrs or overnight in lots of water -Drain, place in a pan, cover with new water, and boil until tender -Drain the remaining water and reserve -Peel and slice the bananas into desired sizes. Add the oil to a hot pan and immediately add the onion. Fry the onions until translucent -Add the beans and plantains to the oil, add some salt and if desired chilli pepper, and fry for about 2 min, stirring constantly. -Add about four cups of water and let the food boil -Reduce to a simmer and cook until plantains are soft -Add the washed and drained amaranth leaves on the cooking mixture, cook covered for another 2 min, stir in the vegetables to mix with the other ingredients, and cook covered for 2 more minutes NB: The amaranth can be cooked with beans excluding the bananas and sometimes with bananas excluding the beans. All the options can be served alone or with rice, ugali or any other starchy staple |

Table 1. Selected amaranth leaf-based dishes.

2.1.2. Grain amaranth

Amaranth grain is reported to have been domesticated between 6000 and 8000 years ago, and it has a long and colourful history in Mexico [11]. When ground, the amaranth flour is generally a pale ivory shade, but the red 'buds' can be ground as well for a red-tinged and very healthful grain. One of the most important aspects of this tiny grain is that it is gluten-free [11, 12], thus providing a viable wheat alternative for millions of people suffering from celiac disease or gluten intolerance.

At about 13–14%, grain amaranth easily trumps the protein content of most other grains, and you may hear the protein in amaranth referred to as 'complete' because it contains lysine, an amino acid missing or negligible in many grains [12]. It also contains other primary proteins called albumin and globulins, which, in comparison with the prolamins in wheat, are more soluble and digestible [12]. A 100 g of raw amaranth contains 14 g of protein, 15 mg of iron, 159 mg of calcium, 4 mg of vitamin C and 18 mg of fibre [9]. The high fibre level results in smooth digestion of food and facilitates an efficient uptake of minerals level. At 105% of the daily value per serving, the manganese in amaranth is off the charts, yet it contains fewer carbohydrates [4]. Amaranth contains 6–10% oil, predominantly unsaturated, or around of which 77% are unsaturated fatty acids, including linoleic acid, acid that is required for optimum nutrition [4]. With all the above nutrients, amaranth grain is a true powerhouse, likely to prevent a number of chronic health conditions such as diabetes, heart disease, cancer, and stroke.

2.1.2.1. Grain amaranth-based dishes

Grain amaranth has been used for food by humans in a number of ways. Being extremely dense, amaranth is too heavy to be used by itself. Although it can be popped and eaten like popcorn or flaked like oatmeal, it is best used with other grains for a lighter texture. The ground grain is used as an enrichment to staple-based diets such as porridge, soups, ugali, etc., thus supplying more nutrients to vulnerable population groups. For instance, amaranth grain porridge (1 cup) combined together with moringa leaf powder (1 tbsp) from moringa leaves not only provides an excellent nutritional food for individuals with compromised immune system (HIV/AIDs), but also those consuming the amaranth/moringa combination are able to take anti-retroviral drugs with no complications [13].

The ground grain is also mixed with wheat flour and used in making more nutritious breads, noodles, pancakes, cereals, cookies and other flour-based products. There are more than 40 products containing amaranth and that can be used by consumers of different social economic/cultural backgrounds. Amaranth grain flour is also used as an exceptional thickener for sauces, soups, stews and even jellies; the four can be made from freshly ground grains of by sprouting/germinating the grain, drying it and milling/grinding it into flour. Eaten as a snack, amaranth can have a light, nutty or peppery-crunchy texture and flavour.

Cooking amaranth grain alone is comparable to cooking pasta or rice: boil plenty of water (six cups of water per one cup of amaranth), measure the grain into it, cook and stir for 15–20 min, drain, rinse, and its ready to eat. **Table 2** gives details of selected dishes based on amaranth grain.

| Dish name | Ingredients | Cooking procedure and serving recommendations |
|---------------------------------|--|---|
| Amaranth polenta with mushrooms | <ul style="list-style-type: none"> -½ cup dried mushrooms -One tbsp cooking oil -One cup amaranth grain -¼ tsp salt -Freshly ground pepper to taste -One medium onion Two cups of hot water | <ul style="list-style-type: none"> -Soak the dried mushrooms in a covered container with hot water for 10 min to soften -When soft chop any large pieces into preferred sizes. Meanwhile, heat the oil in a heavy saucepan, add the onions, and cook till soft and translucent -Stir in the amaranth; add the soaked chopped mushrooms with the soaking liquid, taking care to leave any grit on the bottom of the cup -Bring to a boil, reduce the heat, cover, and simmer for 15 min -Stir in the salt and pepper to taste -Continue simmering, covered, until the mixture is like porridge and the amaranth is tender (about 10–15 min more) -(Tender amaranth should still be crunchy but should not taste hard or gritty) -If mixture is too thick before the amaranth is cooked, stir in more boiling water -Serve in small bowls |
| Enriched porridge | <ul style="list-style-type: none"> -One cup maize meal flour/any other common porridge flour -½ cup amaranth flour -2 ½ cups water -2 ½ cups milk (optional) -Two tbsp. margarine (optional) | <ul style="list-style-type: none"> -Combine amaranth flour and maize meal flour in a medium-sized saucepan -Add in water and stir into a smooth paste; add in all the water; keep stirring -Put the saucepan over high heat and simmer for 15 min, stirring occasionally or until the mixture becomes very thick -Add in the milk; let it simmer for additional 5 min -Add in margarine, cook for 1 min and remove from heat, cool whilst stirring, and serve |
| Enriched 'ugali' | <ul style="list-style-type: none"> -One cup of maize meal flour/any other common ugali flour (cassava flour/ cassava and millet flours) -One cup of amaranth flour -Three cups of water | <ul style="list-style-type: none"> -Mix the flours thoroughly -Add the mixture to boiling water little by little as you stir in the flour with a wooden spoon, keep stirring, and begin to knead with the same spoon as it gets stiffer -Reduce heat slightly and cover to let it cook for about 2 min -Uncover and continue kneading for another 2 min until you begin to smell burning corn -Remove it from heat and turn it over in a serving plate -Can be served with stir-fried amaranth leaves or any other vegetable or/ and any protein dish |
| Chapati | <ul style="list-style-type: none"> -Wheat flour (1400 g) -Popped powdered grain amaranth (600 g) -Water (1000 ml) -Grated carrots (156 g) -Cooking oil (35 ml) -Salt to taste (15 g) | <ul style="list-style-type: none"> -Mix the flour, salt and the popped grain together in a bowl -Add in the grated carrots and onions -Using your finger tips, mix in the oil gently -Add the water and knead into dough -Divide the dough into portions of your preferred size -Roll each portion into flat round shapes; size can be different based on frying pan or personal taste -Put some oil on the frying pan; when oil is hot, reduce heat and put the flat round dough on the pan -Cook one side until cooked (showing spots of light brown) -Flip it over and cook the other size -Serve hot with legume or meat stew |

| Dish name | Ingredients | Cooking procedure and serving recommendations |
|-----------|--|--|
| Pancakes | <ul style="list-style-type: none"> -Cassava flour (500 g) -Popped/germinated grain amaranth flour (250 g) -Freshly peeled sweet bananas (560 g) -Cooking oil (1 litre) | <ul style="list-style-type: none"> -Mix the cassava flour and popped/germinated grain amaranth flour thoroughly -Sift the mixture -Mix in sweet banana and any other spices -Knead the mixture using hands or blender to form a hard dough -Roll the dough flat on a smooth clean surface -Cut into desired shapes -Deep fry until golden brown |

Table 2. Examples of amaranth grain-based dishes.

2.2. Teff

Teff is a tiny fine ivory, red/brown or mixed (ivory, red/brown) grain. Red/brown teff has a subtle hazelnut, almost chocolate-like flavour and a moist texture similar to millet (but more exotic). Ivory teff has a milder flavour than the brown. This grain is the national pride of Ethiopia, where it has been consumed for more than 1000 years (way BC). Teff is scientifically known as *Eragrostis teff*. 'Teffa', the Amharic name for 'lost', is so named because of 'teff's' small size; it is the smallest grain in the world and often is lost in the harvesting and threshing process [14]. It is now starting to get global attention which is good news for all of us especially because it is a durable crop that can grow in almost every climate.

With its subtle nutty flavour, the same flexibility holds also in the kitchen. Teff leads all the known grains by a large margin. Its small size means that the germ and the bran—the most nutrient-dense layers—make up a large proportion of the overall seed as the grain cannot be separated into bran, germ and endosperm. Apart from its gluten-free nature which makes it a delicious wheat alternative, the teff grain is also known for its superior amino acid profile, being high in lysine, a protein essential for muscle repair [15]. Teff is the primary carbohydrate source for most Ethiopians. It has an estimated 20–40% resistant starch and high fibre; these particular components are important in dealing with diabetes and assisting with blood sugar control [15, 16]. 100 g of edible portion of raw teff has 13 g protein, 8 g fibre, 180 mg Calcium and 8 mg iron [9]. Just a cup of cooked teff contains 123 mg of calcium, about the same as half a cup of spinach [2, 15, 16]. It is also high in iron, calcium and vitamin C. It is also packed full of B vitamins, which makes it great for energy. Last but not least, teff packs a little something that the others do not 'vitamin K', a fat soluble vitamin which is required for blood clotting and also bone health [17].

2.2.1. Teff-based dishes

As shown in **Table 3**, Teff has the versatility of corn meal and millet. Delicious in porridge, stews, stuffing and pilaf, teff can be cooked alone or in combination with other grains and vegetables. Alone, teff's cooking time is 20 min, and for each cup of grain, you need three cups of water. All you need to do is combine teff and water in a pot and bring to a boil. Reduce heat, cover and simmer for 20 min, until water is absorbed. You may stir occasionally towards the end of cooking.

| Dish name | Ingredients | Cooking procedure and serving recommendations |
|----------------------------|--|--|
| Injera | <ul style="list-style-type: none"> -1 1/2 cups of teff flour -Two cups pure water -1/2 tsp baking powder -Cooking oil -1/4 tsp salt, to taste | <ul style="list-style-type: none"> -Put teff flour in a large bowl, add water, and stir well till smooth -Cover with a cheesecloth or towel and place on the counter and let it sit for 1 day/24 hrs without any stirring or agitation -After 24 hours, the batter will appear alive and fermenting, stir in the salt, and season with any other preferred spices until you can barely detect the saltiness -Stir in the baking powder -Bring a pan to medium heat; lightly coat the pan with cooking oil -Pour enough batter into the pan to fill the whole surface; cover with a lid or a cookie sheet as it is important to keep a lot of moisture in the pan or the injera will crack -Do not flip or brown its underside -When you see the top bubble like pancakes and start to dry out and the edges begin to curl/dry, remove the injera from the pan -Place on a plate and repeat layering cooked injera with parchment paper until you use up all the batter -Serve with chickpea and sweet potato wat or Ethiopian lentils with berbere spice |
| Teff banana pancakes | <ul style="list-style-type: none"> -Two eggs -Two ripe bananas peeled -1 1/2 cups of milk -One tbsp honey -1 1/2 tsp oil -1 1/2 cups of teff flour -One tbsp baking powder -1/2 tsp cinnamon (optional) -1/4 tsp salt | <ul style="list-style-type: none"> -Mix eggs, banana, milk, vanilla, honey and 1/2 tsp oil, and beat or blend well -In a large mixing bowl, put teff flour, baking powder, salt and cinnamon, and stir in banana the milk mixture -Place the frying pan over medium heat; when the pan is hot, brush on one tsp of oil -Using a tablespoon, scoop up the batter and pour it on the hot pan, one heaping tablespoon for each pancake -Cook pancakes for 3–4 min on the first side or until the top forms bubbles and begins to dry -Flip them over and cook for another minute or two -Feel free to substitute maple syrup for honey, and use juice for milk. Ground-up flax seeds easily take the place of egg -Serve plain or dipped into yoghurt |
| Teff grain/ flour porridge | <ul style="list-style-type: none"> -½ cup teff grains/flour -1 ½ cup water -One tbsp butter/margarine (optional) -¼ cup milk (optional) | <ul style="list-style-type: none"> -If using grains pop the grains first -Add water into the flour or popped grains, and stir well -Put the mixture in a saucepan on medium heat; stir well for about 3 min -Bring to a gentle boil, cover, and cook for about 15–20 min -If the porridge is too thick, add some water or milk, and give it a few more minutes -Stir in the cream or milk; sweeten with sugar, honey or maple syrup to taste |

Table 3. Examples of teff-based dishes.

As the preferred staple in the Ethiopian and Eritrean dishes, teff flour is used in making engera/injera (pronounced en-jer-a and sometimes spelled injera), a flat sour-like fermented pancake that is used with ‘wot’, a stew made with spices, meats and pulses, such as lentils, beans and split peas.

In combination with other ingredients which is a better option as enhances nutrient-nutrient interaction, teff grain and teff flour are wonderful alternatives to wheat, barley and rye

for those on a gluten-free diet. Teff flour will expand food choices beyond potato, corn and rice flour!

2.3. Fonio

There are two types, white fonio (*Digitaria exilis*) and black fonio (*Digitaria iburua*), but both are actually a type of millet grain. White fonio is grown in the Sahel area that borders the Sahara Desert, and it grows well in dry and grassy savannah as well as in richer climates. Black fonio is found in Benin, Niger, Nigeria and Togo and is generally less common (and even more nutritious). Although fonio is found all over West Africa, it is especially prized in the Fouta Djallon region of Guinea and Senegal and the Akposso region of Togo and Central Nigeria [18].

Like teff, fonio matures quickly, producing grain in just 6–8 weeks, which makes it the world's fastest maturing cereal. It can therefore be relied upon in semiarid areas with poor soil and unreliable rainfall [2, 18]. After they are mature, fonio's tiny grains must be dried and removed from their husk before they are ready to cook. Before machines did the dehusking, the fonio was dehusked in a mortar and pestle, where the grains were pounded with sand. Fonio could also be slowly toasted in a large pan until it popped out of its husk and then pounded to separate the grain from its covering [18].

A staple in African cuisine and diets, it is prepared steamed as the anchor in many meals and is also milled into flour to be used in baking. It is called the 'seed of the universe' in Malian mythology [19]. It provides 3.6 calories per gramme of grain that is similar to other cereals [20]. Just as teff and amaranth grain, it is also gluten-free making it another great wheat replacement. Fonio is simpler to digest making it suitable for children and older people [20]. Fonio is consumed as a whole grain; the barn and germ of fonio are full of nutrients. A 100 g of boiled whole-grain black fonio has 3.7 g protein, 21 mg calcium, 4.1 mg iron, 9 mg folate, 181 mg magnesium and 3.1 g of fibre [9]. In addition, fonio has essential amino acids methionine and cysteine which jointly help liver function and help in detoxing process. The high fibre content makes it necessary to keep the digestive system smooth. It helps in bowel motions and helps prevent constipation; in certain parts of Africa, fonio is provided as food to individuals struggling with stomach problems [20]. Fonio has got lower glycemic index. It really is absorbed in body gradually and therefore effect on blood sugar increment is gradual. The presence of essential amino acids helps in preventing liver damage and colon cancer and is also useful in drug removal symptoms, whilst the high levels of folic acid as well as iron play an important role in iron metabolism [20]. It is good in avoiding anaemia. This particular nourishing food is typically suitable for pregnant as well as lactating women in Africa [20]. Moreover, because of its insulin-secreting properties, fonio products have found that diabetics are their key customers.

2.3.1. Fonio-based dishes

The small grains are beloved in Burkina Faso, Guinea, Mali and Nigeria, Senegal and Togo, where fonio is a staple part of most people's diets. Fonio is a favourite in salads, stews and porridges [18]. In Togo, fonio is cooked with black-eyed peas and, in other places, mixed with nutrient-dense sesame seeds to add even more vegetarian nutrition [18].

Fonio grains can be cooked whole, or it can be ground into a gluten-free flour and used as a substitute for wheat flour [18]. **Table 4** provides details of selected fonio-based dishes.

| Dish name | Ingredients | Cooking procedure and serving recommendations |
|----------------------------------|--|---|
| Simple fonio | <ul style="list-style-type: none"> -Two cups of fonio grains -Two cups of water -Salt to taste -(Serves four) | <ul style="list-style-type: none"> -Bring the water to a boil in a pot -Add the salt and the fonio, and cover -Remove from the heat and let stand for 10 min or until the fonio has absorbed all its water -If the fonio is still too chewy for your taste, add a little more boiling water to the pot, cover, and leave for a few more minutes as it absorbs. If there is still water in the pot, put it back on high heat and cook, stirring, until the water boils off -This will substitute rice for a protein-rich, delicious side dish, serve with vegetables, stew or sauce |
| Paleo pancakes using fonio flour | <ul style="list-style-type: none"> -Three tsp baking powder -One tsp salt -1 ¼ cup fonio flour -¼ cup cooking oil/margarine -One tsp vanilla extract -One egg -One cup milk/water -One tbsp of maple syrup -(Serves four) | <ul style="list-style-type: none"> -Mix the fonio flour baking powder and salt -Add ½ of the cooking oil/margarine into the flours and shorted/rub in using finger tips -Add water/milk gradually as you keep mixing to a consistency of your liking -Beat in the egg -Heat a pan; if the pan is non-stick, no need to use oil; if using ordinary pan, put some little oil on the pan; let it heat -Pour a scoop of the mixture in the pan and let it spread or slightly tilt the pan to get it to your preferred size -Cook one side till bubbles appear and begin to dry -Flip it over and cook for a short whilst -Can be served with maple/pancake syrup and/or with ripe bananas and a glass of milk or juice |
| Fonio Pilaf | <ul style="list-style-type: none"> -Two cups of fonio rinsed and drained -Two cups of meat cubed -One carrot diced -One cup cabbage sliced -One cup green peas -Two tbsp cooking oil -One sliced onion -Two peeled sliced tomatoes -Pepper/turmeric/garlic (optional) -Ten cups of water -(Serves six to eight) | <ul style="list-style-type: none"> -Heat oil in the pan and add some sliced onion; cook till the onions are translucent -Add tomato, pepper, turmeric and meat pieces -Add salt to taste, mix everything, and cook for about 2 min -Add to this about ten cups of water and let the ingredients simmer for some time (10–15 min) -Add recently cut cabbage, peas and carrot to mixture and let simmering for additional time -Put the cooked vegetables aside -Add to the mixture two cups of fonio and cook for an additional 5 min -Serve the complete dish |
| Fonio cake | <ul style="list-style-type: none"> -1/2 kg fonio flour -1/2 kg wheat flour -650 g sugar -Three eggs -1/2 Cup dried milk -1/2 margarine -10 g yeast -½ litre water -(Serves six to eight) | <ul style="list-style-type: none"> -Add sugar into the ½ litre water and allow it to dissolve -Add three eggs, ½ cup of dried milk and ½ cup of margarine and mix properly -In a separate bowl, mix the fonio flour and the wheat flour -Gradually add the flour into the mixture and keep kneading with a spatula, up until paste is smooth -Allow this particular paste to stay for half an hour -Preheat oven to 220°C -Grease the cake tins with butter and keep aside -Add the yeast to the dough knead lightly to make sure the yeast is well incorporated -Fill the cake tins with the dough -Put the cake tin in oven for about 10–15 min at 180°C -Let the cakes cool and serve with a few hot chocolate sauces |

| Dish name | Ingredients | Cooking procedure and serving recommendations |
|---------------|---|---|
| Fonio pudding | <ul style="list-style-type: none"> -One cup cleaned fonio grains -A pinch of salt -Six cups of water (or more) -Four tbsp. granulated sugar (or as desired) -Milk (as desired) -Raisins/cashew nuts/groundnuts (as desired)—optional -(Serves three to four) | <ul style="list-style-type: none"> -Place the washed fonio grains in a medium-sized sauce pan, and add about six cups of water to it -Leave to cook on medium heat whilst stirring continuously at the early stage of cooking to prevent lumps from forming. The grains will then lose their grittiness and become fluffy and soft -When the pudding appears thick, remove from heat; add the sugar and milk -You can also add in any other toppings like raisins, cashew nuts or groundnuts -Serve the pudding whilst still hot as it tends to solidify after sitting at room temperature for a whilst -Can be eaten alone or served with akara (bean balls), plantain or even bread |

Table 4. Examples of fonio-based dishes.

2.4. Moringa

The *Moringa oleifera* tree is a small tree that is native to the Himalayas of India and was being used in Indian medicine around 5000 years ago. There are also accounts of it being utilized by the ancient Greeks, Romans and Egyptians [21]. Although there are technically 13 different species of moringa tree [21], for simplicity, this chapter is in reference to the *Moringa oleifera* tree and using the common name ‘moringa’. This tree was, and still is, considered a panacea and is referred to as the ‘The Wonder Tree’, ‘The Divine Tree’ and ‘The Miracle Tree’ amongst many others. It is priced as a multipurpose tree with all parts usable either as a raw or cooked nutrient, medicine or as a water purification additive. It is also known for its long twisted pods, from which it derives its name. ‘Murungai’ means ‘twisted pod’ in the Tamil language [21].

Moringa is beneficial for both food and medicine because of its ability to grow in virtually all countries. Currently, its growth is most prevalent in Africa, Central and South America and Asia. But its effects are being felt around the world [21].

The leaves typically the most common part of the plant are especially high in protein and considered a multivitamin-mineral complex. A 100 g of mature moringa leaves contain 5.7 g protein, 15 mg β -carotene, 459 mg vitamin C, 25 mg vitamin E, 9.2 mg iron and 638 mg calcium [22]. The moringa leaves also contain 18 amino acids, including the 9 essentials: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine [23].

The leaves are harvested and steamed as a green vegetable but are also dried and ground into a powder used in sauces, soups and cooked grains. In these different forms, moringa is used as a vitamin-mineral supplement that is extremely effective at balancing nutritional uptake needed for greater dietary balance. With the high nutrition content, moringa leaves are gaining popularity as a remedy for malnutrition in Africa, especially amongst infants, children and nursing mothers [2]. Moringa could also be a great nutrient safety net because the tree is in full leaf at the end of the dry season when other foods are typically scarce [2]. The seeds and pods can also be eaten just as you would green beans, and the flowers and buds make a nice tea although they contain a laxative effect [24].

2.4.1. Moringa-based foods

Whilst the leaves can be steamed or boiled and eaten as a green leafy vegetable with a slight 'bite' taste to them, the moringa leaf powder has a mild, somewhat spinach-like taste and works well in smoothies, green juices and soups or sprinkled over most anything. **Table 5** provides details on how moringa can be used as leaves and as powder in selected recipes.

| Dish name | Ingredients | Cooking procedure and serving recommendations |
|--|--|---|
| Moringa sprinkles | -Moringa powder -Any prepared food | -Sprinkle one tsp of powder on a plate of food, a cup of soup or on a sandwich -Do this a few times throughout the day, and you are set -You can also add the moringa powder to juice or milkshake -Do not cook moringa powder; it diminishes the nutritional value -Honey works well to mask the moringa taste |
| Moringa, lemon, honey, mint leaves, ginger and ice blend | -Two tsp moringa powder -1 litre chilled water -Two limes, sliced thinly -Two lemons, sliced thinly -Large handful of fresh mint leaves -Three tbsp honey | -Mix as many of the indicated ingredients as you have in a blender -Add plenty of water -How much powder you can handle versus how much honey you need to sweeten the drink depends on your preference -Experiment with the ratios, but know these ingredients all play nice together -To add some more flavour, swap out the water for coconut milk -Leave the mixture to sit in refrigerator for about 2 hours before serving with plenty of ice |
| Stir fried moringa leaves | -Five bunches washed and drained moringa leaves -One tsp cooking oil -Mustard seeds -Red chillies -A medium-size sliced onion -Salt to taste | -In a hot pan, add the oil -When oil is hot, add mustard seeds; when the mustard seeds begin to pop, add slices onions cook till the onions are slightly browned -Add the moringa leaves bit by bit, constantly stirring to ensure they do not stick at the bottom or clump -When the leaves begin to wilt and get soft, add salt -Keep sauntering the leaves, until all the water that tend to come from the leaves during cooking is evaporated -Serve with a starch diet of your choice, i.e. rice and some curry, ugali, matooke, etc. |
| Scrambled eggs with moringa leaves | -Two eggs -Freshly picked moringa leaves -Cooking oil -Salt to taste -Minced fresh garlic cloves or garlic salt (optional) | -Beat the eggs in a bowl add salt and any other spices -Put oil in a pan; heat slightly -Pour the egg on the hot pan with oil; keep stirring with a cooking spoon -As the eggs solidify and are almost ready, add the moringa leaves -As soon as the moringa leaves turn bright green and wilt a bit, your dish is ready |
| Moringa leaves with maize/corn and beans | -Two cups of fresh corn off the cob Two cups of fresh beans from the pods -One onion sliced -Two tomatoes sliced -Cooking oil | -Boil the beans for about 30 min separately until they are soft and cooked -Sauté the onions in the oil until they are translucent -Add the corn, the beans and sauté all together, until the corn just starts to brown on the edges a bit -Stir in the moringa leaves; cook for about 3 min covered -The meal is ready and can be consumed alone |

Table 5. Examples of moringa-based dishes.

2.5. Baobab fruit

The iconic baobab is a common tree in eastern and southern Africa's savannahs [2]. It is one of the most nutrient-dense wholefoods on the planet. It is a 100% organic, raw superfruit that dries naturally on the branch [25]. In Africa, the baobab fruit has been used medicinally for centuries to treat everything from fevers, malaria and gastrointestinal problems to vitamin C deficiency [26].

The unusually high levels of vitamin C in moringa fruit are what contribute to the great potential health benefits of moringa fruit powder and its fresh counterpart [26]. A 100 g of baobab fruit pulp contains 247 mg vitamin C (nearly four times of the daily requirements); therefore, a single serving of baobab powder (10 g or two to three tsp) will have about 24.7 mg of vitamin C providing about 40% of your daily Vitamin C requirement making baobab fruit one of the best sources of vitamin C in the world [25].

Vitamin C plays a crucial role in our bodies. It contributes to normal collagen formation supporting healthy gums, teeth, skin, bones, cartilage and blood vessels; energy release, energy-yielding metabolism and reduction of fatigue; immune function; functioning of the nervous system and psychological function; and protection of cells from oxidative stress [25].

There are two types of fibre that your body needs: soluble and insoluble and baobab being 50% fibre contains equal quantities of both. The soluble fibre in baobab helps to slow down the release of sugar into the bloodstream, thus reducing energy spikes. Fibre also helps maintain a healthy digestive system including bowel regularity, and the fact that it helps you feel fuller for longer, it can be helpful for weight management [25].

Baobab powder has twice the antioxidants gramme per gramme of goji berries and more than blueberries and pomegranates combined, thus having the highest antioxidant content amongst all fruits [25]. Antioxidants are essential for protecting, repairing and preventing cell damage; supporting the ageing process of the skin particularly over the long term; and neutralizing free radicals, unstable atoms and molecules that can cause damage to your body at the cellular level, increasing the risk of degenerative diseases and other signs of ageing, including wrinkles and fine lines on the skin. Antioxidants counteract oxidative stress and the effects of free radicals (unstable molecules that damage collagen causing skin dryness, fine lines, wrinkles and premature ageing). When fresh baobab pulp is used in cooking or concentrated baobab fruit powder added to dishes, it boosts the supply of beneficial minerals including calcium, copper, iron, magnesium, potassium and zinc. These minerals act both individually and synergistically to perform hundreds of tasks in the human body. A 100 g of fresh baobab pulp contains 295 mg calcium, 1.6 mg copper, 9.3 mg iron, 90 mg magnesium, 1240 mg potassium, 27.9 mg sodium and 1.8 mg zinc [26].

2.5.1. Baobab-based dishes

Baobab fruit is very dry so it keeps almost indefinitely, and it is used to make juice by soaking the fruit and straining out the pulp and seeds [2]. The fruit powder (or fresh baobab fruit if you can get) can be added to your diet (liquid or solid) to enhance your body's fat-burning

capacities, especially if you are working on losing weight and your current diet is not rich in vitamin C. Absorption of iron and vitamin C actually increases your body's absorption of iron, which is why vitamin C-rich baobab and iron-rich moringa work so well together. See **Table 6** for selected Baobab-based recipes.

| Dish name | Ingredients | Cooking procedure and serving recommendations |
|---------------------------------|--|--|
| Baobab nutri-shake | -One glass of water -Two scoops (6 g) of baobab fruit powder | -Add the baobab powder to the water and shake or stir -It is ready to drink -NB: Use it as a sports drink when working out, or take it in the morning in place of your coffee; sip it mid-afternoon for a pick me up |
| Tropical baobab-papaya smoothie | -One tsp baobab powder -One cup papaya (pawpaw) -1/2 cup pineapple -Seven cashew nuts/groundnuts (optional) | -Add all the ingredients to a blender and blend until smooth -Add a little water or coconut water if needed to help everything blend or for a thinner texture |

Table 6. Examples of baobab-based dishes.

2.6. Hibiscus

The hibiscus plant (*Hibiscus sabdariffa*) is thought to originate from the areas surrounding central Africa presumably Angola. It is also widely cultivated throughout many tropical and subtropical regions, particularly Mexico, India, Thailand and China [27, 28]. Hibiscus is recognized for its large, colourful flowers that are often used as decorative pieces in gardens and homes. When the petals of the hibiscus flower begin to detach from the main plant, underneath they reveal flower bud-like structures known as calyces. These deep red buds are subsequently used to produce hibiscus tea and hibiscus extract. Whilst the tea is popular with health-conscious consumers, the extract is more versatile. It can be used in a number of different food and beverages and still maintaining its health-promoting properties [27].

Hibiscus is a rich source of vitamins and microelements including 13 organic acids. A 100 g of hibiscus tea will provide approximately 6, 31 and 48% of the daily values of vitamin A, vitamin C and iron [28]. These nutrients and microelements boost your immune system. It makes your blood vessels stronger, lowers the blood pressure and the level of 'bad' cholesterol and even has an antibacterial effect; this makes it prevent and reduce symptoms of metabolic syndrome (a combination of diabetes, obesity and high blood pressure), thus reducing the risk of developing heart disease and stroke [29]. It is also good for the pancreas and liver [28]. Hibiscus erases post-effects of alcohol intoxication and contains antioxidant elements similar to those of red wine; this helps the extract act as an anti-solar agent, by absorbing skin-damaging ultraviolet radiation from the sun. The antioxidants also minimize cell damage from free radicals, which may help to slow down the natural ageing process and reduce the risk of developing a number of age-related diseases [28, 29].

Hibiscus extract is also thought to promote a healthy digestive system. It has antibacterial properties, which may help to maintain a favourable gut flora. Hibiscus can also act as a mild laxative, which may help with symptoms of constipation and indigestion. One study also found that the extract demonstrates anti-urolithiatic activity, meaning that it can help reduce the formation of kidney stones. All these properties explain why the Arabs call carcade ‘the remedy from all illnesses’. It is said that three cups of red tea per day is enough to get the most of it. On the other hand, like any remedy, it is not good for everyone. People with low blood pressure, ulcer or gastritis should be very careful with it.

2.6.1. Hibiscus-based dishes

When dried hibiscus flowers are steeped in hot water, the dark red hibiscus tea is called karkadeh/karkady in Arabic and is popular in North Africa, particularly Egypt and Sudan where it is used to not only maintain normal body temperature, support heart health and encourage fluid balance [2, 29] but also at wedding celebrations as a toasting drink [2]. In West Africa, it is known as bissap, tsoborodo or wonjo; bissap is called the ‘national drink of Senegal’. It is either served hot (it loses a bit of its characteristic sour) or can also be served chilled with ice [2].

The recipes in **Table 7** show that hibiscus powder is added to hot or cold water to make a simple, slightly tart-tasting tea, but it is also increasingly used as a functional ingredient in many applications, from sorbets to confectionary. It can also be used as a colouring and flavouring agent in jams, relishes, sauces and baked goods. In addition, hibiscus extract has been applied as a colourant and antioxidant in the skin and hair care applications.

| Dish name | Ingredients | Cooking procedure and serving recommendations |
|-------------------|---|---|
| Hibiscus water | -Six cups of water -One cup of dried hibiscus petals -Simple syrup to taste -(Syrup—bring one cup of water and one cup of sugar to a boil until sugar dissolves) | -Boil six cups of water -Remove from heat/turn off the heat and add the hibiscus -Let it sit in the hot water for 3 min -Drain the water and add the simple syrup to taste -Let it cool down and serve cold with a lot of ice |
| Hibiscus iced tea | -1/2 cup dried hibiscus flowers (about 1/2 ounce or 15 g) -One cinnamon stick -Four cups of cold water -Two tbsp to 1/4 cup simple syrup -Lime wedges (optional, for serving) | -Put the hibiscus and cinnamon stick in a large container or bowl and add water -Cover and refrigerate overnight (8–12 hours). Add simple syrup to taste -Strain out the solids and serve with ice and a squeeze of lime, if desired -The tea can be taken immediately or brewed covered in the refrigerator for up to one week -You can use four hibiscus tea bags instead of the loose flowers -You can use honey or a sweetener in place of the syrup |
| Hibiscus smoothie | -One tbsp dried hibiscus flowers -1/2 cup boiling water for brewing -Five strawberries/raspberries -One ripe banana | -Brew the hibiscus tea in the boiling water for about 5 min. Allow tea to cool -Once tea is cooled, add the brewed tea, 1/2 of the soaked flowers and the rest of the ingredients to a blender, and process till smooth. Add water to thin out if desired |

Table 7. Examples of hibiscus-based foods.

2.7. Tamarind

Tamarind trees are native to tropical Africa but found in tropical regions throughout the world [2]. The tree produces an abundance of long, curved, brown pods filled with small brown seeds, surrounded by a sticky pulp that dehydrates naturally to a sticky paste. The pods look a bit like huge, brown, overly mature green beans [30].

Just as the other ancient foods do, tamarind has a long history of being used as a medical remedy. It has been known to ease stomach discomfort, aid digestion and act as a laxative [30]. Tamarind preparations are used to relieve fevers, sore throat, rheumatism, inflammation and sunstroke. Dried or boiled tamarind leaves and flowers are made into compresses used for swollen joints, sprains, boils, haemorrhoids and conjunctivitis. Similar to the natural gums and pectins found in other foods, the tamarind sticky pulp contains non-starch polysaccharides, which contribute to its high dietary fibre content (5.1 g/100 g fruit pulp). They bind with bile to help flush waste through the colon, decreasing the chances of it sticking around, thus reducing chances of colon cancer. Prized for its sweet-and-sour flavour, tamarind (also known as ukwaju in Swahili) is used to make juice and is rich in vitamins, minerals and antioxidants [2]. 100 g of tamarind contain 36% of the thiamin, 35% of the iron, 23% of magnesium and 16% of the phosphorus recommended for a day's worth of nutrition [30]. Other prominent nutrients include niacin, calcium, vitamin C, copper and pyridoxine. Tamarinds also contain high levels of tartaric acid, just as citrus fruits contain citric acid, providing not just a zing to the taste buds but evidence of powerful antioxidant action against harmful free radicals floating through your system [30].

Other phytochemicals found in tamarinds include limonene, safrole (a natural oil also found in sassafras), geraniol (a natural antioxidant with a rose-like scent), methyl salicylate (a plant essence with counterirritant properties), cinnamic acid, pyrazine and alkyl-thiazoles (natural flavours and fragrances derived from plants and vegetables). Each of these phytochemicals brings their own healing property and flavour to the fruit's overall make-up [30]. In addition, due to its ability to restore electrolyte imbalance during dehydration, many East African coastal communities will serve a glass of ukwaju (tamarind juice) to a guest coming in from a hot day or as a hangover remedy [2].

2.7.1. Tamarind-based dishes

In addition to being used alone as a drink/juice/tea, **Table 8** shows that the pulp from tamarind fruit is also used as a spice and souring agent in sauces, marinades, salads, stir fries, even sorbets and cool refreshing summer drinks. The English word 'tamarind' is taken from the Arabic tamar-hindi, meaning 'Indian date', and it is popular in equatorial cuisines, such as Indian, Mexican and Thai. Also known as imli, tamarind is used as a souring agent in many cuisines, especially those of South and Southeast Asia. There, you will find it in curries, stirred into drinks, made into relishes and sauces and even cooked down into a sweet-and-spicy dessert paste. The pulp can be pressed to form a 'cake' or processed to make a paste. When used in marinades as indicated earlier, besides adding flavour, the fruit's natural acidity helps to tenderize tougher cuts of beef by breaking down the fibres in the meat. Marinated overnight in a tamarind-tinged liquid, beef becomes succulent and tender. But it is important to note that when marinating fish or chicken, if left in the marinade too long, the tamarind will begin to chemically 'cook' it.

| Dish name | Ingredients | Cooking procedure and serving recommendations |
|--------------------|--|---|
| Tamarind juice | <ul style="list-style-type: none"> •80 g tamarind •2 l water •Sugar or honey to taste | <ul style="list-style-type: none"> -Bring water to a boil -Remove the brown shell from the tamarind to expose the pulp, and place the tamarind pulp in a heatproof container/mixing bowl -Pour boiling water over the tamarind, cover, and allow to sit for about 15 min -Leave to cool completely; then using your hands, separate seeds from the pulp -Once done, strain with a strainer -Dilute the juice with more water and add sugar or honey to taste -Refrigerate and serve chilled -Cinnamon, vanilla or grated ginger can be added to enhance the taste |
| Easy tamarind rice | <ul style="list-style-type: none"> -One tamarind -Small lemon ball size (without seeds) -One cup boiled rice, one tsp salt, ¼ tsp hing, ½ tbsp cooking oil -A handful of roasted peanuts -¼ tsp turmeric powder – two or three red chillies | <ul style="list-style-type: none"> -Take 150 ml of water in a container, add turmeric powder and tamarind -Pressure cook this for 2–3 whistles or boil covered for 30 min -Once cooled mash the contents nicely and keep aside -Heat oil in a non-stick saucepan -Add peanuts and any other spices and fry till golden brown -Add the mashed contents and salt -Let the mixture boil for 5–7 min and tamarind paste is ready -Add the required quantity of tamarind paste to cooked rice and mix well -Serve with fried potato chips/ugali/cooked banana -NB: Tastes best if eaten 3–4 hours after it is made |

Table 8. Examples of tamarind-based dishes.

3. Conclusions

Just as in the Amazon, there are millions of edible plants, insects and animals within tropical Africa that are not only nutrient rich but also contain essential elements beneficial in preventing and/or managing a range of health conditions that are of great public concern. Amaranth, teff, fonio, moringa leaves, baobab fruit, tamarind and hibiscus leaves just to mention a few are some of the superfoods that can be used alone but more importantly transformed into health superdiets to provide simple, acceptable and sustainable remedies that not only address malnutrition but also play a major role in the battle against non-communicable diseases like cardiovascular diseases (heart attacks and stroke), cancers, chronic respiratory diseases and diabetes.

Acknowledgements

The author first acknowledges the authors of all articles cited in this chapter. Secondly, Bioversity International www.bioversityinternational.org is thanked for the staff time spent during the writing of this chapter. Last but not least, the author acknowledges her family for bearing with her as she spent some family time in putting this chapter together.

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