

Vigna subterranean (Bambara groundnut), a possible weapon in fighting the malnutrition war in the arid and sub-arid regions

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Abstract

The global effort in fighting the nutrition war seems to be witnessing a record setback owing to recent climatic changes, growing insecurity, COVID-19 disruptions etc. all resulting in a global rise in food prices. Parts of Africa and Asia have constantly ranked high in the Global Hunger Index (GHI) and are already associated with the poverty and malnutrition crisis. Women and children remain the worst victims of this crisis. Although Africa is a host to a number of locally sourced, nutritious food crops which have been used as food in the time past, these crops remain underutilized while Sub-Saharan Africa remains on the red list for malnutrition. Among these underutilized plants is Bambara groundnut (*Vigna subterranean* (L.) Verdc, synonym; *Voandzeia subterranean* (L.) Thouars. The seeds contain about 64.4% carbohydrate, 23.6% protein, 6.5% fat, 5.5% fiber and a lot of minerals as well as a number of secondary metabolites. In Africa, the nuts have been processed into various meals which are cheaper sources of protein with high acceptability. Bambara nuts, with such a rich nutritional content can be cultivated even in the arid and semi-arid regions of the world which are ravaged by malnutrition. Highlighting and promoting such cheaper, highly nutritious foods, can be a very effective weapon for dealing with the current malnutrition crisis in the world. With this, the global sustainable development goals #2 and #3, already grossly set back by COVID-19 and global insecurity etc., may still be attainable by the year 2030.

Keywords: Bambara groundnuts; Malnutrition war; *Vigna subterranean* (L.); Neglected plants.

1. Introduction

The major indices of malnutrition have been identified by UNICEF as stunting, wasting and lack of essential micronutrients [1]. Malnutrition has posed a major threat to various regions of the world. It, however, remains about the least addressed issues among development challenges, leaving women and children to be the worst victims [2]. The Russia-Ukraine conflict as well as climatic changes, economic shocks and melt down, growing inequalities etc. seem to be reversing the world's effort in fighting the nutrition war according to State of Food Security and Nutrition in the World (SOFI) report [3]. An estimated 50 million children under five years of age suffer from wasting, 159 million have stunted growth and development due to a chronic lack of nutritious food in their diets while 41 million are affected by obesity/overweight with undernutrition associated with 45% of child deaths [4]. In Nigeria and various parts of Africa, insecurity has worsened the insufficiency and malnutrition coupled with an astronomical soaring of the prices of food substances.

Although Africa and Asia have been known to rank high in malnutrition and poverty crises, Africa remains a host to numerous currently neglected/underutilized plant species some of which have been locally sourced and inculcated in highly nutritious traditional meals in the time past. The current nutrition crisis, worsened by the high cost of nutritious

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food and ready-to-use therapeutic food (RUTF) has necessitated the investigation of such neglected traditional foods in order to highlight those of them with proven nutrition. The promotion of the health benefits of such foods and the promotion of its consumption can be considered critical to achieving Sustainable Development Goal (SDG) #2 (To end hunger and ensure safe, nutritious and sufficient food all year round by 2030) and SDG #3 (To ensure healthy lives and promote well-being for all at all ages).

Among such plants is Bambara groundnut (*Vigna subterranean* (L.) Verdc, synonym; *Voandzeia subterranea* (L.) Thouars. Bambara groundnut has been described as a neglected, underutilized and under researched crop [5,6]. It has been recognized as a rich source of human and animal nutrition especially in scarcity [7]. *V. subterranean* is a legume believed to have originated from West Africa but widely distributed throughout the semi-arid zone of sub-Saharan Africa [8]. It is mostly grown in North-Eastern Nigeria and Northern Cameroon, in West Africa and sparsely in some Asian countries such as India, Malaysia, Philippines and Thailand [9].

V. subterranean is a member of the family Fabaceae, the bean, legume or pulse family. It is an annual legume, a flowering plant with creeping stems and smooth trifoliolate leaves. It produces seeds underground just like the pea nuts (*Arachis hypogea*). It has a taproot surrounded by abundant side root nodules, a host to some nitrogen-fixing bacteria.

V. subterranean is also known by many local names in different parts of the world: Bambara nut, Bambara groundnut, Bambara bean, Congo goober, earth pea, hog-peanut or ground bean. In Nigeria, it is referred to as called *Okpa*, with the pudding from its seed known as *ntucha* or *igba* (Igbo), *Epa-Roro* (Yoruba), *Kwaruru* or *Gurijiya* (Hausa). In Zimbabwe, it is called *Nyimo* beans, in Zambia, *Ntoyo cibema* and in South Africa it is referred to as *Izindlubu*.

V. subterranean seed is currently being processed into various widely acceptable meals in Africa with the advantage of a significant decrease of its antinutritive content to a tolerable level [10]. This paper targets to present this easily grown legume, *V. subterranean* as a major tool in fighting the global hunger and nutrition war which has received a major setback in various parts of Africa and Asia in this post COVID-19 era. This highlight may also encourage the diversification of processing methods till much better acceptability of such *V. subterranean* meals are achieved.

2. The hydra headed battle with malnutrition

Malnutrition, according to WHO (2022) is deficiencies or excesses in nutrition intake, imbalance of essential nutrients or impaired nutrient utilization. It could manifest as stunting, wasting or overweight [1] or even underweight. Its current global impact has been likened to a silent war which is closely associated with, yet, worse than the armed wars ravaging countries such as Yemen, Somalia, South Sudan and Nigeria [1].

The Global Hunger Index [11] show hunger to be at alarming levels in five (5) countries viz: Central African Republic, Chad, Democratic Republic of Congo, Madagascar and Yemen, the next additionally alarmed countries being Burundi, Somalia, South Sudan and Syria.

It has been projected that by the end of 2022, an additional 9.3 million wasted children, 2.6 million stunted children, 168,000 child deaths, 2.1 million maternal anemia cases, 2.1 million children born to women with low body mass index (BMI) would emerge as a result of COVID-19 related disruptions [12]. Nigeria has been ranked 103 out of 121 countries according to the Global Hunger Index of 2022 with a 12.7 % undernourished [13] Women are not spared globally as 240 million of them were reported to be underweight while about 468 million had anemia [14].

Interestingly, a mention of the term ‘malnutrition’ draws attention to other indices such as stunting, wasting, and underweight while the aspect of overweight often goes unnoticed. Numerous remote factors have been associated with malnutrition ranging from inflation and poverty, illiteracy, natural disasters (such as flooding, desert encroachment), rising insecurity, climatic changes, COVID-19 disruptions etc. Malnutrition, which affects mostly women (especially pregnant and lactating) and children (whose nutritional needs are high relative to their body size) can increase the risk of illness and death [12]. The malnutrition war can therefore be seen as real and necessitates much more urgent attention if the global effort in fighting the nutrition war must not become futile.

3. Bambara nuts, a suitable solution

A number of recent reports have presented Bambara nut (*Vigna subterranean* (L.) Verdc as being able to address most of the facets of this silent nutrition war. It is important to note that most of the regions so far reported to have been ravaged by the nutrition crisis due to diverse factors: Sub Sahara Africa and Asia, coincide with regions where Bambara

nuts have been successfully cultivated. Over 2 billion people have been reported to live in the arid regions globally [15,16] with parts of West Africa including the northern part of Africa inclusive. Cultivation of Bambara nut could help in minimizing the land occupied by this population to avoid further land degradation [17].

4. Nutrition content/health benefits of Bambara nuts

With a 64.4% carbohydrate, 23.6% protein, 6.5% fat, 5.5% fiber and a rich mineral content [18,19], Bambara nuts can be considered a food stuff for a complete meal directly suitable for addressing the nutritional war. The carbohydrate readily provides energy while the protein content prevents Kwashiorkor in children. It is a good source of essential amino acids such as leucine and lysine with a low concentration of methionine. This makes it a good combination with cereals [20]. Its lysine (which the human body cannot produce) content also enhances the decrease in cholesterol levels in the human blood by breaking down fatty acids, a much-needed quality in managing obesity.

Its mineral content of potassium, magnesium, phosphorus, zinc and iron are found to be often higher than that reported in common edible legumes [18]. Calcium and phosphorus assist the body in the prevention of bone related diseases such as arthritis, osteoporosis. Processing methods and mineral chelation, may, however, reduce the availability of these minerals to the human body such that the human dietary needs may not be met through the consumption of Bambara nuts alone [21].

Significant levels of alkaloids, flavonoid conjugates (including epicatechin, catechin, [21] quercetin, kaempferol, apigenin, glycosides), saponins, steroids, triterpenoids, phenols, anthocyanins and carotenoids have also been reported [22, 23, 24]. The highest concentration of tannins and flavonoids have been found in red and brown *V. subterranean*. [25]. Flavonoids, alkaloids and most of these phytochemicals reported in Bambara nuts are known to show good antioxidant [19], anti-inflammatory and antimicrobial activities. Consequently, its frequent consumption is expected to contribute to a general well-being of the human body as observed among the locals who consume it.

The fermentation process used in the production of *Dawa dawa* (a Nigerian local seasoning) as well as a flour for the production of milk and yoghurt from Bambara nuts is associated with the growth of a range of probiotic bacteria for instance *Bacillus subtilis*, *Bacillus licheniformis*, *Bacillus pumilus* [26], *Lactobacillus bulgaricus*, *Streptococcus thermophiles* L. plantarum [27] etc. The presence of these probiotic bacteria in human systems helps to minimize the proliferation and activity of pathogens [26]. This quality is considered essential especially in overpopulated internally displaced people's (IDP) camps where a reasonable population have ended up in many regions in Africa and Asia due to displacements caused by natural disasters, insecurity etc.

Fermentation in Bambara nut processing should, however, be controlled to prevent the proliferation of aflatoxins [28]

5. Tackling malnutrition through economic advancement with Bambara nuts

As the global inflation crisis worsens, there is evidence of a tendency for individuals to consume more of highly processed carbohydrate-rich foods in order to satisfy hunger as more nutritious foods like fruits, vegetables and protein rich meals become too expensive to procure [29,30]. Such processed carbohydrate-rich foods becomes a major part of the menu, resulting in different forms of malnutrition. *V. subterranean*, a locally sourced food crop can be adopted being a cheaper, more nutritious and more easily available option. It is cultivated primarily for its seeds as food for both humans and also animals, if surplus. After processing, its hulls are basically used to feed animals and thus enhance another good source of proteins. The leafy shoots, rich in potassium and nitrogen are used as fodder [31] and animal feed.

In Africa, Bambara groundnut is the third most commonly eaten legume after peanut (*Arachis hypogea*) and cowpea (*Vigna unguiculata*) [32]. Nigeria, is one of the largest producers of Bambara groundnut [8]. Women and children are the commonest cultivators of Bambara groundnut [12]. They are also the most affected by poverty and malnutrition. Since the cultivation of *V. subterranean* is not capital intensive, it can become a good source of income for the empowerment of such, often poor, local women. With this, they can improve on the nutrition of their families.

The fact that Bambara nuts is an underutilized crop has, however, limited the market as its demand remains relatively low. In fact, in most parts of Africa, the cultivation of Bambara nuts is on small scales and is associated with the poor local women. This may be as a result of a culture influenced by its ease/low cost of cultivation and harvesting. As the nutritional values and its relevance in fighting the global malnutrition war are further highlighted, its market demand is expected to soar, translating to more resources to the farmers.

Cultivation of Bambara groundnuts, therefore, needs to be moved from a small, subsistent scale, to a much larger scale. This cannot be achieved without government interventions.

6. Restoration of soil nutrients with Bambara nuts to improve production of other nutritious crops

Soil conditions in several parts of the sub-Saharan region are too dry for common crops such as pea nuts (*Arachis hypogea*), maize (*Zea mays* L.) and sorghum (*Sorghum bicolor*) but may not be for Bambara nuts. It is actually cultivated by farmers as a famine culture crop due to its agronomic values and the ability to produce in soils that are considered poor or insufficiently fertile for cultivation of other more favoured species such as common beans and groundnuts [33,34]. This makes Bambara nuts suitable for cultivation in such regions where soil nutrient has been eroded by erosion, where there are threats of desert encroachment or during drought conditions without having any effect on the quality of the nutrition of the seed [35]. As legumes, they are known to fix atmospheric nitrogen through some nitrogen fixing bacteria such as Rhizobium, Clostridium, and Azotobacter [36]. This ends up enriching the soil hence diminishing the need for artificial fertilizers. Consequently, the crop is grown by subsistence farmers in unfavorable and stressful environments without fertilizers, irrigation or pest and diseases control [37]. Several local farmers are also known to inter plant Bambara nuts with non-leguminous crops such as maize, yam resulting in a better yield [38] while others practice crop rotation with it. Bambara nut is recognized as an important nutritious food source when food is scarce [19].

7. Repurposing of Bambara nuts

Legumes serve as a good source of non-processed proteins for rural and urban dwellers of the population especially in the poor countries of the world [39].

In most parts of Africa, Bambara nuts have been traditionally boiled or roasted and eaten as snacks. In some parts of Nigeria, the dried seeds are ground and prepared with palm oil (and sometimes leafy vegetables), into a pudding that has an appealing taste. In Southern Nigeria, this pudding, known as 'okpa', *ntucha* or *ígbà* is a regular part of the family menu. It is also commercially available in the morning on the streets, serving as regular quick breakfast. This may have contributed to the observed lower malnutrition index among children in southern Nigeria than in Northern Nigeria [40].

However, with all the report on its nutritional content and availability in malnutrition-struck zones of the sub-Saharan Africa, *V. subterranean* remains under-utilized. This is possibly because it takes a long time to cook, contains anti-nutritional factors and does not deshell easily [8]. Anti-nutritive factors present in *V. subterranean* include phytic acids, oxalates and condensed tannins. Phytic acids limit the action of digestive enzymes such as trypsin, amylase. Condensed tannins are a group of polyphenolic substances often found in legumes. They affect digestion by forming irreversible complexes and as such, reduce the bioavailability of the amino acids in the *V. subterranean* seeds for animals and humans [41].

Consequently, diverse methods of processing and preparing Bambara nut seed have since been devised in order to reduce the difficulty in cooking and improve acceptability. These processing methods also seek to reduce the antinutritive factors and increase the variety of food. Such mild processing methods including sprouting, fermentation, dehulling, soaking, boiling etc. have led to the development of better dietary options. These processing methods applied in some Bambara nut dietary options evidently minimize the anti-nutritive content of Bambara nuts [42, 43].

For instance, flour made from sprouted red Bambara nuts have significantly enhanced polyphenolic profiles [44]. Cooking and roasting reportedly significantly reduces the amount of tannin in Bambara groundnuts [41]. Boiling also increases the in-vitro digestibility and bioavailability of protein by the destruction of heat labile antinutritive factors, reducing the proteins into smaller polypeptides [19]. The process of sprouting, too, reduces the carbohydrate and lipid content, while it increases the protein and amino acid profile [45,46, 47]. It has however, been suggested that, at low concentrations, these anti-nutrients may be considered beneficial to humans and animals [48, 49].

One of the leading factors encouraging malnutrition in Africa is that most cultural foods in Africa are based on grains, roots (which are basically carbohydrates) and vegetables with little or no milk or other sources of animal protein. This is insufficient for daily nutrition as children require milk for their development [50]. Coupled with the fact that animal milk, fish and meat are found expensive by the poor locals, there is a need to introduce diverse and cheaper varieties of food stuff with sufficient amounts of protein in order to win the malnutrition war. This will also accommodate vegetarians as well as the few individuals with lactose intolerance.

Plant based milk has since been tried out from different legumes. Milk produced from Bambara nut are not only comparable (in terms of nutrition) to other plant-based milks such as that from cow pea, pigeon pea, soybean etc. [51] but are found to be more acceptable than them. This is due to its unique appealing flavour, taste and light colour [52]. In fact, it has been suggested as a suitable weaning food due to its rich nutritional content [53].

Other nutritious and acceptable milk products such as yoghurt have been reported from Bambara nut milk [54,55] with a shelf life of about 28 days. However, its shelf life can further be extended through other technologies such as spray drying or the foam mat drying method. These drying methods not only increase the shelf life of yoghurt but also makes packaging, handling and transportation much easier. The milk products so derived are also reported to have retained its nutrient [56].

Innovation is still ongoing in the processing of Bambara nuts resulting in some flour blends containing varying proportions of Bambara nuts [45, 47, 56] which have successfully been used in baking bread. In parts of Nigeria, a blend of flour made from Bambara nuts and grains such as maize, sorghum, is recently being used in preparing a local dish known as *fufu* or *foofoo* [57]. This is another way of introducing more protein into the African daily food consumption.

8. Managing cultural setbacks in acceptability of Bambara nuts

Traditionally, Bambara groundnuts are cultivated by the poor locals in Africa, most especially women and children. This has created a subtle stigma around its cultivation and consumption. Proper enlightenment on its nutritional benefits has become necessary in order to overcome the challenges of the nutritional war. Appealing, yet efficient packaging of Bambara nut flour, can be effective in introducing Bambara nuts to the global family menu for the preparation of a variety of meals. Promotion of its milk and yoghurt can also be beneficial. A positive adjustment in culture could largely promote the consumption of Bambara groundnuts thereby revitalizing the already set back 'zero hunger, healthy lives and well-being' goals of the SDG #2 and SDG #3.

9. Conclusion

As the effects of the climatic change, insecurity and COVID-19 disruptions continue to further manifest, the result has included malnutrition occurring as wasting, stunting, underweight and overweight/obesity as well as anemia etc. The arid and semi-arid regions of the world remain the worst hit by malnutrition. *Vigna subterranean* (Bambara groundnuts), is a rich nutritional crop culturally cultivated by women and the poor in sub-Saharan Africa. It is economical to cultivate and can survive even in these arid and semi-arid regions of the world. Bambara groundnuts can be processed into a number of food varieties and more varieties are being introduced. This provides more protein rich dietary options in the menu and can be used to manage obesity. Highlighting and promoting Bambara groundnuts, can therefore be considered a very effective weapon for dealing with the current malnutrition crisis in the world. With this, the global sustainable development goals #2 and #3, already grossly set back by COVID-19 and global insecurity etc., may still be attainable by the year 2030.

Compliance with ethical standards

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Disclosure of conflict of interest

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