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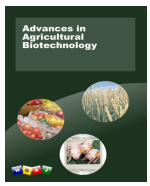

Bambara groundnut: an Under-Utilized Nut in Africa

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ABSTRACT

This review dwelled on the description, propagation, planting, growth development, harvesting, and foremost, utilization of the nut. Furthermore, it focuses on Bambara groundnut's nutritional and Anti-nutritional composition, Nitrogen fixation properties of the nut and its usage in different parts of Africa. Again, it proffered the way forward for ending the underutilization of the nut, and bringing the nut out of its seeming obscurity. Finally, it posits that there should be effort by the governments involved for support for research on the cultivation and use of the nut.

1. Introduction

Legumes have historically been part of inexpensive meals throughout the world as they have a major role in the fight against malnutrition. It is therefore necessary that their levels of consumption, which are already too low in a number of developing countries, be increased [1]. Plant proteins provide nearly 65% of the world supply of proteins for humans; 45-50% cereals and 10-15% legumes [2]. Legumes serve as a source of non-processed protein for rural and urban dwellers of the population especially in the poor countries of the world [3] and as a good source of fiber, resistant starch, and other nutrients, they are one of the least glycemic sources of carbohydrates, because the starch is either slowly absorbed or resistant.

The Bambara groundnut's botanical name is *Voandzeia subterranean* (L.) *thousars*, synonyms of *Vigna subterranean* and belongs to the plantea of the family of fabaceae and sub family of Faboidea. The crop is a legume species of African origin [1] with subterranean fruit–set which is widespread south of the Sahara [4]. It serves as an important source of protein in the diets of a large percentage of the population in Africa, particularly to poorer people who cannot afford expensive animal protein. It is used for both human and ani-

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mal consumption. Bambara groundnut *is* cultivated by smallholders over much of semi-arid Africa [5] and principally by farmers as a "famine culture" crop because it has several natural agronomic advantages including high nutritional value, drought tolerance and the ability to produce in soils considered insufficiently fertile for cultivation of other more favoured species such as common beans and groundnuts (*Arachid hypogea)* [6, 7]. The nuts are also known as jugo beans (South Africa), ntoyo ciBemba (Republic of Zambia), Gurjiya or Kwaruru (Hausa, Nigeria), Okpa (Ibo, Nigeria), Epa-Roro (Yoruba, Nigeria) and Nyimo beans (Zimbabwe). It originated in the Sahelian region of present day West Africa, from the Bambara tribe near Timbuktu who now live mainly in Central Mali [8], (hence it's name Bambara Groundnut).

The Bambara Groundnut is regarded as the third most important crop after groundnuts (*Arachis hypogea*) and cowpeas (*Vigna unguiculata*) in Africa but due to its low status, it is seen as a snack or food supplement but not a lucrative cash crop [3, 9, 10, 11] (Sellschop, 1962; Doku & Karikari, 1970; Rachie & Silvestre, 1977; Linnemann, 1992). Additionally, it is usually given less value and less priority in land allocation because it is grown by women. Between 10-40% of the harvest is sold, the rest is consumed by the rural farmers themselves. Bambara groundnut seeds vary in shape, size and colour of the seed coat. They may be round or elliptical in shape with cream, broom, red, mottled or black – eyed with seed weight ranging between 280 and 320g [12] (Ojimelukwe, 1992). The crop has been widely cultivated in tropical regions since the seventeenth century. In addition to sub-Saharan Africa, it is now found in many parts of South America, Asia and Oceania [13] (Baudoin and Mergeai, 2001). It can produce high yield levels with low input and is an ideal crop for farmers. It was found that about 98% of farmers in Swaziland regard Bambara groundnuts as a profitable crop [14, 15] (Sesay *et al.,* 1999; Begemann *et al.,* 2002). Bambara groundnut is a promising commodity which needs more publicity, both as a crop and as a food. According to Coudert [16], the annual production is about 330 000 tons of which Africa produces half, with Nigeria being the major producing country. The yields are low because production and improvement of Bambara groundnut has been neglected for many years by researchers, even though the crop is important for the small scale farmers due to its considerable commercial potential. Though, grown extensively in Nigeria [17, 18] (Oguntunde, 1985; Enwere, 1998), it is still one of the lesser utilized and unexploited legume therefore the purpose of this review was to bring together some of the data on the propagation, nutritional composition and its utilization in different parts of Africa.

Figure 1: Different types of Bambara groundnuts

Source: Swanevelder [19]

Nutritional composition of Bambara groundnut

The plant has the potential to improve malnutrition and boost food availability. The seed makes a complete food, as it contains sufficient quantities of protein, carbohydrate and fat. Several workers have examined the biochemical composition of the seed [20, 21, 22, 23] (Owusu- Domfeh *et al.* 1970; Oluyemi *et al.* 1976; Oliveira 1976; Linnemann 1987). On average, the seeds contain 63% carbohydrate, 19% protein and 6.5% oil. Despite the relatively low oil content, some tribes in Congo reportedly roasted the seeds and pounded them for oil extraction [24] (Karikari 1971). The gross energy value of Bambara groundnut seed is greater than that of other common pulses such as cowpea, lentil and pigeon pea [25] (FAO 1982). Ihekoronye and Ngoddy (1985) [26] reported that it is richer than groundnuts in essential amino acids such as isoleucine, leucine, lysine, methionine, phenylalanine, threonine and valine. Bambara groundnut is a non-oily leguminous seed which contains only about 6% of ether extract therefore could not give a cash crop status, a great importance in food industry. In addition, the fatty acid content is predominantly linoleic, palmitic and linolenic acids [27] (Minka and Bruneteau 2000). The carbohydrate fraction of it is predominantly composed of starch and non-starch polysaccharides with lesser amount of reducing and non – reducing sugar. Addo [28] (1986) reported that Bambara groundnut con-

tains high amount of lysine than other legumes, while the seed contain more methionine than any other grain legume.

Table 1 shows the proximate composition of different varieties of Bambara groundnuts' seed, seed coat and flour, there was no much difference in all varieties so when consuming any of them, the embedded nutrients are still available. Red seeds could be useful in areas where iron deficiency is a problem as they contain almost twice as much iron as the cream seeds. It contains an appreciable amount of lysine and minimum amount of trypsin and chymo-trypsin [29] (Oyenuga, 1968). It has a high content of Nitrogen, fairly well supplied with Calcium and Iron though poor in phosphorous and Magnesium as shown in Table 2. It contains thiamine, riboflavin, niacin and carotene but very low in ascorbic acid [29] (Oyenuga, 1968). The essential amino acid content of bambara groundnut such as lysine 6.82g/16gN, methoinine 1.85g/16gN and cysteine 1.24g/16gN is comparable to that of soyabean (6.24g/16gN lysine, 1.14g/16gN methionine and 1.80g/16gN cysteine) [30] (Fetuga *et al.*, 1975). From Table 3, it can be seen that Bambara Groundnut compares favourably well with other well known and highly commercialized beans.

Table 1: Proximate composition of different varieties of Bambara Groundnut seeds, flour and seed coat.

Cultivars	Crude Protein	Fat (%)	Moisture content	CHO soluble	CHO content	Ash content
Red	19.5	6.5	8.0	7.6	54.4	3.0
Black	21.7	8.5	9.0	4.0	52.8	3.5
Cream	19.5	6.0	9.7	6.5	56.0	2.5
Brown	19.0	6.5	10.3	12.0	54.4	3.0
	FLOUR					
Red	20.9	3.0	9.3	2.2	48.0	2.0
Black	22.6	4.0	9.0	1.4	32.0	2.0
Cream	22.3	3.0	9.0	1.6	49.6	1.5
Brown	19.4	3.5	10.0	2.9	48.0	2.0
	SEED COAT					
Red	5.7	0.5	3.0	2.6	8.4	1.0
Black	6.1	2.0	3.5	3.0	6.0	1.5
Cream	6.8	1.0	3.0	1.8	9.2	1.0
Brown	6.3	2.0	3.0	0.5	9.1	1.0

Source (Ojimelukwe *et al*; [12]

Table 2: Macro-elements of Bambara groundnuts (% dry matter)

	K	Mg	Ca	P	N
Roots	1.5	0.6	0.9	0.2	2.7
Leaves	1.1	0.5	2.6	0.2	1.8
Seed	1.6	0.2	0.9	0.6	3.9

Source: Mkandawire [31]

Table 3: Nutritional comparison of some legume crops

	Bambara	Soya	Cowpea	Kidney	Broadbean	Chickpea
Calories (kCal)	390	416	343	333	341	364
Protein (g)	20.8	36.5	23.8	23.6	26.1	19.3
Carbohydrates (g)	61.9	30.2	59.6	60	58.3	60.6
Fat (g)	6.55	19.9	2.1	0.8	5.7	6.0

Source : Caroline de Kock [32]

Anti-nutritional components of Bambara Groundnut

Low levels of trypsin inhibitor and phenolic compounds have been identified in Bambara groundnut seed [33, 34] (Poulter, 1981; Brough *et al*,. 1993).The trypsin inhibitor is inactivated by autoclaving but was discovered that substantial proportion of the trypsin inhibitor activity remained after heat treatment; total activity was reduced with presence of a heat stable (tannin) and heat – liable (protein factor). Tannin is located mainly in the seed coat and their concentration is correlated with seed colour as it is in common beans.
Poulter [33] found that the highest level of tannin was found in Bambara groundnut accession with brown, red seed and lowest tannin level in accession with cream coloured seed. No cyanogenic glucoside, alkaloid or phytohalmagglutinin were found in Bambara groundnut [35]. (Linnemann, 1990).

DESCRIPTION

Often called bambara groundnut, it is conventionally classified a bean, but its seeds are actually dug from the ground like peanuts. To outsiders, only the shape seems unusual: the pods are larger and rounder than peanut shells and the seeds inside are shaped more like peas than peanuts. Those spherical legumes are, however, exceptionally tasty and nutritious. They are also attractive—appearing in varying colors and patterns, characterized by pretty local names such as *dove eyes*, *nightjar*, and *butterfly [36]*

Bambara groundnut is a herbaceous, intermediate, annual plant, with creeping stems at ground level The plant is leguminous and has numerous nitrogen fixing nodules on the roots. Evidence has shown that based on the root nodules, the plant supports land care provision in Africa [36]. The leguminous plant is grown for its underground seeds. The entire plant is similar to the common peanut, being a low, flat annual with compound leaves of three leaflets. There is also an erect form. Like the peanut, it forms pods and seeds on or just below the ground. To achieve this, the flower stalk elongates and penetrates the soil. The bulbous tip creates a tunnel through which the fertilized flower, attached just behind the tip, is drawn into the soil [37]

The pods are round, wrinkled, and over ½ inch long. Each contains one or two seeds that are round, smooth, and very hard when dried. There are numerous nitrogen-fixing nodules on the roots. The seed is hard, smooth, usually round and varying in size up to about 1.5cm in diameter [38] (Kay, 1979). It can also vary in colour from white, cream, dark-brown, red or black and may be speckled or patterned with combination of these colours.

Bambara groundnut is probably the most drought–resistant of the grain legumes and may be found surviving successfully where annual rainfall is below 500 mm and optimum between 900–1000 mm per year [4]. The plant can be grown under dry climatic conditions where the rainfall during the rainy season would be adequate to enable them to accomplish their vegetative cycle [1].

Bambara groundnut is a small herb that grows to about 0.30–0.35 m in height, and like the groundnut has compound leaves of three leaflets. Both prostrate and erect forms occur. The plant is considered to be autogamous [13] (Baudoin and Mergaei, 2001). Pale yellow flowers are borne on the freely branching stems and after fertilization the stem of the flower grows down towards the soil, taking the developing seed with it. The pod (1.25–2.5 cm in diameter) is drawn into the soil and ends up lying about 1 cm beneath the surface. The much –branched stems root at the nodes to form a bunched herbaceous annual crop with a thick taproot which forms a profusion of lateral roots towards its tip [39] (Tweneboah, 2000). The general appearance of the plant is bunched leaves arising from branched stems which form a crown on the soil surface. Stem branching begins very early, about one week after germination, and as many as twenty branches may be produced [40] (Goli, 1995). The plant has a bushy habit. It consists of about ten running stems with very short internodes. Roots grow from the nodes at each stem. The leaves with erect petioles are alternate and trifoliate. The peduncles are auxiliary, elongating from the stem nodes, each peduncle bearing one to three flowers (usually two) [41] (Gibbon and Pain, 1985).

Propagation and Planting

Seed planting is always the main method of developing the crop and is inter-planted with either cereals (pearl millet, root crops or other legumes) or in pure stands [41]. Ocran *et al*. [4] reported that the crop may be grown either as a single stand or intercropped with groundnut, millet or sorghum. In rotations, it may be planted as an opening crop perhaps followed by cassava, or in the second year it may be intercropped with cereals, vegetables, groundnuts or other pulses. Doku [42] stated that there is also a trend towards mixed cropping with yams, the bambara groundnut being planted on yam mounds protect the mounds from erosion, conserves moisture and creates fewer temperature fluctuations in the mound. The crop performs best on deeply ploughed field with a fine seedbed, eventually allowing the plant to bury its developing fruits. Ridging is advisable if the soil is shallow or prone to water logging [43]. Baudoin and Mergeai [13] reported that proper loosening of the soil helps pod penetration during fructification and improves the yield. Tweneboah [39] also mentioned that a well prepared friable seed bed is required to enable the plants bury their pods after fertilization. Tindall

[44] indicated that seeds, normally shelled are sown on beds or ridges in rows 40-50 cm apart, 20-30 cm between plants. According to Ocran *et al.* [4], the recommended row spacing is usually 10-45 cm with an intra row spacing of 15-17 cm. One seed is sown per hole 3-5 cm deep. Seed rate varies in several location, that is 35 kg/ha in Tanzania; 25-45 kg/ha in Kenya; higher rate of 60-75 kg/ha in South Africa when rat damage is expected [45]. Gibbon and Pain [41] observed that the normal seed rate is 30-60 kg/ha of shelled nut giving 150,000 plants/ha.

Sowing dates vary considerably within locations. In Zambia and Botswana, for example, sowing takes place from November to February. Sometimes phased planting occurs, examples, in Skumaland, Tanzania [43]. In the derived savanna zone of Ghana, two crops are possible, the first crop sown in May -June and the second crop in October. In the northern part of Nigeria, the main planting period is between August–September [39]. In the Guinea savanna zone, the crop is usually grown during the minor season (September-November) when the rainfall is reliable. In the Sudan Savanna zone, it is usually cultivated towards the end of the single long rainy season [42].

Growth and Development

Bambara groundnut is a fast growing plant, which requires warm temperatures and does not tolerate freezing temperatures at any stage of growth. An average day temperature that is ideal for the crop development is from 20 to 28^0 C and the optimum temperature for germination of bambara groundnut seed is 30-35^{o}C. Extreme temperatures cause dying of the leaves, resulting in the reduction of the biomass yield. Wych *et al.* [46] indicated that cool temperatures are conducive to longer seed filling periods and as a result increased yield in grain crops. The crop requires an average rainfall of about 600 to 700 mm during the growing season [19] and too much rainfall at harvest may result in yield losses. Emergence takes 5-21 days. Vegetative development may continue after reproductive development has started. Flowering starts 30-55 days after sowing and may continue until the plant dies [43]. After fertilization the pods form and reach their maximum size about 30 days. The seeds expand and reach maturity during the following 10 days [5]. The duration of the crop cycle is between 100-180 days [13].

Harvesting

Harvesting usually starts about four months after sowing when the pods are mature and the plants' leaves are beginning to yellow. The plants are simply pulled out of the ground, with the attached nuts manually [41]. In a dry environment, harvesting takes place when the entire foliage dries up. In humid ecosystems, however, pod rotting or early seed germination (in the pod) may take place while the leaves are still partially green. Harvesting is then recommended before full foliage drying [40]. According to Karikari [47], in Botswana, immature pods are usually harvested about two months before the pods dry completely. Although a farmer may harvest a crop as immature for immediate use, but for commercial purpose, only mature dry seeds are harvested.

Figure 2: Harvested Bambara groundnuts
Source: Swanevelder [19]

Pest and Diseases

Doku [42] mentioned that the crop is relatively pest and disease–free apart from weevil attack during storage. Gibbon and Pain [41] observed that no serious pest or diseases are reported for this crop but damage is sometimes caused by leaf hoppers *(Hilda patruelis]and Empoasca facialis).* Tanimu and Aliyu [48] have also made similar observations that bambara groundnut is relatively free of the insect pests that plague other legumes, such as the cowpea and peanut. And on the whole, pesticides are hardly used by farmers when cultivating bambara groundnut.

The common fungal diseases that affects the plant are cercospora leaf spot *(Cercospora spp.),* powdery mildew *(Erysiple polygoni)* and Fusaruim wilt (*Fusarium oxysporum*) [43]. According to Goli [40] in dry weather, pod attacks by termites have been consistently observed and root knot nematode *(Meloidogyne javanica)* also attacks the roots of the plant in sandy soils.

Nitrogen fixation of Bambara groundnut

Bambara groundnut has an indirect beneficial use in agriculture because it is a legume, which has a symbiotic relationship with bacteria that form root nodules. The bacteria can make use of the free nitrogen from the

air and assimilate it in the plant root tissue. By so doing, they directly increase the level of the soil nitrogen, and in turn the yields of the cereal that may follow legumes in plant rotation, is increased [49].

Utilization of Bambara groundnut in different parts of Africa

Bambara groundnut is a complete food and is eaten in various forms either immature or fully mature. Bambara groundnut has long been used as an animal feed [50] and seeds have been successfully used to feed chicks [21]. The leaves are suitable for animal grazing because they are rich in nitrogen and phosphorus [51]. Foremost food uses, the seed coats of legumes including Bambara are removed to reduce the anti-physiological factors and fibre content, and this result in better appearance, texture, cooking quality, palatability and digestibility of the products [52]. Dehulling can be accomplished manually or mechanically depending on the type of legume and/or quantity involved [53].

In **Botswana**, bambara groundnut is predominantly grown for human consumption. Consumers often prefer the immature seeds, which are boiled in the pod, salted, and consumed, either on their own or mixed with maize seeds. When the seeds are ripe and dry, they are pounded into a flour and used to make a variety of cakes, or are mixed with cereals and used to prepare several types of porridge. Livestock, especially goats, are very fond of the stem or stalk, which they are allowed to graze on at the end of the season, after the pods have been harvested. The seeds of the mature black landrace are used in traditional medicine [54].

In **Burkina Faso**, the bambara groundnut is primarily consumed by its producers, during the period before the cereals are harvested. Along with the cowpea (*Vigna unguiculata* (L.) Walp.), it constitutes the main source of vegetable protein for the rural populace. Its leaves, which are rich in protein and phosphorus, are used as fodder for livestock [55]

In northern **Ghana**, the fresh immature beans are boiled and consumed after adding a little salt. The dry beans are also boiled, crushed and made into cakes or balls, which are then fried and used to prepare stews. In southern Ghana, the beans are usually soaked overnight, after which they are boiled until soft, to produce a kind of porridge/blancmange. Capsicum pepper and salt may be added during the boiling process. This preparation, called 'aboboi', is served with 'gari' (roasted, grated cassava) or with mashed, fried, ripe plantain. In the early 1960s, bambara groundnut was canned in Ghana, in tomato sauce with pieces of meat, in brine, or as 'aboboi' [42].

In **Kenya**, Ngugi, [56] reported the uses of Bambara groundnut according to the different tribes.

Uses by the Kambe/ Giriama

Among the Kambe and Giriama peoples of the Coast Province, Bambara groundnut is normally cooked or used when vegetables are in short supply.

When the seeds are dry, they are pounded in a 'kinu' (mortar) to remove the seed coat (they do not break), winnowed and boiled until they are cooked. They are then pounded using a 'kipawa' (serving spoon made from the coconut shell) or 'mwiko' (wooden spoon), and 'tui' (coconut juice) is added. The mixture is boiled until cooked and stirred with a wooden stirrer ('lufidzo') until smooth. It is then served with rice or 'ugali' (a stiff maize meal porridge).

· When the seeds are still green, the seed coat is peeled off by hand and the seeds are then prepared in the same way as the dry ones (described above).

Uses among thee Lubya people of Kenya

The Luhya consume bambara groundnut in the following ways:

- Cooked fresh in its pods (green pods are washed and boiled in salted water, which is said to penetrate the pods). This is reported to be the tastiest snack among the many that are made from bambara groundnut, and is rated even more highly than the peanut.
- The dry seeds are salted while roasting (the seeds may be washed before roasting). Owing to the hardness of the seeds, this dish is not a favourite, especially with children. Sometimes, a small number of seeds is reportedly roasted with a greater proportion of peanuts, to reduce the hardness effect.
- Dry seeds can either be pounded or ground and the resultant meal made into some stew (or sauce). The stew/sauce is then added to the traditionally prepared leafy vegetables, particularly 'sikhubi'/'elikhubi' (cowpea) and cooked. This may be served with 'ugali' or potatoes.
- Boiled with maize and beans and served as a snack, especially with tea.
- Fried (like peanuts), usually with sesame seeds.
- Boiled, then mixed with boiled sweet potatoes and mashed (a popular children's
- dish). It is also consumed plain, after being boiled and mashed.
- Unshelled pods are boiled, fried and served with potatoes, bananas or 'ugali'

Uses among the Luo people of Kenya

Bambara groundnut is also prepared in a number of ways by the Luo:

- Used in the same way as kidney beans, to make 'nyoyo' (a mixture of beans and maize boiled together), or plain boiled. This is served with tea, 'nyuka' (porridge), or on its own.
- Dried, ground using a 'pong' (grinding stone), or pounded in a 'pany' (mortar), then cooked in the same way as greengrams, in a sauce traditionally known as 'ogira', this is served with other foods, such as potatoes. Traditionally it was eaten using a 'sare' (bivalve shell from lake Victoria).
- Roasted like the peanut; this is not common, because the seeds remain hard after roasting. Peanuts are normally added, probably to reduce the effect of hardness.
- Water from the boiled maize and pulse mixture is drunk to treat diarrhoea.
- The leaves are pounded with those of *Lantana trifolia* L. ('nyabend winyo','nyamrithi'), then water is added to make a solution used to wash livestock as a preventative against ticks. This solution is used as a pesticide on vegetables too.
- The leaves can be combined with those of 'nyajagra' (mexican marigold) and *L. trifolia*, pounded, and water added. This mixture can also be used as an insecticide. When applying the solution to vegetables, care needs to be taken to apply it to the ground, and not to pour it on the leaves, as it is reported to burn them.
- When dry, the leaves are pounded with traditional salt ('mbala', harvested at Sindo and Homalime), and fed to cattle infected with 'tuoolao' (a type of mouth disease). The leaves cauterize and heal the animals' wounds.

Medicinal uses in Kenya

Water from boiled maize and **Bambara groundnut** is drunk to treat diarrhoea.

- The leaves are pounded with those of Lantana trifolia L. ('nyabend winyo', 'nyamrithi'), then water is added to make a solution used to wash livestock as a preventative against ticks. This solution is used as a pesticide on vegetables too.
- The leaves can be combined with those of 'nyajagra' (mexican marigold) and L. trifolia, pounded, and water added. This mixture can also be used as an insecticide. When applying the solution to vegetables, care needs to be taken to apply it to the ground, and not to pour it on the leaves, as it is reported to burn them.
- When dry, the leaves are pounded with traditional salt ('mbala', harvested at Sindo and Homalime), and fed to cattle infected with 'tuoolao' (a type of mouthdisease). The leaves cauterize and heal the animals' wounds [56].

In south Africa, the following culinary uses of the crop were reported by Swanevelder [19]:

'Sekome' (Sesutho), 'tihove' (Shangaan) or 'tshidzimba' (Venda) is prepared by adding 'njugo' beans and peanuts, or just one of the two, to maize or millet-meal and boiling the mixture until it forms a stiff dough. This is salted and pounded into a ball, and will often keep fresh for several days.

- Bambara groundnuts are boiled and then stirred, to make a thin porridge, which is known as 'tshipupu' (Venda). Like maize, they may also be added to 'lupida', a porridge made from peanuts.
- 'Njugo' beans are often eaten when still immature, simply boiled until soft, and shelled. When quite dry and hard, they are generally shelled, and then boiled to make a stiff porridge.
- Bambara groundnut can be cooked with maize and pounded into a thick, sticky dough known as 'dithaku' (in Sesutho).

The only use of bambara groundnut observed among the local white population was of the dried beans, to make a soup.

In **Nigeria**, the freshly harvested pods are cooked, shelled and eaten as a vegetable snack, while dry seeds are either roasted and eaten as a snack in a manner similar to boiled peanuts [38, 57] or milled into flour (figure 3) and used in preparation of moin-moin [58] or '*okpa*' among the Igbo tribe of Nigeria [18].

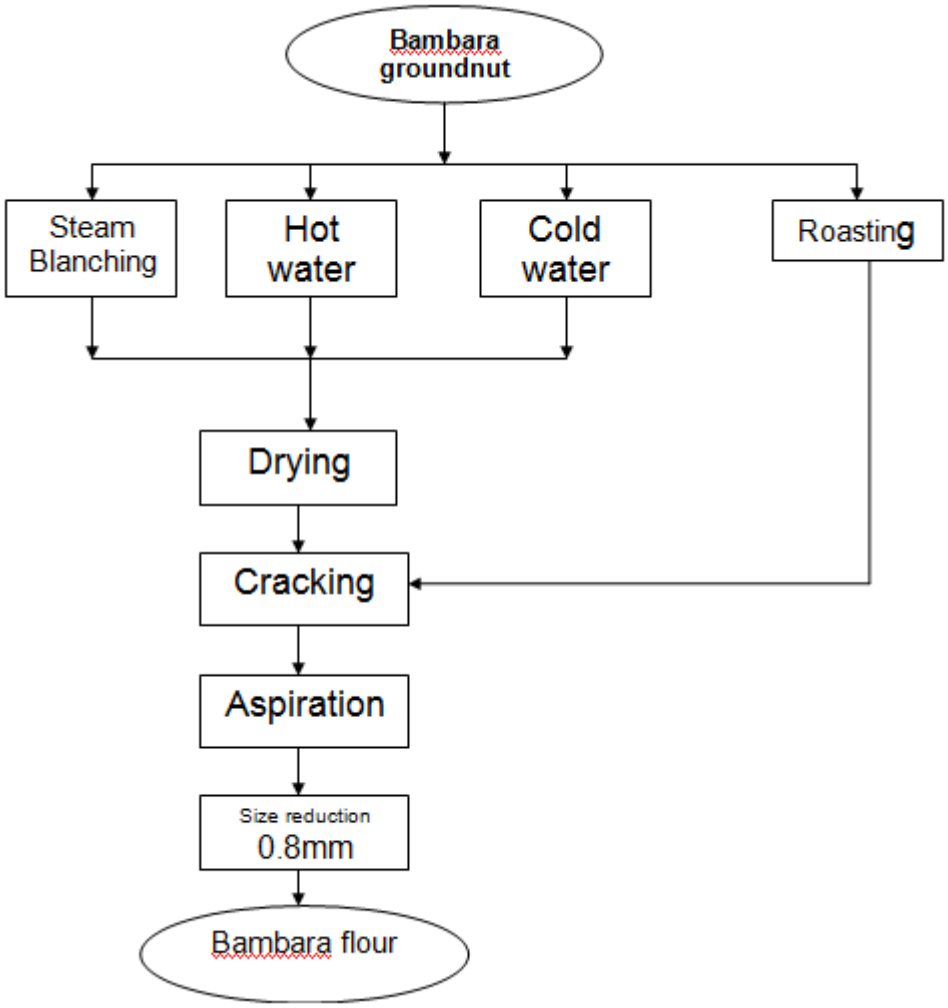

Figure 3: Flow chart for different processes of preparation of Bambara flour.

Source: Olapade and Adetuyi [63]

The stem or stalk is used for livestock feed, while in the Northern part of Nigeria, the seeds are often crushed into flour, to prepare the following dishes: 'alele', 'alelen ganye', 'danwake', 'gauda', 'kosai', 'kunu','tuwo' and 'waina' [23]. The fresh immature seeds are also eaten raw [48]. Bambara groundnut milk was a modified method for the extraction of cowpea milk [34]. The dried mature seeds can be converted into paste, steamed and eaten with vegetable soup or sauce. Bambara groundnut can also be fermented. A known dadawa type product is made from Bambara groundnut using a solid substrate fermentation method [59].

Also the flour could also be use as composite flour (figure 4) used for cereal based confectionaries e.g. Biscuit \ Cakes, bread [28]. The extract from the nut particularly the protein extracts can be used directly in cosmetic formulations and provides specific and notable effects. The nut can also be used quite freely to replace the high-prized lumps of meat without sacrificing adequate nutrition [60].

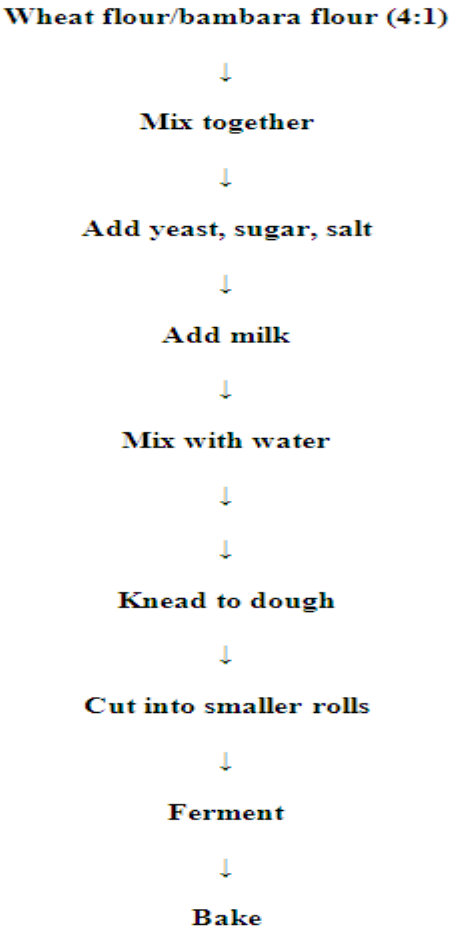

Figure 4: Flow chart for Bambara groundnut composite Bread.

Source: Okoye and Okaka [64]

It has been reported that in Zambia, Bambara groundnut is used for bread making [34] while Poulter and Caygill [61], also reported that it could be used for milk making. Tanimu, and Aliyu [62] described the great genetic diversity potential of bambara groundnutIn countries such as Angola and Mozambique, boiled salted seeds are often served as appetizers. Commercial canning of Bambara groundnuts as gravy is a successful industry in countries such as Zimbabwe and Ghana. Recently, a trial of bambara groundnut milk (figure 5) was carried out which compared its flavour and composition with those milk prepared from cowpea, pigeon pea and soyabean [34].

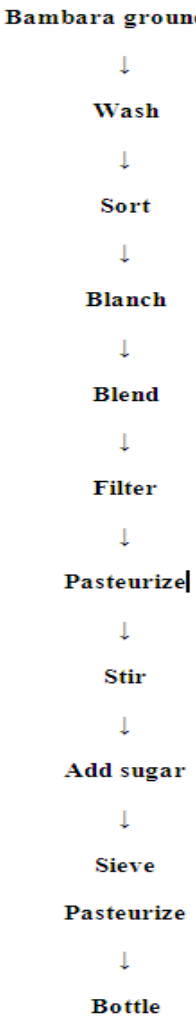

Figure 5: Flow chart for Bambara groundnut milk. Source: Okoye and Okaka [64]

Conclusion

Although Bambara groundnut is largely unexploited, cheap and given little or no priority, there is an urgent need for awareness campaigns on its uses, nutritional benefits, and as a matter of urgency it should be positioned as a cash crop. Bambara groundnut production, conservation, and utilization should be pursued since the degree of cultivation and use in Africa and beyond is nothing to write home about. Given the rate at which agriculture production is to growth in world population, the production and use of this often neglected crop should be improved. Again, the nut should not only be seen and cultivated as subsistence-female crop; rather it should be seen as a crop that is relevant to food security. Lastly, there should be a concerted effort by the international community for support for and research on the cultivation, use and storage of Bambara groundnut which is presently low.

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