BAMBARA GROUNDNUT SITUATION ANALYSIS AND VALUE CHAINS FOR MALAWI, MOZAMBIQUE AND TANZANIA

UNIVERSITY OF MALAWI

IIAM- NAMPULA

NALIENDELE AGRICULTURAL RESEARCH INSTITUTE

NATURAL RESOURCES INSTITUTE

NATURAL PLANT GENETIC RESOURCE CENTRE

MALAWI

BUNDA COLLEGE OF AGRICULTURE
P.O. BOX 219
LILONGWE
MALAWI
Agnes Mwangwela, Donald Makoka

NATIONAL PLANT GENETIC RESOURCES CENTRE
CHITEDZE RESEARCH STATION
LILONGWE
MALAWI
Lawrent Pungulani

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LIST OF ACRONYMS

CICOD	:	Center for Integrated Community Development
MARDEF	:	Malawi Rural Development Fund
MoA	:	Ministry of Agriculture
GDP	:	Gross Domestic Product
GoM	:	Government of Malawi
EPA	:	Extension Planning Area
MPGRC	:	Malawi Plant Genetic Resource Centre
T/A	:	Traditional Authority
Kg	:	Kilogram
GPS	:	Global Positioning System

1.1 INTRODUCTION

McKnight Foundation commissioned a baseline study on production and utilization of bambara nuts in Malawi, Tanzania and Mocambique. The study aimed at ascertaining production trends, opportunities, and challenges affecting sustainable production and utilization of bambara nuts in the three countries. Results of the baseline would form a basis for supporting bigger project that would upscale production of the cropping by looking at whole value chain i.e production to utlisation. In Malawi the study was conducted through a survey in Mwanza, Thyolo, Ntcheu, Mchinji, Ntchisi and Mzimba as indicated in figure 1. The primary survey was conducted in November 2009. The period coincided with planting season and this provided an opportunity to practically note production challenges in the villages visited.

Figure 1: Map of Malawi showing the districts of Thyolo, Ntcheu, Mchinji, Ntchisi and Mzimba districts

1.1.1 Background

Agriculture's role as the potential main driver of poverty-reducing growth is widely recognized by the Malawi Government. Normally, agriculture alone contributes about 38 percent of value-added to GDP, employs 85 percent of the workforce, and contributes 80 percent of foreign exchange earnings (GoM 2007). Agriculture's structure is dualistic, comprising a dominant smallholder sector, and about 300,000 medium and large scale estates. Average cultivated area in the past five years have been 2.7 million hectares, of which 1 million hectares is held in the estate sector under leasehold / freehold tenure and the remainder is held in the smallholder sector under customary tenure.

The performance of the agricultural sector has historically been weak with limited growth in productivity and occasional production volatility associated with floods or drought. Correspondingly, a major national objective has been to strengthen the country's food security by subsidizing the maize production and trade. These policies have contributed to the achievement of a major maize production surplus. Despite Government efforts to promote agricultural production some crops still remain underexploited in order to realize their full potential. Bambara is one of such crops. The crop has significantly lagged behind though smallholder farmers derive their livelihoods. The crop has no readily available information on agronomic practices that can reduce harvest losses in terms of disease and pest control, intercropping practices, proper planting period, and post-harvest handling. Farmers mostly rely on their ingenuity to produce the crop with minimal support from research institutions.

Bambara groundnut (*Vigna subterranea* (L.) Verdc) is a crop originating from Africa and it is eaten in almost all parts of Malawi. It makes a complete food as it contains sufficient quantities of protein, carbohydrate and fat (Goli, 1997) and its gross energy exceeds that of other common pulses such as cowpea, lentils and pigeon pea (FAO, 1982).In addition to the food it provides, bambara nut is beneficial to the farming system because of its potential to fix nitrogen in the soil. Bambara nut is reported to be tolerant to drought, poor soils and extreme heat, hence making it a suitable crop to the low-input production systems ((Karikari, 1996). It is also reported that under severe drought conditions where groundnuts did not have any kernels, Bambara nut produces small filled pods (Mazhani and Appa-Rao, 1985). Yield potential of Bambara nut ranging between 497kg/ha and 799 kg/ha (Drabo,1987). In other experiments best accessions are reported to yield as high as 3500 kg/ha (Ng et al, 1991). From the experiment conducted by Malawi Plant Genetic Resources Centre, it has been shown that an appreciable yield as high as 1500 kg/ ha can be obtained.

Despite its potential to supply poor resource families with a reasonable yield, in many countries research on this crop has been very minimal. Lack of detailed information and the enormous unfulfilled potential on Bambara nut has been cited by several authors (Linnemann, 1987, Linnemann and Azam-Ali, 1991).

1.2 METHODOLOGY

1.2.1 Site selection

Using documentation system for Malawi Plant Genetic Resources Centre for Bambara groundnuts, especially on germplasm collection, the following districts were purposively

sampled: Mzimba and Nkhatabay in the northern region, Ntchisi and Mchinji in the central region and Mulanje and Mwanza in the southern region. However due to transport logistical problems during the survey time, Nkhatabay district was not visited. In each district, one T/A was purposively sampled in consultation with the District Agricultural Office, and then one EPA within the selected T/A was randomly sampled. The selection of the T/A was done to ensure that data are collected from leading Bambara groundnut growing areas in each district. In each EPA two villages were sampled from which 10 households who had ever produced bambara groundnuts were sampled. This gave 20 households in each district.

1.2.2 Data Collection and analysis

Data was collected using a structured questionnaire and was administered to individual farmers in all the villages sampled. In addition to the structured questionnaire, Focus group discussions were conducted in Mchinji, Ntchisi and Mzimba districts. Two EPAs were selected in each district purposively to choose areas that grow Bambara nuts. A total of 97 people participated in the focus group discussions with 40% being women and 60% men. The collected data was entered in Statistical Package for Social Scientists.

1.3 STUDY FINDINGS

1.3.1 Household Characteristics

The baseline study was conducted in six districts of Malawi namely Ntchisi, Ntcheu, Thyolo, Mchinji, Mwanza and Mzimba. Table 1.1 contains the figures of the respondents from each district. The respondents were mostly women (75%) who came from male headed households (75%). 71 % of the respondents were married in a monogamous relationship. 19% were either divorced or widowed while 11% were single or married in polygamous relationship. The average household had 5.6 members of which 2.6 members were involved full time in farming while 1.7 members were involved in farming on part time basis. This provided a good platform for data collection since women are usually responsible for most leguminous crops more especially those for consumption in the home of which in Malawi is taken to be the responsibility of women.

Table 1.1: Distribution of respondents from the different districts

District	Frequency	Percent
Ntchisi	28	29
Ntcheu	6	6
Mchinji	20	20
Mwanza	13	13
Thyolo	10	10
Mzimba	17	17
Total	**94**	**100**

A majority (74%) of the respondents was illiterate or having attained junior primary school.

The major source of income for these households was sales of crop produce as indicated in Table 1.2. Education could affect the understanding and adoption of farming technologies. In the focus group discussions the farmers indicated that literate people were the ones that broke the cultural barriers (taboos) associated with bambara groundnuts. In subsequent interventions it would therefore be important to target some literate people to promote bambara groundnuts especially in areas such as Mzimba that showed that beliefs were strong limiting the growing of bambara groundnuts.

Table 1.2: Household source of income

Source	**Primary**		**Secondary**		**Tertiary**	
	Frequency	%	Frequency	%	Frequency	%
Crop production and sales	70	74	16	17	4	4
Livestock sales	1	1	39	42	23	25
Non-farm income sources	21	22	20	21	10	11
Not applicable	2	2	19	20	56	60

1.3.2 Crop production

A majority (71%) of the respondents had an experience of less than 10 years as shown in Table 3 below. This could be as a result of a perception by the majority that the crop is associated with the elderly. In addition to age, in Mzimba district growing of bambara groundnuts is restricted to post menopausal women or women who have lost a child in death. It is as such likely to have a majority have a less than 10 years' experience in Bambara farming.

Table 1.3: Respondents experience in farming

Time	**Farming experience**	**Bambara farming experience**	
	%	**Frequency**	**%**
<10year	27	66	71
11-20	27	12	13
21-30	16	5	5
31-40	14	5	5
41 and above	15	5	5

Of the farmers who had <10 year Bambara production experience; 41 % had 1 year experience in producing Bambara. This further indicates that new farmers are picking up the crop. The farmers cited several reasons as why they started producing the crop. Home consumption was the major reason cited by 85% of the respondents. Only 8% of the farmers indicated that they started producing bambara ground nut for sale while 4% indicated its nitrogen fixing characteristics.

Of the 94 respondents interviewed 35% of the farmers had been growing the crop without stopping in some seasons. 61% of the farmers had stopped growing the crop at one point due to lack of seed while 2% of the farmers indicated lack of high yielding varieties as the reason for stopping production of the crop.

Productions estimates obtained from six EPAs of Mikundi, Chioshya, Chipuka, Kalira, Efeni and Luwerezi showed that Bambara nuts production is low and is not recorded as part of crop estimates it is grouped as pulses.

1.3.2.1 Land allocation

The average land holding size of the respondents was 3.35 Acres, with a minimum of 1 Acre and a maximum of 8.5 Acres. Bambara groundnuts were given less priority by a majority of farmers. It is mostly grown in marginalized areas of the main field or it is planted when they run out of seed for the priority crops and if there are a few ridges still remaining then they would plant bambara groundnuts. In some cases the women reported that they would plant the crop at the middle of the main field without their husband knowing for fear of being shouted at for wasting land by planting a less important crop. 28% of the respondents reported that they did not adopt bambara groundnuts due to land shortages. Land shortages makes the people give first priority to crops that they feel are important and profitable like maize for food and tobacco or soya for cash. This can be seen from Table 1.4 below.

However a majority (70%) grow Bambara nuts on a pure stand citing they do not perform well when inter planted with other crops. Some intercropped due to shortage of land.

Table 1.4: Land allocation for crop production and cropping system

Land allocation	**Crop**			
	Maize	Beans (n= 41)	Ground nuts (n=71)	Bambara groundnuts
Respondents own land used (Acres)	1.6 (0.94)	0.29 (0.54)	0.44 (0.4)	0.38 (0.3)
Hired land used (Acres)	0.38 (1.4)	0.13 (0.76)	0.12 (0.48)	0.05 (0.15)
Cropping system				
Mono cropping	58.7%	44%	80%	69.6
Intercropping	41.3%	56%	20%	21.7

1.3.2.2 Crop husbandry in Bambara nuts

In all the focus group discussions, all the respondents agreed that bambara groundnuts are mostly grown by women and mostly by old aged women. The crop is unpopular with men because it has no market hence regarded as being unprofitable. It is mainly grown for food especially to be used as relish which is the responsibility of women in a home.

During focus group discussions it was agreed that the crop is grown by people from all income levels. Both the poor and the better off grow bambara groundnuts. However, they admitted that it depends on individual preference and background. For those whose parents have been growing the crop they continue to grow the crop and find it useful.

In Mchinji and Ntchisi (central region), it was agreed that no one was prohibited from growing bambara groundnuts and this would be the case in the southern region. It is just the perceptions of different people and ignorance on the importance of the crop to many.

The situation was different from the culture in Mzimba where the respondents said everyone can make ridges, pluck the pods and shell. But children, married and unmarried men and women that have not lost at least a child to death cannot plant, weed, bank or dig/lift bambara groundnuts because according to their culture that will be inviting deaths into their family. Only postmenopausal women and people that have lost at least a child are allowed to grow bambara groundnuts. Asked what would happen if the so prohibited people grew and dug ground beans, they said nothing could happen. "We just follow it as taught by our fathers," said one woman in Luwerezi. All the respondents admitted that they just followed the tradition. One man said, "*wanyithu wakupanda zgama ku Rumphi waliyose waka, kuno nkhati niyambe kweni wakiza munthu kuzakanifumba mbwenu nilileka* (our colleagues in Rumphi everyone plants Bambara, when I came I started planting but one elder came to ask me then I stopped)."

1.3.2.3 Seed system

Seed is one of the important production factors that affect volume of production for bambara groundnuts. Lack of seed was cited by 57% of the respondents as one of the challenges facing bambara groundnut production. Seed of the crop is found with very few individuals, mostly the elderly. Use of the farmer's own recycled seed is the main (36.9%) source of seed for bambara groundnuts followed by provision of recycled seeds by relatives (23.8%), then the seed bank (20.2%) and purchasing from the local market (19.5%). Some farmers in Ntchisi, Thyolo and Mzimba received seed from the NPGRC and the seed bank organized by CICCOD (Table 1.5).

Table 1.5: Sources of bambara groundnut seed

District	Own recycled		Open market		Relative		Seed bank	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Ntchisi	9	29	2	12.5	7	35	5	29.4
Ntcheu	3	9.7	3	18.7	0	0	0	0
Thyolo	1	3.2	1	6.3	2	10.0	6	35.3
Mchinji	7	22.5	6	37.5	5	25.0	0	0
Mwanza	5	16.1	2	12.5	3	15.0	0	0
Mzimba	6	19.4	2	12.5	3	15.0	6	35.3
Total	**31**	**100**	**16**	**100**	**20**		**17**	**100**

In Ntchisi and Mchinji it was reported that parents would give a young woman about a cup of bambara groundnut seeds as she goes to her new marriage home. However, in Mzimba district it was reported that people do not ask or beg for seed since it would mean that you are asking for death. However, if you have money you can buy the kernels since it is not known whether it is for seed or consumption. As such farmers who do not have money for seed find it difficult to access seed. Other wise if the farmer does not have money to buy the seed it was reported that a farmer would just collect a handful from some ones drying mat without asking. From this discussion it was evident that seed shortage was a major challenge for some farmers.

1.3.2.4 Pests and diseases

Table 1.6 below shows the pests and diseases that farmers experience in the areas in which the study was carried out. On pests, grasshoppers were reported to have caused major attack to

Bambara nuts followed by Aphids. On diseases, leaf spot were reported by a majority (43%) of the respondents to have attacked Bambara nuts more. During focus group discussions the farmers did not know how to treat the diseases. They did not even report to the extension workers for help.

Table 1.6: Pests and diseases observed in bambara groundnut fields

Pest/ Disease	Description	Frequency	%
Pests	Aphids (*Nsabwe*)	31	34
	Termites	19	21
	Grasshoppers	5	56
	Leaf beetles	9	10
	Larvae	10	11
	Weevils	6	7
	Don't know	11	12
Diseases	Leaf spot	39	43
	Mosaic	17	19
	Thuku/ chitukula	11	12
	Don't know	24	26

1.3.2.5 Extension services for bambara groundnut farmers

From the study a majority (72%) had access to extension services (Table 7). However, during focus group discussions the farmers reported that they did not receive any information on bambara groundnuts production. They did not even bother to ask for more information about bambara groundnuts from the extension workers.

In separate interviews with individual extension workers the following issues came out:

- There is lack of seed
- There are no new technologies to be promoted among farmers. Farmers are still producing same old varieties which are low yielding and this is disincentive to the farmer
- It is difficult to promote increasing hectareage for those producing the crop because there is no market for possible surplus
- In addition there are no specific efforts to promote the crop among farmers.
- Bambara groundnut are discussed with farmers from the perceptive of dietary diversity which is a policy for nutrition in the country
- However, the extension workers cited that there is demand for extension service for bambara groundnut production.

Table 1.7: Source of extension services available to farmers

Source of extension services	Name of district					
	Ntchisi	Ntcheu	Thyolo	Mchinji	Mwanza	Mzimba
Extension officer	13	4	4	6	7	7
NGOs	0	0	1	0	0	1
Lead farmer	4	0	2	1	0	2
Radio	5	0	1	1	3	1
Cicod	1	0	1	0	0	1
Not applicable	3	2	1	11	3	5
Total	**26**	**6**	**10**	**19**	**13**	**17**

1.3.3 Consumption and utilization

Fresh and dry bambara groundnuts are consumed at household level in the following ways :

1. *Chuwa* (cooked green pods with kernels)
2. *Chipere*, this is decorticated nuts that are boiled and mashed.
3. Roasted
4. Stewed and seasoned according to taste
5. Mixed with groundnuts (*Mndavwa*)
6. Mixed with cooked maize

Chuwa and the stewed nuts are the most common dishes that are preferred by consumers. Cooked *chuwa* is sold by women along the streets and on market days. The stewed Bambara nuts are consumed as an entrée or accompaniment of the main staple thick maize porridge. In times of food shortage some respondents indicated that mashed Bambara groundnuts would be consumed as a main meal on its own. It was evident that there are no value added or derived products from Bambara groundnuts that are being consumed or sold in the villages.

Due to the small harvests of this crop, households have little amounts and the consumption frequency of the beans when they are available is mostly once a week as reported by 45% of the respondents (Figure 2). This level of consumption frequency indicates that if farmers would harvest adequate amounts, consumption would increase in most households. It was reported during focus group discussions that the low frequency consumption is mostly due to the scarcity of the product, such that people treat consumption of Bambara groundnut as a specialty.

Consumption of Bambara groundnuts is faced by several challenges. It was indicated that some people did not like the large size of the nuts because it was a mouthful when eating as such would prefer the small sized nuts especially for the stewed dish.

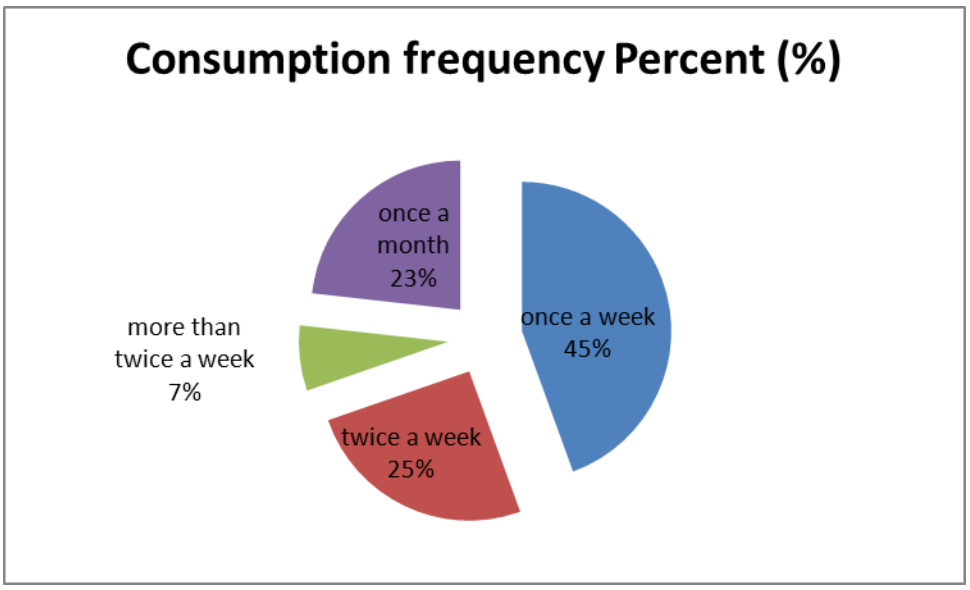

Figure 2: Bambara groundnut consumption frequency

There are several beliefs that are associated with consumption of Bambara groundnuts for individuals as well as households. It is a common belief that Bambara ground nut resemble bullets as such all people whose line of work predispose them to a gun shot should desist from consuming Bambara groundnuts. Therefore most men who serve as soldiers, police officers, hunters and criminals would not eat Bambara groundnuts since it is believed that a person becomes an easy target for enemy fire. However, during focus group discussion it emerged that traditional doctors use Bambara groundnuts as a talisman for making protective portions to make the body impermeable to a bullet. Therefore, it was believed that those that ate Bambara nuts at their home were shot and died faster than those who did not eat Bambara nuts. The same applied to hunters.

Similarly, it was learnt that traditional doctors use Bambara groundnuts as part of herbal medicine to protect an individual or a household from being attacked by witches. Livestock pens are also protected from thieves and wild animals using similar concoctions. In such cases, the households are advised not to cook or consume Bambara groundnuts.

Bambara groundnuts are also mixed with other herbs and used to prevent doves from flying away from the owner. Some people also believe that the portion also helps doves to reproduce quickly hatching two birds at a time not one as it occurs sometimes. In the same way it was reported in Mzimba and Mchinji district it was learnt that Bambara ground nuts which have two seeds in one pod are also used as part of a love portion so that a husband does not have extramarital affairs just as a pair of doves. As such some men would not eat Bambara groundnuts, while people who beg are usually given shelled nuts only. One man in Mchinji was quoted as saying *'nzama zimazamitsa mtima wa wanthu wamuna kuti asamayendeyende, azingokhala pakhomo.'* (ground beans stabilizes the heart of a man so that they do not go out but stays at home always).

It was also learnt that young men especially those of the *gule wamkulu* sect are sometimes discouraged from consuming bambara groundnuts by a saying which says that if you eat bambara groundnuts you have eaten your scrotum as such the person would be barren.

1.3.3.1 Knowledge on nutritional value of bambara groundnuts by farmers

From the study it was discovered that about 30% of the respondents did not know any specific benefit of Bambara groundnut consumption at their household. 60% of the respondents knew Bambara nuts as just being the source of food (relish for the home) whereas 8% of the respondents said Bambara nuts helps to improve their soil fertility. The farmers reported that bambara ground helps the farmers to mitigate the effect of hunger during lean periods. The dry grain is prepared into a mashed thick paste and is consumed as a main meal.

1.3.3.2 Cooking characteristics of Bambara groundnuts

According to the farmers reported cooking time of dry Bambara groundnuts varied from one and a half to two and a half hours which is comparable to the cooking time of most dry legume seeds such as common beans and cowpeas (Mwangwela *et al* 2007). This observation was also echoed by 56% of the farmers who indicated that bambara groundnuts takes less time to cook than other pulses while 6% of the respondents said it takes around the same time to cook ground beans as other pulses.

1.3.4 Marketing of Bambara nuts

Marketing includes all services involved in moving the commodity from the point of production to point of consumption. It comprises all functions and agencies that perform activities that are necessary in order to profitably exploit opportunities in the market. Bambara groundnuts are sold in the following forms, fresh mature pods, cooked fresh mature pods, dry grains and dry pods (Table 1.8). From the study it was reported that 82% of the respondents had not sold green bambara groundnut to anyone. All that they produced was for home consumption. 18% of the respondents had sold green Bambara nuts.

Table 1.8: Farmers selling green or dry Bambara nuts

Bambara groundnut sold	Frequency	Percentage (%)
Selling green Bambara nuts	16	18
Selling dry Bambara nuts	33	38
Pods only	4	5
Kernels only	24	28
Both Pods and kernels	3	4

1.3.4.1 Buyers of Bambara ground nuts

Bambara groundnuts are mainly produced for household consumption and there is limited trading taking place. In the study 8% of the respondents reported that they sold the bambara groundnuts to people within the village while 1% of the respondents sold bambara groundnuts to informal trader or vendors while another 1% of the respondents sold bambara groundnuts at an open market. There is no formal market for Bambara groundnuts.

1.3.4.2 Major constraints faced in Bambara nuts marketing

Three marketing related challenges were mentioned by the respondents as outlined in Table 1.9. These marketing challenges are a major contribution the low production of the crop since it is only grown for home consumption. Due to lack of organized market the crop is regarded to be unprofitable by all farmers and commonly men who are also major decision makers on which crop to grow and where to grow it. When the farmers were asked if they would grow the crop if it had a ready market like that of other crops like soya or if was offered at MK100/kg, "all people would grow," the farmers answered in a chorus since bambara groundnuts has many advantages over other leguminous crops and is heavier in weight.

Table 1.9: Three major constraints faced in bambara groundnuts marketing

Constraint	Frequency	Percent (%)
Lack of markets	17	19
Bambara produce is of low quality	4	5
Low prices	12	14
The scales are dubious	2	2

1.3.5 Access to credit

In 2008/2009, of the respondents interviewed 79% had no access to credit for farming, whereas 21% of the interviewed farmers had access to credit. Among those that had access to credit got it from CICOD, CUMO, MARDEF and other lending institutions (Figure **). The credit was in the form of cash (14%), agricultural input (4%) and livestock (1%).

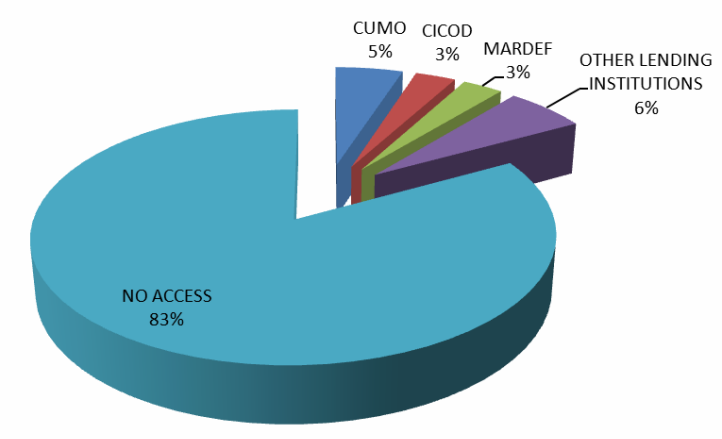

Figure 3 : Access to credit by bambara groundnut farmers in Malawi.

1.3.6 Production challenges

The following are the major challenges facing the adoption of Bambara groundnut by farmers in Malawi:

a. Lack of markets for Bambara groundnuts

b. Shortage of land (28%)

c. Shortage of seed (57%)

d. Lack of knowledge on the importance and nutritive value of the crop

e. Misconceptions and attitudes of younger farmers towards the crop. Young farmers usually view the crop as for the elderly and someone planting the crop is seen as archaic and old fashioned.

f. Lack of knowledge on the different products that can be processed from Bambara which would add value to the crop.

g. Beliefs and taboos associated with production and consumption of bambara groundnuts.

1.4 CONCLUSIONS

Bambara groundnuts are mainly grown by elderly women on marginal areas of the field or remaining ridges after planting other crops like groundnuts. While in the central and southern regions culture bars no one from growing the crop, in Mzimba district of the northern region there exists some prohibitions.

There is no formal marketing for the crop and men regard it as unprofitable and hence it is left to be grown by women for relish since women are the ones responsible for food preparation.

Bambara nuts are attacked by several pests and diseases. The pests that attack bambara groundnuts include aphids, grasshoppers, leaf beetles, weevils and termites. Among the diseases that attack bambara groundnuts include leaf spot and mosaic. Farmers did not know how to control these pests and diseases.

Despite the majority having access to extension services, the extension agents had no technological messages to disseminate on bambara groundnuts.

Bambara nuts are prepared traditionally as beans, *chuwa, chipere*, or prepared as a mashed meal. Usually people prefer to take bambara groundnuts as *chuwa* and prepare them as beans with nsima. Bambara groundnut is mostly included in local dishes once a week.

Bambara groundnut production is very low in Malawi as compared to other pulses. This was attributed among other challenges to lack of markets for bambara groundnuts, scarcity of seed, beliefs, negative attitudes and taboos and shortage of land. The other challenge was lack of knowledge on the nutritive value of bambara groundnuts.

1.5 RECOMMENDATIONS

Providing bambara groundnut seed to farmers and introducing improved seed: All participants in the discussions suggested that seed for bambara groundnut is very scarce. Seed is usually found with the elderly who often grow bambara groundnut. The case is severe among the north where it is prohibited to ask for bambara groundnut seed can only be bought from the market.

Making technical information on bambara groundnut production available to extension workers: Lack of technical information on the crop contributes to poor extension services on the crop.

Establishment of markets for bambara groundnuts: Vendors and other large scale traders do not buy the crop. Farmers indicated that if there was market for the crop men will adopt the crop and that everybody will start growing bambara groundnut regardless of the existing cultural taboos.

Training farmers on the benefits and nutritive value of bambara groundnuts: Training will sensitize other farmer that believes and values that they hold about bambara groundnuts are not true and that if you grow bambara groundnuts you will not die. They cited the example of when eating of eggs by children was a taboo. Through training the taboo was proven wrong and children now eat eggs.

Organizing field demonstrations for Bambara and giving priority to the crop in agriculture demonstrations: It was further suggested that bambara groundnuts must be part of field demonstrations just like other crops. Other farmers will be able to learn from the field demonstrations on the benefits of bambara groundnuts.

Introducing farmer clubs growing bambara groundnuts from which other farmers can learn from: Farmers cited the need to establish farmer group in the villages that can be given bambara groundnuts seed and be supported. The farmer groups will help multiply bambara groundnuts seed so that many farmers access the seed. These will also help farmers that believe in the taboos that only families that have lost a child should plant bambara groundnuts. They will be able to see families that have not lost children growing bambara groundnuts through the supported farmer groups.

Conducting training on other products that would be processed from bambara groundnuts: The farmers also asked for training on the different products that can be processed from bambara groundnuts. The farmers were interested in learning the different ways of preparing bambara groundnuts citing an instance when officers from the nutrition department came and taught them the different nutritious products that can be prepared from soya beans. The training coupled with a good market led to the boom in soya bean production.

Introducing promotion programs: No intervention has been made to promote bambara groundnuts. Both farmers and extension workers in separate interviews suggested programs and deliberate policies to promote bambara groundnuts. One extension worker said since he joined the government in 1993, this is the first study on Bambara nuts.

2.0 CONSUMER ACCEPTANCE OF COOKED BAMBARA GROUNDNUTS IN MALAWI

2.1 INTRODUCTION

Bambara groundnut is a food crop with potential to improve nutrition, boost food security, foster rural development and support sustainable land care, (National Research Council, 2006). In Malawi bambara groundnut is grown in small patches throughout the country. Farmers are encouraged to grow the crop as it a good source of nutrients, (Ministry of Agriculture Irrigation and Food Security 2005). However, the utilization of Bambara groundnuts as is the case with other legumes like cowpeas faces challenges such as long cooking time that is required for the cowpeas to attain soft texture and be palatable for consumption (Taiwo, 1998). Long cooking time of legumes leads to increased energy use particularly in rural and peri urban areas where fuel wood is the main source of household energy (Brouwer, Hartog, Kamwendo and Heldens, 1996). Cooking quality in legumes encompasses several characteristics such as cooking time, splitting during cooking, texture and other sensory attributes.

The objective of this study was to determine the protein content and consumer acceptance of bambara groundnuts in Malawi. The following were specific objectives.

i. To determine and compare crude protein content of the different bambara groundnut varieties.
ii. To determine and compare seed size, water absorption during soaking, water absorption during cooking, hydration capacity, seed bulk density, cooking time and degree of splitting during cooking of the different bambara groundnut varieties.
iii. To determine consumer acceptability of the different bambara groundnut varieties.

2.2 MATERIALS AND METHODS

Six bambara groundnut varieties were obtained from Chitedze Research Station, Malawi Plant Genetic Resources Centre for the study. The bambara groundnut samples were cleaned to remove chaff, shrivelled and broken seeds.

2.2.1 Moisture and Crude protein determination

Moisture content of the bambara groundnut seeds was determined according to the method of Ajibola, Aviara and Ajetumobi (2003). Crude protein was determined using the Macro Kjeldahl method (AOAC, 1984).

2.2.2 Seed size and seed bulk density determination

The size of Bambara nut seeds was expressed as the weight of 100 seeds weighed using a Precisa (0.01g) top loading balance. Bambara nut seed bulk density was determined according to the method described by Fasina *et al*. (1999). The Bambara nut seeds were placed in a metal funnel and allowed to flow from 15.5 cm height into a 500 ml metal cup. The seeds were leveled

without pressing with a metal scraper. The ratio of the weight of sample in the metal cup to the volume of the cup was expressed as kg m^{-3} and recorded as bulk density.

2.2.3 Determination of water absorption during soaking and hydration capacity

Water absorption during soaking was determined according to a modified method of Agbo, Hosfield, Uebersax, and Kimparens, (1987). Approximately 10 g of Bambara nut seeds were placed in 100 ml Erlenmeyer flasks containing 50 ml deionised water. The Erlenmeyer flasks were placed in an incubator at 22 °C for 1, 2, 3, 4, 5 and 6 h. After soaking, the excess water was drained using a metal sieve (2.5 mm) and the cowpeas were blotted dry with absorbent paper to remove excess water and weighed. The gain in weight was expressed as g of water kg^{-1} bambara. The amount of water (g) absorbed by 10 g of Bambara nut after 18 hours of soaking reflected the hydration capacity (g water kg^{-1} bambara) as reported by Wang, Daun and Malcolmson (2003).

2.2.4 Determination of water absorption during cooking

The amount of water absorbed during cooking was determined according to a modified method of Cenkowski and Sosulski (1997). For each Bambara nut variety approximately 10 g of Bambara nut seeds were placed in 100 ml Erlenmeyer flasks containing 50 ml deionised water. The Erlenmeyer flasks were placed in a heavy aluminium pan containing 1500 ml of deionised water. The pan was tightly covered and brought to boil, allowing 5 min for heating up. The Bambara nuts were cooked up to 120 min. Every 15 min, two sample flasks per Bambara nut variety were removed and excess water was drained using a metal sieve (2.5 mm). Bambara nut were cooled to room temperature (22 ± 2 °C) for 1 h, blotted dry with absorbent paper to remove excess water and weighed. The gain in weight (g) was expressed as g water kg^{-1} bambara. The boiled Bambara nuts were then used to determine splitting and texture.

2.2.5 Determination of splitting during cooking of bambara groundnut

The tendency of seeds to split during cooking was determined according to the method of van Buren, Bourne, Downing, Quele, Chise, and Comstock (1996). The Bambara nut with split seed coats and cotyledon were counted as splits. The degree of split was calculated as follows:

$$\frac{\text{Number of split seeds}}{\text{Number of whole seeds}} \times 100$$

2.2.6 Determination of cooking time

A custom made Mattson bean cooker was used to determine the cooking time of the different Bambara nut varieties. For each test sample, 25 Bambara nuts seeds were positioned in the perforations of the cooker and placed in an aluminum pan with 1500 ml of deionised water and cooked. The cooking time of the Bambara nut was recorded as the moment when 80 % of the pins had fallen through the softened seeds.

2.2.7 Consumer evaluation of cooked bambara groundnuts

Bambara groundnut consumers from around Bunda College of Agriculture were invited to participate in the evaluation of the samples. A semi-structured questionnaire (Appendix 1) with a Food Action rating scores was used for the study.

2.2.8 Data analysis

Crude protein content seed bulk density, seed size and Bambara nuts cooking characterisation data was analysed using Analysis of Variance (ANOVA) to generate and compare means and the Least Significance Difference (LSD) was used to separate means using Statistical Package for Social Sciences (SPSS) version 12.0. Consumer evaluation and acceptance sensory test data was also entered in Statistical Package for Social Sciences (SPSS) version 12.0 where descriptive statistics were generated.

2.3 FINDINGS

2.3.1 Moisture and crude protein content of bambara groundnut

Moisture content of the bambara groundnuts samples varied as shown in Table 2.1. Nanyati had the lowest value of 98.12 g of water Kg^{-1} bambara and 181 red had the highest moisture content of 116.11 g of water Kg^{-1} bambara. The crude protein content of the Bambara nuts ranged from 17.5% to 23.6% for Chikope cha nyani and Nanyati respectively as shown in Table 2.1. The values for crude protein content in the study are within the range of those reported in literature, (Amarteifio, Sawula and Gibbons, 1997).

2.3.2 Seed size and bulk density

Seed size of the bambara groundnut samples also varied as shown in Table 2.1. Chikope cha nyani variety was small seeded while 181 cream was found to be the large seeded variety. Farmers had indicated that the large seeded varieties are preferred for the fresh market, while the small seeded varieties are preferred for dry grain consumption.

Table 2.1: Moisture, protein and physical characteristics of bambara groundnut varieties

Bambara variety	Moisture (g /100g)	Protein (g/100g)	Seed size (Weight of 100 seeds in g)	Seed bulk density (Kg/m^3)
Nanyati	9.8±0.1^{a}	23.60±1.1^{b}	55.02±1.8^{b}	
Mazira a mpheta	10.3±0.9^{ab}	18.28±1.4^{a}	61.67±1.4^{c}	764.67±13.0^{a}
Chikope cha nyani	11.2±1.6^{abc}	17.5±0.7^{a}	49.97±2.5^{a}	816.00±7.2^{b}
181 cream	11.6±0.1^{c}	21.01±1.3^{b}	75.77±2.5^{d}	825.20±9.1^{b}
181 red	12.6±0.08^{cd}	23.05±0.3^{b}	53.93±1.7^{b}	850.40±15.1^{c}
2768	13.8±0.5^{d}	22.82±0.2^{b}	52.17±1.7^{ab}	861.86±11.1^{c}

Means in the same column with different letters as superscripts are significantly different, ($p< 0.05$).

Seed bulk density varied among the bambara groundnuts varieties as shown in Table 2.1. The variety 2768 and 181 red had the highest seed bulk density as compared to the other varieties. Seed bulk density was related conversely with seed size of the bambara groundnuts variety (Table 2.1).

2.3.3 Hydration properties of bambara groundnut

Soaking is used to shorten cooking time in legumes by enhancing rehydration of the seeds during cooking (Mwangwela, Waniska and Minnaar, 2005). In all the bambara groundnuts varieties the amount of water absorbed per kilogram of the bambara groundnuts increased with increasing soaking time as shown in Figure 2.1. However, Nanyati variety had the highest water absorption capacity during soaking. The trend of increasing water absorption capacity with progressive increase in soaking time was reported in other legumes like cowpeas (Taiwo, Akanbi and Ajibola, 1998). High rate of water absorption during soaking is related to amorphous and thin seed coats (Sefa-Dedeh and Stanley, 1979).

Hydration capacity during 18 hours of soaking also varied considerably among the six bambara groundnuts varieties as shown in Table 2.2. Nanyati and 2768 varieties had the highest water uptake capacity during the 18 hours of soaking as compared to the other varieties.

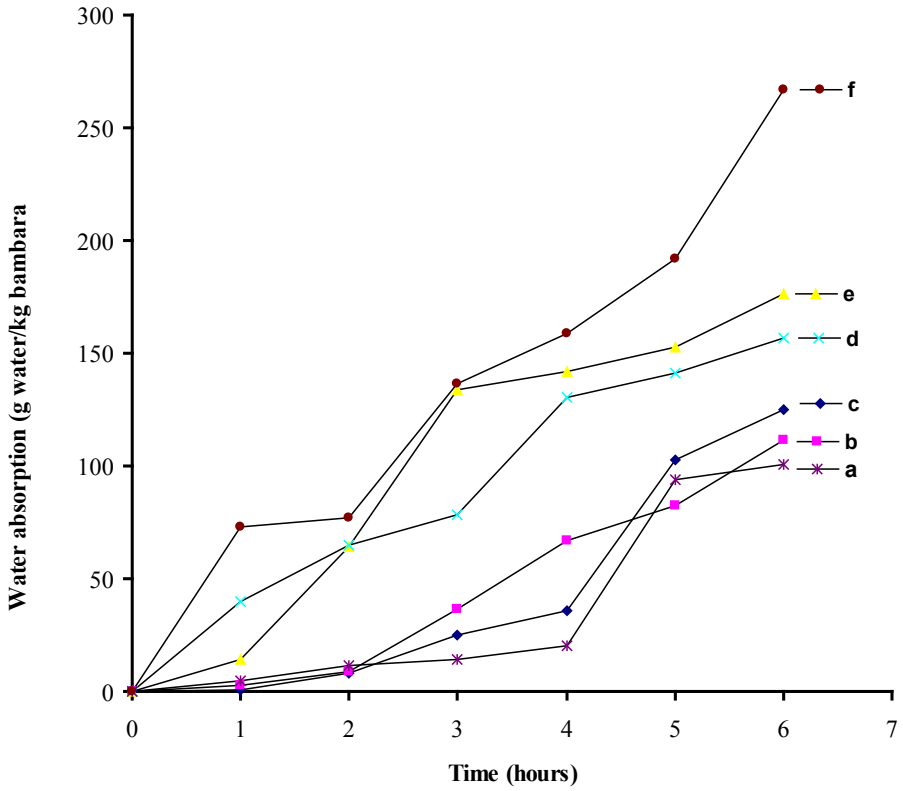

Figure 2.1: Water absorption during soaking of the six Bambara seed varieties.
Key: a: Mazira a mpheta**, b:** 181 red**, c:** 181 cream **d:** Chikope cha nyani**, e:** 2768 **f:** Nanyati

2.3.4 Determination of water absorption during cooking

The amount of water absorbed by all the Bambara nut varieties increased with increase in cooking time (Figure 2.2). The increase in the amount of water absorbed by legumes for example cowpeas is reported to be due to starch gelatinization. Bambara nuts contain approximately 53.1% starch, which undergoes the process of gelatinisation during cooking (Amarteifio, Sawula and Gibbons, 1997). Nanyati variety again showed a high water absorption capacity during cooking.

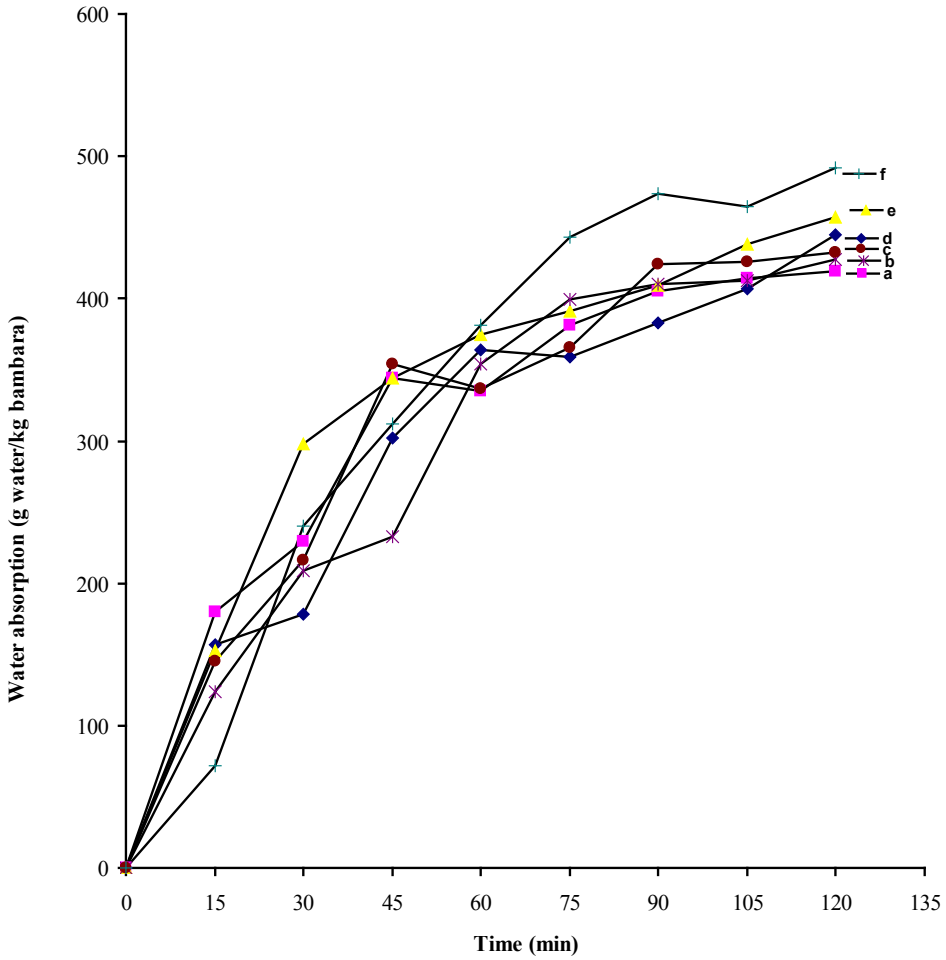

Figure 2.2: Water absorption during cooking of six Bambara seed varieties. **Key: a**: 181 red; **b**: Chikope cha nyani, **c**: Mazira a mpheta, **d:** 181 cream, **e**: 2768, **f**: Nanyati

2.3.5 Determination of cooking time

Cooking time of legumes is one of the most important cooking qualities that is considered by consumers. Cooking time also varied among the six bambara groundnut varieties as shown in Table 2.2. Nanyati took the shortest period of time to cook while 181 cream took the longest period of time to cook.

Table 2.2: Cooking time and splitting of the six bambara groundnut seed varieties

Bambara variety	Hydration capacity (g /Kg)	Cooking time (min)	Splitting %
Nanyati	444.26±17.2^{c}	106.33±3.0^{a}	48.39±3.2^{c}
Chikope cha nyani	396.09±17.3^{bc}	134.00±2.0^{b}	23.81±3.0^{b}
Mazira a mpheta	386.84±54.1^{bc}	137.67±1.1^{b}	90.04±1.5^{d}
2768	412.37±37.0^{c}	143.33±2.5^{c}	44.59±5.7^{c}
181 red	339.31±22.7^{ab}	154.67±1.5^{d}	18.05±1.0^{a}
181 cream	295.57±48.0^{a}	158.33±1.5^{d}	

Means in the same column with different letters as superscripts are significantly different, ($p< 0.05$).

2.3.6 Determination of splitting during cooking of bambara groundnut

Among the five varieties of bambara groundnuts, 2768 had the highest number of splits as compared to the other varieties as shown in Table 4 and Figure 3. In a study on physico-chemical and cooking characterization of nine cowpea (*Vigna unguiculata* L. Walp) varieties extensive splitting of cooked whole cowpeas was reported to be an undesirable characteristic, (Mwangwela, Waniska and Minnaar, 2005). Therefore, 2768 bambara groundnut variety exhibited an undesirable characteristic of extensive splitting during cooking.

2.3.7 Consumer evaluation of cooked Bambara groundnuts

2.3.7.1 Description of the consumer panel

A total of 197 people participated in the study. Among the respondents 104 were males representing 52.8 % while 93 of them were females representing 47.2%. The minimum age of the respondents was 16 years and the maximum was 50 years with an average age of 23 years. Twenty seven percent (27%) of the respondents indicated Lilongwe as their home district while the remaining percentage indicated other various districts as their home districts.

A total of 77 respondents (39.1%) had grown bambara groundnut at some point. Among the respondents 187 (94.9%) indicated that they eat Bambara nuts albeit rarely (Table 2.3), while 10 (5.1%) respondents indicated that they do not eat Bambara nuts because they do not like the taste of the groundnuts. Most of the households (74%) indicate that they prepare adequate bambara groundnuts for the family to consume over 2 meals and each of the household members would consume about a cup (250 ml) of cooked bambara at a time.

Table 2.3: Frequency of Bambara groundnut consumption

Response	Frequency (n)	Percentage (%)
More than once a week	11	5.8
Once a week	28	14.8
More than once in two weeks	5	2.6
Once in a month	19	10.1
Rarely	126	66.7
Total	**189**	**100**

Table 2.4: Amount of Bambara groundnut consumed at a time

Response	Frequency (n)	Percentage (%)
1 cup	91	48.1
Half cup	42	22.2
Quarter cup	56	29.6
Total	**189**	**100.0**

2.3.7.2 Bambara dishes prepared in homes

Most of the respondents reported traditional bambara groundnut dishes as shown in Table 2.5. These dishes were rarely consumed by the consumers due to the scarcity of the bambara groundnut on the market.

Table 2.5: Bambara groundnut dishes prepared in respondent homes

Name of dish	Consumption frequency	Reasons for frequency of consumption
Bambara groundnuts and g/nuts	Rarely	Scarcity of bambara groundnuts
Vegetables and Bambara groundnuts	Rarely	Scarcity of bambara groundnuts
Beans and bambara groundnuts	Rarely	Scarcity of bambara groundnuts
Boiled Bambara groundnuts (snack)	Rarely	Scarcity of bambara groundnuts
Fresh boiled Bambara groundnuts (*makata/chuwa*)	Rarely	Seasonality of bambara groundnuts
Boiled and mashed bambara groundnuts (chipere)	Rarely	Scarcity of bambara groundnuts
Bambara nuts stew	Rarely	Scarcity of bambara groundnuts
Bambara nuts boiled mixed with cowpeas	Rarely	Scarcity of bambara groundnuts
Boiled Bambara nuts (relish)	Rarely	Scarcity of bambara groundnuts
Fresh cooked Bambara nuts (chuwa)	Rarely	Scarcity of bambara groundnuts
Bambara flour added to porridge	Rarely	Very filling food

2.3.7.3 Bambara dishes known but not cooked in home

Among the respondents 9.6% of them indicated that they know some Bambara nut dishes that are not prepared in their homes. Table 2.6 below is a summary of the dishes and the reasons why they are not prepared in their homes.

Table 2.6: Bambara dishes known but not cooked in home

Dish known but not prepared at home	Reason for not prepared at home
Beans or g/nuts mixed with bambara groundnuts	Scarcity of bambara groundnuts
Boiled and mashed bambara groundnuts	Not tasty and difficult to prepare
Bambara groundnuts mixed with cassava	We are not used to the dish
Bambara groundnut flour used in baking	Takes time, knowledge and skill to prepare
Bambara groundnut flour added to porridge	Not tasty
Bambara groundnut cooked with beef	Scarcity of bambara groundnuts
Bambara groundnut cooked mixed with g/nuts	Scarcity of bambara groundnuts
Bambara groundnut cooked mixed with beef	Scarcity of bambara groundnuts
Beans and Bambara groundnut	Cooking time and high heat energy demand
Bambara groundnut mixed with maize and boiled	Not liked
Bambara groundnut with sweet potato	Not liked

2.3.7.4 Commonly prepared relish in homes

The most commonly prepared relish in homes was beans (40.6%) as shown in Table 2.6

Table 2.7: Commonly prepared relish in homes

Relish	Frequency (n)	Percentage (%)
Bambara groundnuts	4	2.0
Common beans	80	40.6
Beef	24	12.2
Chicken	8	4.1
Cow peas	1	0.5
Fish	30	15.2
Meat	8	4.1
Pigeon peas	3	1.5
Vegetables	38	19.3
Total	**197**	**100.0**

2.3.7.5 Source of bambara groundnuts for use in homes

A total of 122 respondents (63.2%) indicated that they buy the bambara groundnuts they use in their homes. On the other hand 22.8% and 14.0% of the respondents obtain bambara groundnuts from their own farms and from gifts respectively. Among the respondents who indicated that they buy bambara groundnuts 82% of them reported that they buy the bambara groundnuts from local markets and 47% of these respondents buy 1 Kg while 27% buy 2 Kg at a time.

2.3.7.6 Factors considered when choosing Bambara nuts for use in homes

The respondents indicated that they consider the following factors when choosing bambara groundnuts for use in their homes; seed colour, seed size, plumpness, variety, cooking time, taste (from previous experience), thickness of seed coat, freshness, whole seed, freedom from weevil attacks, not rotten seeds and no bruises.

2.3.7.7 Knowledge on benefits associated with bambara groundnut consumption

The respondents reported the following benefits associated with bambara groundnut consumption; protection against diseases, weight gain, fast body growth, good health, improved nutritional status, repair of worn out tissues, source of proteins, source of energy, body building, and source of fiber.

2.3.7.8 Problems associated with bambara groundnut consumption

On problems associated with bambara groundnut consumption, 79.2% of the respondents indicated that they do not face any problems with bambara groundnut consumption while the

remaining 20.8% reported that they face some problems. The problems reported include the following; heart burn, constipation, excess excretion if eaten too much, body rushes, stomach ache, develop sores, cultural beliefs and taboos, vomiting and uncomfortably.

2.3.7.9 Acceptability of cooked bambara groundnut

Table 2.8 show the acceptability scores of the different bambara groundnut varieties. The results suggest that the consumers would eat bambara groundnuts.

Table 2.8: Consumer acceptability of cooked bambara groundnuts

Bambara groundnut variety	Average acceptability Score
2768	6.15±1.7
181 cream	5.87±1.0
181 red	5.75±1.1
Chikope cha nyani	6.44±1.4
Mazira a mpheta	5.50±2.0

2.4 CONCLUSION

Significant differences in crude protein content, seed size, seed bulk density and cooking qualities among the six bambara groundnut varieties exist. Bambara nut consumption is limited due to scarcity of the nuts. People consume bambara groundnuts using traditional and unimproved food preparation methods. The consumer acceptance results suggest that there is potential for bambara groundnut acceptance and consumption in Malawi.

3.0 CHARACTERIZATION OF BAMBARA GROUNDNUT LANDRACES IN MALAWI

3.1 INTRODUCTION

Bambara groundnut is reported to be tolerant to drought, poor soils and extreme heat (Karikari, 1996) and is able to fix nitrogen in the soil, hence making it a suitable crop to the low-input production systems. It also reported that under severe drought conditions where groundnuts did not have any kernels, bambara groundnut produces small filled pods (Mazhani and Appa-Rao, 1985). Yield potential of bambara groundnut ranging between 497kg/ha and 799 kg/ha on landraces were reported by (Drabo 1987). Drabo, 1987 also reported yields as high as 3500 from his experiment.

Despite its potential to supply poor resource families with a reasonable yield nutritive values, in many countries research on this crop has been very minimal. Lack of detailed information and the enormous unfulfilled potential on bambara groundnut has been cited by several authors (Linnemann, 1987; Linnemann and Azam –Ali, 1991). Due to absence of improvement on the crop, it is said to be so erratic in its attribute especially yield since it lacks broad adaptation genotypes show strong zonal adaptation (Ng *et al*, 1991, Karikari, 1996). Trials in Nigeria and Burkina Faso revealed variation in yield from one year to another , with a strong location effect (Goli, 1997). However, through a judicious selection and breeding, the development of cultivars with greater flexibility or wide adaptation to specific environmental niches ought to be possible (Karikari , 1996). There is a lot of germplasm diversity in bambara groundnut and this offers higher prospects for crop improvement (Goli *et al*, 1991). Single plant selection can be employed to utilize the potential still hidden in the heterogeneity of most of the samples. The crop being predominantly self-pollinated (Doku and Karikari, 1970) improvement through selection of homozygous lines is possible and this will require multi-locational evaluation of lines (Karikari, 1996). During the early years of characterization and selection work there is need to classify the different genotypes into adaptability environments. Development of land races with yield stability should be an important priority (Karikari, 1996). In 2009 Bunda College of Agriculture with support from the McKnight Foundation commissioned a study to understand production trends of bambara groundnut. Part of the study involved collection of bambara groundnut landraces for on station evaluation. A total of 47 samples were collected from different sites and they were characterized at Chitedze Research Station.

Objective

To characterize and evaluate bambara groundnut accessions for agronomic traits.

3.2 MATERIALS AND METHODS

A total of 47 accessions were collected from different areas in all the three regions of Malawi during the collecting mission and exploratory survey. All the 47 samples (16 accessions from Northern region, 15 accessions from Central region, 16 accessions from Southern region) were collected in 2009 from the Malawian smallholder farmers. The collected accessions were planted during 2009/2010 growing season I.e. December – May for characterization and evaluation on station at Chitedze Research station located along the Mchinji M1 road, i.e. 16km

west of Lilongwe city. The seeds were planted in a well ploughed clay loam soil without replication cropping pattern shown below. On farm evaluation could not done due to shortage of seed

Seed per station	Spacing between station	Spacing between ridges	Ridge length	No. of ridges
1	15cm	75cm	10m	5

Table 3.1 : Traditional names of the ascensions collected

Name	Number of samples	Districts
Kadzikwirire/kadziunde	11	Mwanza, Ntchisi, Mzimba, Mchinji
Chikope chanyani	14	Mwanza, Blantyre, Ntchisi, Mzimba, Mchinji
Nanyati	6	Mwanza, Ntcheu,Mchinji, Blantyre
Kayera	6	Mwanza, Blantyre, Mzimba,
Mazira a mpheta	6	Ntchisi, Mchinji, Mzimba
Yakuda (Black)	3	Mzimba, Mchinji
Makata	1	Mchinji
Total	47	

Data recording was done basing on the *Vigna Subterranea* IPGRI descriptor: the following characters were recorded: Growth habit, Stem hairness, Number of days from sowing to first flowering, Number of days from sowing to 50% flowering, pod shape, pod texture, seed shape, Testa with pure colour without eye pattern around hilum, testa with pure colour with an eye pattern around hilum, Testa with mixed or without eye pattern around hilum, peduncle length (mm) Number of flowers per peduncle, Number of leaves, terminal leaflet length (mm) terminal leaflet width (mm), petiole length (mm), plant spread (cm), plant height (cm), internode length (cm), Number of nodes per stem, Number of branches per stem, Number of stem per plant, pod length (mm) pod width (mm), shell thickness (1/100 mm), shelling percentage (%), Number of pods per plant, seed length (mm), seed width (mm).

Statistical data summaries were done using Genstat Statistical Package. Both descriptive and quantitative statistics were used in the analysis.

3.3 RESULTS

The study has indicated that there is variation in almost all the characters scored. Results of the descriptive statistics are shown in Table 3.2 below. The results are summarized in terms of character, value of the scored character, frequency and percentages based on the 47 samples planted in the field. For quantitative characters, the results are shown in Table 3.3. The quantitative characters were summarized in terms of mean, minimum, maximum, standard deviation and coefficient of variation. Disease assessment was done based on visual scoring.

Table 3.2a: Descriptive statistics of bambara groundnut samples characterization and evaluation in Malawi: Vegetative characters

Character	Value	Frequency	%
Primary leaf colour	Dark green	1	2.1
	Dark purple	3	6.4
	Light green	6	12.8
	Light purple	18	38.3
	Purple	19	40.4
Growth habit	2-Semi bunch type	31	66
	3-Spreading type (open)	16	34
Terminal leaflet shape	3-Lanceolate	39	83
	4-Elliptic	8	14.9
Colour of fully expanded terminal leaflet	1-Green	43	91.5
	2-Green & Purple	4	6.4
Stem hairiness	0-Absent	4	8.5
	3-Sparse	42	87.2
	7-Dense	1	2.1

TABLE 3.2b: Descriptive statistics of bambara groundnut samples characterization and evaluation in Malawi: Pod characteristics

Character	Value	Frequency	%
Pod shape	2-End in a point, round on the other side	35	74.5
	3-End in appoint, with nook on the other side	12	25.5
Pod colour	1-Yellowish brown	23	48.9
	1&2-yellowish brown and brown	1	2.1
	2-Brown	22	46.8
	Purple	1	2.1
Pod texture	1-Smooth	2	4.3
	2-Little grooves	36	76.6
	3-Much grooved	9	19.1

TABLE 3.2c: Descriptive statistics of bambara groundnut samples characterization and evaluation in Malawi: **Seed characteristics**

Character	Value	Frequency	%
Seed shape	1-Round	5	10.6
	2-Oval	42	89.4
Testa with pure colour ,without eye pattern around hilum	1-Cream	9	33.3
	2-Grey	3	11.1
	3-Light red	5	18.5
	4-Dark red	1	3.7
	5-Light brownish red	5	18.5
	6-Dark brown	1	3.7
	8-Black	3	11.1
Testa with pure colour, with eye pattern around hilum	1-Cream Testa with black butterfly -like eye	4	26.7
	3-Cream testa with grey testa like eye	9	60
	9-Cream testa with brown circular eye	2	13.3
Testa with mixed colour, with or without eye pattern around hilum	1-Black small dotted spots or brown background without an eye	1	14.3
	2-Dark brown small dotted spots on cream background without an eye	1	14.3
	3-Black and grey mottles on cream background without eye	1	14.3
	5-Black marbled spots on cream background with grey butterfly like-eye	1	14.3
	6-Dark brown marbled spots on cream background with grey butterfly-like eye	3	42.9

TABLE 3.3: Quantitative statistics of bambara nut samples characterization and evaluation in Malawi.

Character	Mean	Min	Max	SD	CV%
Days to first flowering	27	23	69	11.76	42.48
Days to 50% flowering	66	64	92	5.45	8.16
Peduncle length(cm)	27.45	16.20	56.60	8.92	32.48
Number of flowers per peduncle	2.028	1.400	3	0.462	22.787
Number of leaves	109	53	202	36.4	33.3
Terminal leaflet length (mm)	56.14	45.33	72.87	5.77	10.28
Terminal leaflet width (mm)	24.63	18.53	53.27	5.05	20.49
Petiole length (mm)	131.6	97.9	183.3	15.2	11.5
Plant spread (cm)	45.61	32.70	63.10	7.13	15.62
Plant height (cm)	24.38	19.20	32.10	2.41	9.87
Internode length (mm	20.88	13.00	37.93	4.20	20.11
Number of nodes per stem	6	4	13	1.686	25.436
Number of branches per stem	2.956	1.500	5.468	1.115	37.705
Number of stem per plant	11	6	16	2.319	19.988
Pod length (mm)	18.70	13.30	27.60	3.55	18.96
Pod width (mm	11.389	9.400	14.300	1.284	11.273
Shell thickness (1/100mm)	1.0000	1.0000	1.0000	0.0000	0.0000
Shelling percentage (%)	72.54	54.80	98.20	7.41	10.21
Number of pods per plant	12	10	18	0.036	18.886
Seed length (mm)	10.949	7.700	16.400	1.619	14.785
Seed width (mm)	7.166	5.200	11.800	1.065	1.135

3.4 DISCUSSION

The results of the experiment cannot lead to concrete conclusion due to limited sample size during planting. The experiment did not have replication as such conclusions from the experiment should be taken care. Characterization of accessions has shown that farmers name accessions varieties according to appearance and physiological behavior list of name of the samples collected is shown in Table 3.1. The naming of varieties is almost similar in different sites visited. All the varieties collected were homogenous. The collected samples have shown that there is high variability in terms of different characters scored. This indicates the potential of improving agronomic characters to meet market demand. Such characters include: Days to first flowering, Days to 50% flowering, Number of leaves, Plant spread, Pod length, Shelling percentage, Number of pods per plant, Seed length. Manipulation of these characters to suit market demand will significantly contribute to increased production of the crop in Malawi.

3.5 CONCLUSION AND RECOMMENDATIONS

The study has shown that there is phenotypic variability in various characters studied. The agronomic study needs to be further explored to fully understand genetic differences among the collection of bambara groundnut. Further research should concentrate on post harvest losses as it has been observed that bruchids attack seeds starting from the field. In addition to improving

storage period, it is important to develop appropriate agronomic practices that would improve productivity of bambara groundnuts. From the survey conducted it was noted that seed availability remains a big challenge. In order to curb this problem it important to establish strong community seed production system that will sustain production of the crop.

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