ESJ Natural/Life/Medical Sciences

Post-Harvest Management Practices Of Bambara Groundnut (Vigna Subterranea (L.) Verdc) Seeds In Burkina Faso

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Doi:10.19044/esj.2022.v18n14p239

Submitted: 04 February 2022
Accepted: 03 April 2022
Published: 30 April 2022

Cite As:
Ouili S.A., Maiga Y., Ouoba A., Nankangré H., Compaoré C.O.T., Nikiéma M., Ouedraogo M & Ouattara A.S (2022). *Post-Harvest Management Practices Of Bambara Groundnut (Vigna Subterranea (L.) Verdc) Seeds In Burkina Faso* European Scientific Journal, ESJ, 18 (14), 239. https://doi.org/10.19044/esj.2022.v18n14p239

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Abstract

Bambara groundnut plays a major role in the production systems and diets of farmers in Burkina Faso. This crop, due to certain production, storage, or preservation conditions, is subject to damage by insects and fungi. Effective post-harvest management can contribute significantly to reducing losses during storage. This study was carried out in the three agro-ecological areas in Burkina Faso to assess post-harvest management practices of Bambara groundnut among farmers. The data were collected from 180 farmers using surveys. The results showed that the culture of Bambara groundnut was mainly carried out by women (74.4%) on small farms (0.25-0.5ha). The harvested crops were dried at home during a period of 5 to 14 days. About 53% of farmers stored seeds for more than 3 months. Seeds were mainly stored in hermetically sealed cans (45.6%) and in plastic bags (31.1%). Some products such as wood ash and chemicals were used for seed storage. Challenges during seed storage were insects (91.4%) and fungi (42.9%). In the case of seeds attacked by pests (insects, fungi, etc.), farmers (84.4%) adopt a set of measures consisting of sorting, winnowing, drying, and repackaging the seeds. Besides the existence of traditional storage techniques, there is still a need to develop effective storage techniques and continue building farmers' awareness on improved storage technologies to avoid post-harvest losses.

Keywords: Bambara groundnut, post-harvest, storage, insects, fungi

1. Introduction

Post-harvest pests affect agricultural productions around the world, causing sometimes significant yield losses, exacerbating food insecurity especially in developing countries like those located in the Sahelian region of sub Saharan Africa. In order to strengthen the resilience of African populations to food insecurity, crops diversification and a reduction of post-harvest losses are required (Ngamo & Hance, 2007). To contribute addressing such challenges, research programmes at national and sub-regional levels have shown renewed interest in food crops that were previously neglected (Coly, 2007). Hence, many studies have been conducted to improve the yield of different food crops, with a particular focus on cereals and legumes (Abate et al., 2012; Macauley & Ramadjita, 2015). In Burkina Faso, as part of the improvement the productivity of legumes, the Institut of Environnement and Agricoles research (INERA) has implemented a research and development programme on the Bambara groundnut, a previously neglected crop, starting from 2003. Bambara groundnut (*Vigna subterranea*) is the 3rd most important leguminous crop in Africa after peanut (*Arachis hypogea*) and cowpea (*Vigna unguiculata*) (Puozaa et al., 2017). *Vigna subterranea* L. (Bambara groundnut) is a legume cultivated by small farm holders over much of

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

semiarid Africa (Majola & Gerrano, 2021). It is one of the most ancient legumes and is a staple food for many people in Burkina Faso (Ouédraogo et al., 2013; Ouoba et al., 2016). Its high carbohydrate (68%), protein (22.9%), lipid (9.2%), ash (5.1%), and fiber (7.2%) content which makes it a complete meal (Mazahib et al., 2013; Mubaiwa et al., 2017). Unfortunately, the cultivation of this highly legume (Bambara groundnut) is subjected to many constraints, including the deterioration of crops during storage by insects and their contamination by fungi (Ouoba et al., 2016). Therefore, the objective of the present study was to collect informations about post-harvest and storage practices of Bambara groundnuts in rural Burkina Faso in order to propose adequate storage methods in the long term.

2. Methods

2.1. Study area

This study was conducted from October to December 2020 in the three agro-ecological zones (Sahelian, Sudano-Sahelian and Sudanian) of Burkina Faso (Figure 1). The distribution of these three zones is mainly based on the annual rainfall amounts and the thermal regime (Thiombiano & Kampmann, 2010). Hence, the Sahelian zone, is the least watered of the country with a dry season lasting 8 to 9 months. Its annual rainfall is less than 600 mm with high evapotranspiration and average annual temperature of 29 °C. This zone represents about 25% of the country's surface area. The Sudano-Sahelian zone has 4 to 5 months of rainfall with water depths between 600 and 900 mm and average annual temperature of 28 °C. This is the largest climatic zone, as it extends over the entire central and eastern part of the country. The Sudanian zone has 5 to 6 months of rainfall with water levels ranging from 900 mm to 1200 mm per year and small fluctuations of average annual temperature (27 °C). It include the southern and south-western part of the country.

2.1.1. Sites selection

The locations surveyed were randomly selected in each of the three agro-ecological zones (Sahelian zone, Sudano-Sahelian zone and Sudanian zone) from a list initially drawn up according to accessibility, the level of Bambara groundnut production and the need to cover the study area. Accordingly, nine sites were selected in the Sahelian zone, 21 in the Sudano-Sahelian zone and 14 in the Sudanian zone (Table 1).

From these sites, a total of 180 randomly selected rural farmers were interviewed, which included 30 farmers in the Sahelian zone, 88 farmers in the Sudano-Sahelian zone and 62 farmers in the Sudanian zone (Table 1)

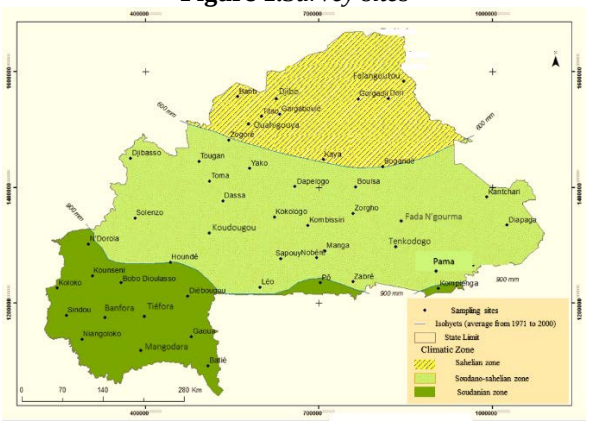
 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Table 1. Number of sites surveyed, and producers interviewed by agro-ecological zone

Agro-climatic zone	Sahelian zone	Sudano-Sahelian zone	Sudanian zone	Number
selected sites	09	21	14	44
farmers	30	88	62	180

The selected farmers were interviewed using a semi-structured questionnaire with open and close-ended questions. Quantitative and qualitative data were collected especially on the socio-economic characteristics of the farmers (gender, age, level of education, etc.), the drying processes (pod storage time, pod storage locations), the storage techniques (storage equipment, products associated with seed or pod storage), the pests responsible for seed attacks during storage, the period of seeds attack and actions undertaken after stock attacks. The collected data through interviews addressed directly with farmers. The interviews were conducted in the local dialect spoken by the producers, with the help of interpreters in some sites.

Figure 1.*Survey sites*



Note. The map shows the locations that were surveyed

2.2. Data analyses

The survey form and data collection were carried out using the Sphinx Plus²-V5 software (The sphinx Development 7450 Chavanod, France). Descriptive statistical analyses of frequencies and means were carried out on the data collected using SPSS software (IBM SPSS Statistics Version 21).

3. Results

3.1. Characteristics of the surveyed population

The results showed that Bammbara groundnut is mainly grown by women (74.4%) (Table 2). In addition, most (82%) of respondents are illiterate and sixty-two percent are between 31- 40 years of age. In general, most (74%) of the respondents, reported using less than one hectare to produce Bambara groundnut (Table 2).

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Table 2. Characteristics of the surveyed population (%)

Variable	% Surveyed people
Gender	
Female	74.4
Male	25.6
Age	
18-30	12.0
31-40	62.0
41-50	18.0
Over 50	8.0
Education level	
None	82.0
Basic Literacy	11.0
Primary School	7.0
High School	0.0
Tertiary/University	0.0
Size of farmland for the Bambara groundnut production	
0, 25 ha- 0, 50 ha	74.0
0,5 ha-1,00 ha	23.0
+1 ha	2.0

3.2. Drying practices of Bambara groundnut

Farmers use several techniques to dry Bambara groundnut pods (Table 3). All respondents reported the use sunlight as energy source to reduce the humidity of the seeds to acceptable levels before storage. Most (98.9%) of the respondents reported drying Bambara groundnut pods at home on plastic sheeting, on terraces, on the ground or on the roof of their sheds, while only 1.1% of respondents do so on their farm. Harvesting generally takes place during the dry season (late September, early October), which favors the drying operation. The time necessary for drying the pods varies from five to fourteen days according to the harvest period (presence/absence of clouds) and the climatic zone. Indeed, 42.2% of the respondents expose their pods to the sun for fourteen days, while others (40.0%) expose them for seven days. A relatively few (12.2%) farmers surveyed expose the pods to the sun for 10 days. Only 4.4% and 1.1% of the farmers dry the pods for nine and five days respectively (Table 3).

After drying, most (88%) of farmers reported using a mortar and pestle to shell the pods (Table 3). To achieve the same result, other farmers placed the pods in cloth bags and trampled them to separate the seeds from the shells.

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Table 3. Duration and location of drying, methods used to shell Bambara groundnut pods

Variable	Surveyed people			
	Sahelian region (n=30)	**Soudano-sahelian region (n=88)**	**Sudanian (n=62)**	**Over all (n=182)**
Duration of drying				
5 days	0%	2%	0%	1.1%
7 days	66%	36%	32%	40.0%
9 days	13%	2%	3%	4.4%
10 days	6%	18%	6%	12.2%
14 days	13%	40%	58,5%	42.2%
Location of drying				
Farm	-	-	-	1.1%
Housse	-	-	-	98.9%
Methods used to shell the Bambara groundnut pods				
Slight pestle strokes on the pods	-	-	-	88.0%
Slight trampling of the bags containing the pods	-	-	-	12.0%

3.3. Storage practices

3.3.1. Duration of storage and materials used

The study revealed that the farmers use simple and inexpensive storage methods to preserve their stocks of Bambara groundnut seeds or pods. About half (53%) of the farmers store their crops for six to nine months. Several materials are used for the storage of Bambara groundnuts. After shelling the pods, the grains are stored in hermetically sealed cans (45.6%), in plastic bags (31.1%), in traditional ceramic containers (10%), in jars (7.8%), and in metal barrels (6.7%) (Figure 2). In addition, some (4.4%) farmers store their pods in granaries while other use holes in their house as a storage structure (1.1%). Finally, more modern storage techniques such as triplicate bagging are used (14.4%) (Table 4).

3.3.2. Pest control methods

Most (64%) of the surveyed farmers do not mix a product with the seeds of Bambara groundnuts during the storage. However, some farmers mix their seeds with either a chemical product or a natural phytosanitary product. The natural phytosanitary products used during storage are mainly wood ash (14%), fine sand (7%) and plant powders with insecticidal or insect repellent properties (2%). The plant most commonly associated with Bambara groundnut storage is *Azadirachta indic*a. The use of chemical insecticides is

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

also widespread with chemicals such as phostoxin (20%) and bextoxin (4%) (The active ingredient of these chemicals is 56% aluminum phosphide.), the most frequently used by farmers. Unknown chemicals (1%) are also used (Table 4).

3.3.3. Challenges during storage

Despite the actions undertaken by the farmers, Bambara groundnut seeds continue to be subjected to frequent attacks. Thus, 36.7% of the surveyed farmers reported that their stocks are attacked by insects (91.4%) and fungi (42.9%) (Table 4). According to them, the attacks occur in an average period of three months after storage.

3.3.4. Actions undertaken following the attack on stocks

After an attack on stocks is noted, the farmers will adopt several conservative measures to limit the losses (85.5%). The most common technique is to sort, winnow, dry and repackage the seeds (84.4%). However, 9.4% of the farmers, after sorting, winnowing and drying their product, prefer to sell it, while 3.1% of them use it for consumption (Table 4).

Table 4. Storage practices of Bambara groundnut in rural areas of Burkina Faso

Storage practices	**Modality of storage**		**Frequency**
Form of seeds storage	Storage with pods		4.4%
	Storage without pods		95.6%
Storage systems	hermetically sealed can		45.6%
	Plastics bags		31.1%
	Triplicate bagging		14.4%
	Traditional ceramic container		10.0%
	Jar		7.8%
	Metal barrel		6.7%
	Granary		4.4%
	Hole		1.1%
Products used for pest control	Natural products	wood ash	14.0%
		Fine sand	7.0%
		powder of *Azadirachta indica* plant	2.0%
	Chemical pesticides	Phostoxin	20.0%
		Bethoxin	4.0%
		Unknown	1.0%
Duration of storage	Less than 3 months		12.0%
	3-6 months		53.0%
	6-9 months		27.0%
	9 or more months		8.0%
Challenges during storage	Insect damage		91.4%
	Fungi contamination		42.9%
	Sorting, winnowing, drying and repackaging		84.4%
	Sorting, winnowing, drying and selling		9.4%

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Actions taken following the attack on stocks	Sorting, winnowing, drying and consumption	3.1%

3.4. Post-harvest and storage activities for Bambara groundnut

Based on the survey results, the diagram of the post-harvest operations of Bambara groundnut can be summarized as follows:

The pods are harvested either by hand or with a hoe. After harvesting, the pods are transported home for drying. After drying, the pods are either stored directly in a granary or shelled with a mortar. After hulling, the seeds are separated from the shells by winnowing and then stored in hermetically sealed cans, plastic bags, traditional ceramic containers, jars, metal barrels, etc. (Figure 2).

Figure 2.*Schematic representation of post-harvest and storage practices of Bambara groundnut in rural area of Burkina Faso*

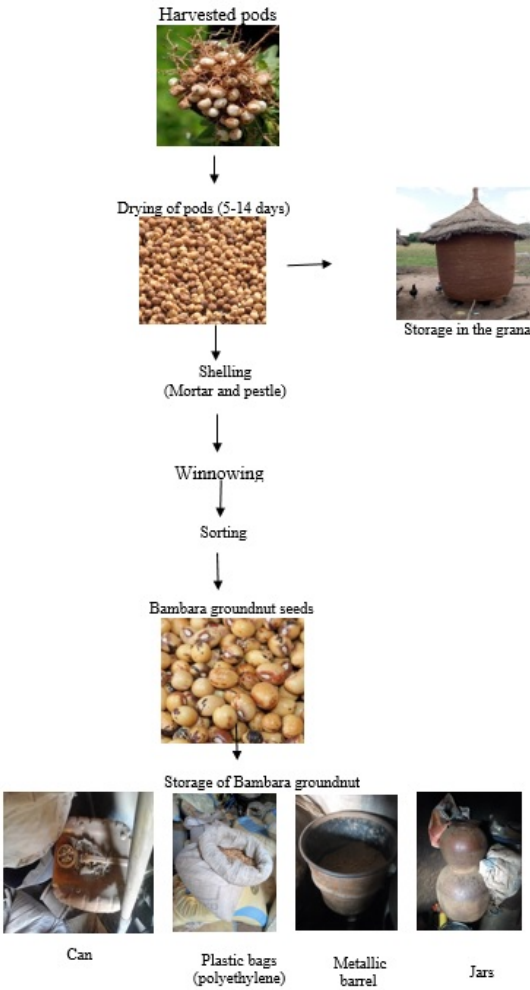

Diagram of post-harvest and storage techniques for Bambara groundnut

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4. Discussion

4.1. Characteristics of farmers and drying practices of Bambara groundnut pods

The study showed that in Burkina Faso, Bambara groundnut is mainly grown by women on small areas. The research of Ouoba et al. (2016) also showed that Bambara groundnut is mainly grown by women on areas less than one hectare. In boundary countries such as Côte d'Ivoire and Benin, Bambara groundnut production is also reserved for women (Gbaguidi et al., 2015; Touré et al., 2013). This is partly due to social considerations reserving this activity for women (Ouoba et al., 2016). The use of small areas to produce this legume could be explained by the fact that Bambara groundnut is a crop of second option compared to crops like cereals such as maize, millet and sorghum. In addition, due to the fact that women are not landowners, small portions of land are allocated to them; furthermore, these farmlands are not exclusively devoted to growing Bambara groundnut, but also, for other crops such as okra, sorrel, groundnut, cowpeas, etc. (Bamshaiye et al., 2011). Most of the respondents were between the ages of 31 and 40. Bambara groundnut growing is an activity that requires a lot of effort. This could explain the relatively youthfulness of the farmers. This may be an advantage to the adoption of new technologies which has a positive impact on food security. However, the surveyed persons did not have a high level of education, which may negatively influence their ability to make sound post-harvest management decisions. The period of the harvest depends on the condition of the plant or the degree of maturity of the pods. Sometimes, the harvest period is conducted in rainy season in some areas. This is often the case in areas where rainfall is relatively abundant. The Sudanian and Sudano-Sahelian zones of Burkina Faso have rainy periods of up to 6 months, making the weather almost cloudy in these areas (Thiombiano & Kampmann, 2010). This complicates the drying of the harvested pods, the sun being the main source of energy. Thus, insufficient, or low light intensity in these areas extend the time necessary for adequate drying. Long drying periods of pods on open surfaces expose the crop to spoilage of small ruminants and rodents or poultry. In addition to this spoilage, these animals could be a source of fungal contamination. The insufficiently dried seeds are prone to fungal damage and the production of mycotoxins during the storage (Daou et al., 2021). Issues associated with crops drying during the rainy season should be addressed with the introduction of appropriate technologies.

Farmers use traditional methods to shell the Bambara groundnut including the use of mortar and pestle, trampling on polythene or cloth bags containing the pods, followed by winnowing and sorting to separate the seeds from the hull debris. The equipment and techniques used can be sources of fungal contamination. Indeed, the mortars used to dehusk the Bambara groundnut are

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also used for other activities (processing dry and wet leaves, shelling groundnut pods, maize cobs, millet, etc.) and this can favor the contamination of the Bambara groundnut by micro-organisms from other sources. In addition, excessive shelling can damage the seeds and increase their vulnerability to insects and fungal attacks.

4.2. Storage practices

To protect the seeds, the farmers use several traditional storage methods. Hermetically sealed plastic drums (cans) and plastic bags are the most widely used methods for storage. Modern storage techniques are also used by the farmers including the triple bottom bags. Some farmers mix the seeds with wood ash or chemical product (Bextoxin or phostoxin) as tablets or powder for the storage. These modern techniques are not used enough because they are not always affordable. Ouoba et al. (2016) showed that most Bambara groundnut producers in Burkina Faso store their crops in hermetically sealed drums. According to the same results, 30.15 % of the surveyed farmers mix the seeds with ash for storage. According to the research conducted by Agboka et al. (2018), most Bambara groundnut producers in Togo also store their crops in hermetically sealed drums and mix the seeds with ash, plant leaves or bark, sand and chemical insecticide (Bextoxin, actellic) . With sealed bags, pest damage and aflatoxin contamination are mitigated (Maina et al., 2016; Njoroge et al., 2019; Williams et al., 2014). Improved storage prevents seed attack by insects, rodents, and fungi (Adetunji, 2007).

The sorting and drying practices applied by the farmers before storage can be considered as recommendable practices since they contribute to reducing the water content thus, the risk of fungal infection of the Bambara groundnut. Indeed, these operations were reported by Bankole & Adebanjo (2003) as good and recommendable practices against fungal infection and development on stored seeds.

4.3. Challenges during the storage and actions undertaken seeds attacks

The major challenges during Bambara groundnut storage are insects since their attacks during storage are considered the most damaging. Insects such as *Callosobruchus subinnotatus* and *Callosobruchus maculatus* cause serious damage to Bambara groundnut during storage (Agboka et al., 2018; Kabir et al., 2017). The presence of fungi in Bambara groundnut stocks has also been reported by other producers. The presence of these pests in Bambara groundnut stocks could be explained by a lack of good drying and storage practices. Insects and fungi can cause quantitative, qualitative and nutritional losses to stored seeds. Leaky storage materials could create favorable conditions for the development of insects. Seeds with high humidity could facilitate the fungal growth and the production of mycotoxins during the storage especially in the case of long storage conditions. Kaaya and

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Kyamuhangire (2006) reported that the concentration of aflatoxin in maize increases with storage duration. In the case of insect and fungal contamination of stocks, farmers adopt measures such as sorting, winnowing, drying and repackaging of seeds. These operations were found to be the most common and to have a positive effect on reducing stock losses. Good seed is recognized as an important input in any agricultural production system. Thus, the improvement of storage conditions to have high quality of seeds is necessary, and this requires the use of adequate storage materials. To achieve this, it is important to improve and promote pre- and post-harvest management practices to increase the use of new technologies such as improved seeds, dryers and hermetic storages devices.

Conclusion

The post-harvest practices such as sorting and drying of seeds before storage are commonly used by all Bambara groundnut producers. Storage materials such as hermetically sealed cans and plastic bags are used by most producers. The traditional storage methods used by the farmers are sometimes not efficient since insect and fungal attacks have been reported as serious challenges. To preserve their crops, several farmers use chemicals, but some of them are prohibited. This practice could lead to food poisoning after the consumption of such crops. Therefore, there is a need to improve and promote safe and efficient pre-harvest and post-harvest management practices to avoid seeds loss and contribute to food security.

Acknowledgements

The authors are grateful to the Mcknighht Fondation (Mcknight 18-097 project), International Fondation for Science (IFS) and the Committee on Scientific and Technological Cooperation (COMSTECH) of the Organization of Islamic Conference (OIC) for funding this research work. The rural farmers are also highly acknowledged for their enthusiastic participation in answering the questions.

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 ISSN: 1857-7881 (Print) e - ISSN 1857-7431