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Participatory diagnosis of post-harvest practices and storage constraints for *Senegalia macrostachya* seeds among farmers in the « Boucle du Mouhoun » region, Burkina Faso

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ABSTRACT: Non-timber forest products (NTFPs) in semi-arid regions of sub-Saharan Africa, play a crucial role in supporting local livelihoods by providing food, income, and raw materials. Particularly in Burkina Faso, the seeds of *Senegalia macrostachya* (Reichenb. ex DC.) (Zamnè) are highly valued by all social strata due to their nutritional, economic and pharmaceutical importance. However, post-harvest preservation of these seeds remains a major constraint. This study aimed to assess the various post-harvest practices used for *S. macrostachya* seeds in the rural areas. Data were collected through a structured, interviewer-assisted questionnaire survey. Results revealed that 87.9% of the respondents store their *S. macrostachya* seeds in polypropylene bags, 52.42% in 20l plastic drums and 24.19% in taditional clay containers. The majority of respondents (99.19%), identified insect infestation as the primary cause of post-harvest losses. Seed preservation is also intended to meet both household consumption and market supply needs. The most commonly employed pest control method is heat-based pre-cooking (90.32% of respondents). In the absence of control measures substancial damage can occur as early as the first week of storage. A better understanding of post-harvest strategies in rural contest is crucial for developing more effective management practises for this important food resource. Through the direct involvement of local farmers, the research seeks to: (i) document current practices, (ii) identify technical and socio-economic bottlenecks, and (iii) provide a baseline for the development of locally adapted, sustainable seed handling and storage strategies.

KEYWORDS: practices, post-harvest, pest, *Senegalia macrostachya,* traditional storage.

1 INTRODUCTION

In semi-arid regions of sub-Saharan Africa, non-timber forest products (NTFPs) play a crucial role in supporting local livelihoods by providing food, income, and raw materials [1], [2]. Among these, *Senegalia macrostachya* (Rchb. ex DC.) a multipurpose leguminous tree species, has gained increasing attention for its ecological, nutritional, and socio-economic potential [3], [4]. In Burkina Faso, the seeds of *Senegalia macrostachya* (Reichenb ex. DC), commonly known as "*zamnè*", hold an important position among wild legumes. Native to the Sudano-Sahelian zone, this species is traditionally exploited for fuelwood, animal fodder, soil enrichment, and, more recently, for its seeds which show promising nutritional properties [5], [6]. From a nutritional standpoint, these seeds contribute meaningfully to the local diet due to their high protein content (35.76%) [7] and their richness in essential micronutrients such as calcium (68.40mg/100g), zinc (5.34mg/100g) and iron (4.77mg/100g), they also contain appreciable levels of potassium and sodium with concentrations ranging from 10.45mg/100g to 14.60mg/100g and 22.75mg/100g to 72.18mg/100g respectively [5]. Economically, the trade of these seeds generates substancial income for rural communauties [8] and these seeds are also considered to have potential applications in the pharmaceutical industry [9]. Despite their nutritional and economic importance, the development of these legumes is severely hindered by insect pests, which compromise both the avaibility and quality of the seeds throughout the year [10], [11], [12]. *Caryedon furcatus,* the principal insect pest of *S. macrostachya* seeds, causes significant post-harvest losses, includint weight reduction, diminished seed quality and decreased germination capacity [11], [13], [14]. In response to these damage, various control methods have been explored, such as hermetic storage, the use of biopesticides and synthetic chemical treatments. However, effective conservation strategies require a comprehensible uderstanding of current post-harvest handling and storage practices. Unfortenately, such knowledge remains limited and poorly documented, particularly in rural agricultural settings. While some insights have been provided by [15] in the Boulkiemdé province, little is known about pratices in other key production areas. The present study aims to fill this knowledge gap by conducting a participatory diagnosis of post-havest practices and storage constraints related to *S. macrostachya* seeds in the Mouhoun region of Burkina Faso.

2 METHODOLOGY

2.1 STUDY SITE DESCRIPTION

This study was conducted in the Boucle du Mouhoun region of Burkina Faso, specifically in the Mouhoun province. Located in the northwestern part of the country, The Boucle du Mouhoun region lies between longitudes 02° 26' and 04° 38' West and latitudes 11° 15' and 13° 44' North. It covers a total area of 34,497 km^{2,} representing approximately 12.50% of the national territory [16]. The region has a predominantly rural population, with 1,901,269 inhabitants accross six (6) urban communes, 41 rural communes and 1,042 villages [17]. The climate of this region is classified as Sudano-Sahelian characterized by relatively abundant rainfall, though unevenly distributed in space and time. Average annual temperatures range from 24°C and 28°C, with peaks often exceeding 40°C during the hottest periods. Dédougou, the regional capital, is located approximately, 247 km west of Ouagadougou via the town of Koudougou. The study was carried out in the urban area of Dédougou (specifically in sectors 2, 3, 4 and 5), the urban area of Toma and the rural commune of Souri (Figure 1).

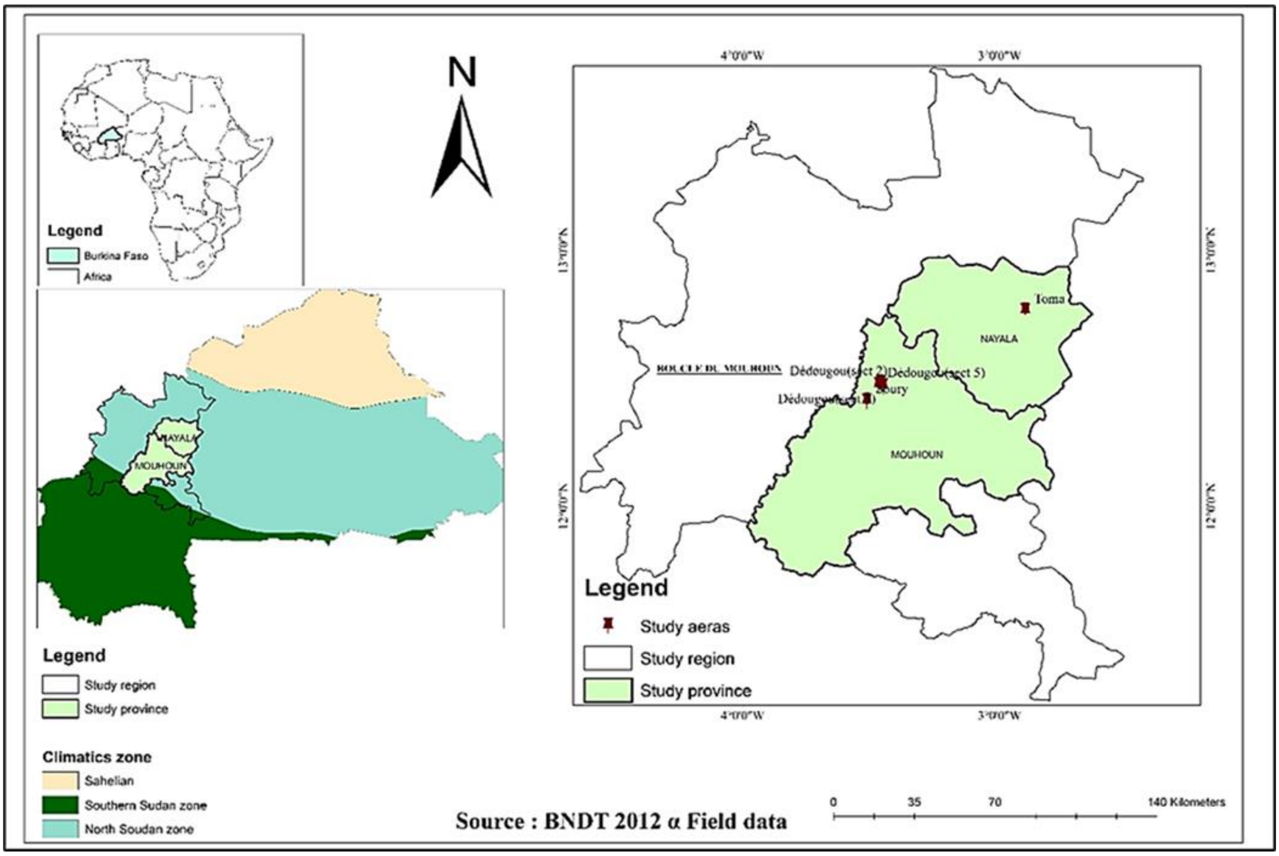

Fig. 1. Map of the surveyed sites in the Boucle du Mouhoun region

Fig. 1 shows the markets surveyed.

2.2 DIAGNOSIS OF STORAGE CONSTRAINTS IN THE FARMING ENVIRONMENT

A questionnaire-based survey was conducted among seeds collectors for the purposes of this study. The questionnaire was adapted from the one developed by [15] and included sections on general informations such as the identity and characteristics of the respondents (age, sex, education level), the various practices adopted by collectors from harvesting to storage, storage infrastructure and methods, as well as final use or destination of the stored products. Each respondent was interviewed individually to minimize peer influence and ensure the accuracy of responses, following the approach recommended by [18]. The three localities selected for the survey were chosen due to the presence of stands of *Senegalia macrostachya* and the availability of seed stocks from collectors [8]. In total, one hundred and twenty-four (124) people were surveyed. The sample size was determined using the method described by [19]. A preliminary survey was conducted to estimate the proportion of individuals who perceived insect infestation as a major to the preservation of *Senegalia macrostachya* seeds. A total of 97% of respondents confirmed this constraint, which served as a basis for calculating the require sample size. According to [19] 's formula, the resulting sample size was 124 respondents, distributed as follows: 78 in Dédougou, 25 in Toma, and 21 in Souri.

$$N = \frac{\mu^2\, 1 - {}^{\alpha}/_{2}\, Pi(1 - Pi)}{d^2}$$

Where N = total number of individuals to be surveyed representing the sample size;

$\mu 1\text{-}\alpha/2$: value of the standard normal variable corresponding to a significant level $\alpha = 0.05$;

($\mu 1\text{-}\alpha/2 = 1.96$);

d = margin of error considered in the survey, where $1\% < d < 15\%$, in the case $d = 0.03$;

P*i* = estimated proportion of respondents who reported that *Senegalia macrostachya* stands are heavily infested with insects and lack any control measures.

2.3 STATISTICAL ANALYSIS OF DATA

Data collected during the survey were entered into Microsoft Excel 2019, which was also use to calculate response proportions and to generate some descriptive graphs. Further statical analyses were conducted using R software version 4.3.1 (2023-06-16). The Shapiro-Wilk test was applied to assess the normality of the data distribution, specifically for the price of a can of tomatoes and the shelf life of *zamnè* seeds, using the shapiro.test function. Based on the normality results, appropriate non-parametric tests were selected. The Mann-Whitney-Wilcoxon test was performed using the Wilcox test function at the 5% significance level ($\alpha = 0.05$).

3 RESULTS

3.1 CHARACTERISTICS OF THE RESPONDENTS

The results indicate that the most represented age group among the respondents is 25 to 40 years accounting for 45.97% of the sample (Table 1). Moreover, the majority of the respondents are female (95.97%) and illiterate (79.03%). Nevertheless, a small proportion has attained primary or secondary education and minority (2.42%) has pursue higher education.

Tableau 1. Characteristics of the surveyed population

Variables	Frequency	Percentage (%)
Sex		
Female	119	95.97
Male	05	4.03
Age (year)		
[16-25 [	10	8.06
[25-40 [	57	45.97
[40-60 [	45	36.29
≥ 60	12	9.68
Level of education		
None	98	79.03
Primary	14	11.29
Secondary	9	7.26
Bachelor	3	2.42
Organised as a cooperative		
No	99	79.84
Yes	25	20.16

3.2 Post-Harvest Practices

The results of this study indicate that the majority of collectors (55.65%) shell the pods immediately after harvest and store the seeds without any additional drying (Table 2). It is not worth noting that a small proportion of respondents (3.23%) purchased seeds that have already been shelled. Other post-harvest practices prior to seed storage are also commonly reported, such as shelling (including threshing and winnowing) immediately after harvest, followed by further drying of the seeds before storage (35.48%). Furthermore, the average interval between harvest and pod drying ranged from 1 to 7 days, for 38.71% of respondents. However, 12.90% and 24.19% of the respondents reported drying durations of 7-14 days and 14-21 days, respectively (Figure 2).

Tableau 2. Distribution of respondents' answers regarding post-harvest practices prior to seed storage

Post-harvest activities	Percentage of responses(%)
Pods shelled immediately after harvest; seeds stored without further drying	55.65
Pods shelled immediately after harvest ; seeds dried before storage	35.48
Pods dried, seeds further dried before storage	23.39
Pods dried and stored without shelling	20.97
Pods dried, then shelled before seed storage	20.97
Seeds purchased already shelled and dried	3.23

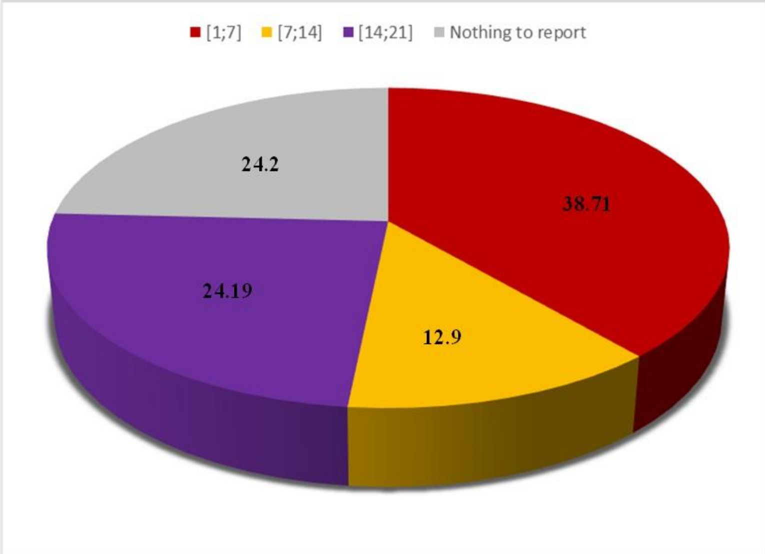

Fig. 2. Distribution of respondents' answers on the drying duration of S. macrostachya pods prior to storage

Fig. 2 shows the average interval between harvest and pod drying ranged *S. macrostachya* seeds.

3.3 SEED STORAGE STRUCTURES FOR SENEGALIA MACROSTACHYA

Figure 3 illustrates the various types of seed storage structures used, along with their respective frequencies of use. The majority of respondents (87.90%) reported storing seeds in polypropylene bags line with plastic. Other commonly used storage structures included 20 litre plastic drums (52.42%), earthenware jars (24.19%), and traditional granaries (20.16%).

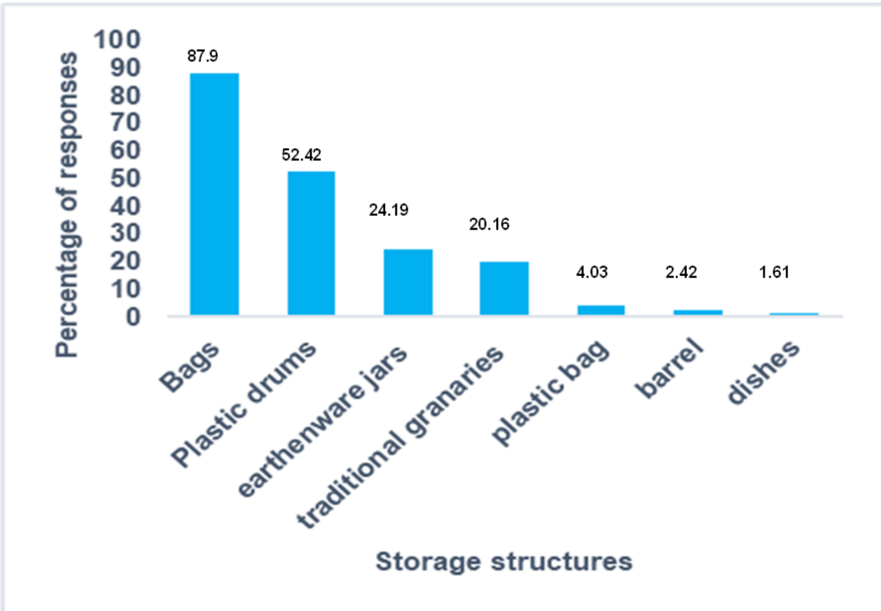

Fig. 3. Distribution of respondents' answers on S. macrostachya seed storage structures

Fig. 3 shows the various types of seed storage structures used.

3.4 NATURE OF THE POST-HARVEST DAMAGE TO S. MACROSTACHYA SEEDS

According to stakeholders in the sector, various types of damage occur are after harvest, both during and after storage. The most frequently reported form of damage was perforation seeds (97.58%), followed by insect infestation and the presence of frass or meal residues (40.32%). Broken seeds and loss of germination were also reported accounting for 33.87% and 20.16% of cases, respectively, while damage due to seed was less frequent 8.06% (Table 3). Furthermore, the vast majority of respondents (99.19%), identified insects as the primary cause of damage to *Senegalia macrostachya* seeds, followed by moulds (21.77%) and rodents, particularly mice (20.16%) (Figure4).

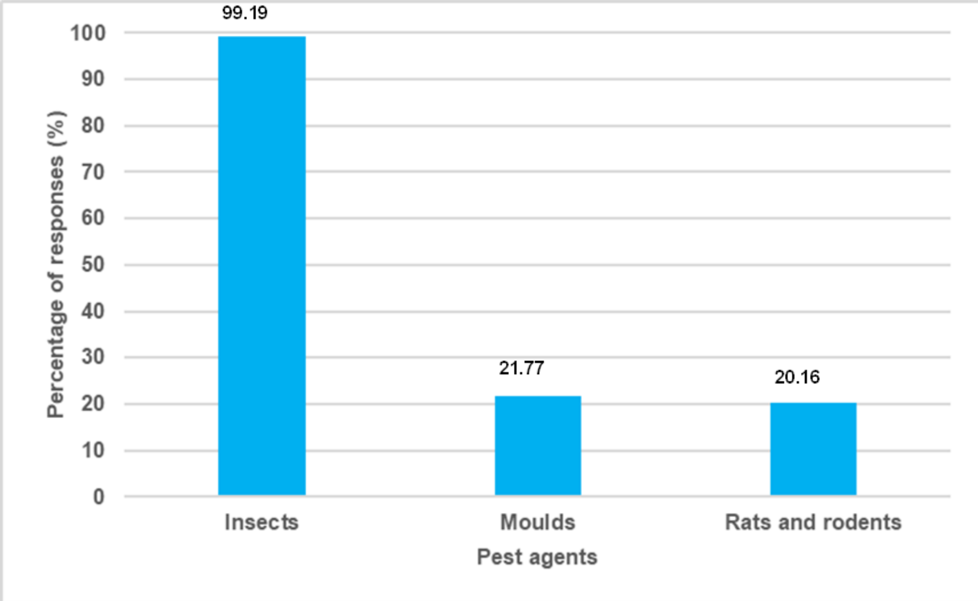

Fig. 4. Respondents' answers on the main causes of damage to S. macrostachya seed stocks

Fig. 4 shows the various cause of damage to *Senegalia macrostachya* seeds.

Tableau 3. Respondents' perception of the nature of damage caused by storage pests

Nature of damage	Proportion of answers (%)
Seeds perforation	97.58
Insect infestation	40.32
Broken or damaged seeds	33.87
Loss of germination capacity	20.16
Seeds rot	8.06
Other	0.81

3.5 Methods Of Protection And Destination Of Stocks Of S. Macrostachya Seeds

The results of this study reveal that both traditional (e.g., precooking with heat, hermetic storage, use of mineral substances, especially ash) and modern (chemical treatments) methods are employed to preserve *S. macrostachya* seeds (Figure 5). According to the respondents, the most frequently used preservation technique is heat precooking, cited by (90.32%) of them. The second most commonly employedis hermetic method (30.65%). This technique involves placing the seeds in 20 litre plastic drums and packing tightly to reduce intergranular air, thereby limiting pest infestation and moisture accumulation. Other methods mentioned, in decreasing order of frequency, include the use of mineral substances (21.77%), mainly wood ash, and the use of plant-base substances (20.16%) particularly neem oil. The former consists of sprinkling ash directly onto the seeds, while the latter involves mixing the seeds with neem oil prior to sotrage in plastic drums or metal barrel. The least utilized method is chemical treatments (1.61%), primarily with phostoxin. It is typically applied in tablet form, wrapped with cloth, and placed withing the seed containers during the storage. The motivations for storing *S. macrostachya* seeds vary among respondents. The majority (67.74%) reported storing seeds primarily for later sale to meet specific financial needs. Others indicated that they store seeds to sell when market prices rise (46.77%), for year-round household consumption (41.13%) or for ceremonial purposes such as weddings, engagements, baptisms, and funerals (30.65%) (Table 4). A small proportion (3.23%) reported storing seeds specifically for consumption during the lean season. Therefore, the study revealed that the market price of *S. macrostachya* seeds fluctuated significantly depending on the time of year (W = 0.8592, p-value = 1.693e-09). On average, the price of a tomato can (2 kg) rose from 1167.742 FCFA during the harvest period (December) to 1722.177 FCFA in August, coinciding dwith the lean season, with a peak price recorded at 2500 FCFA (Figure 6).

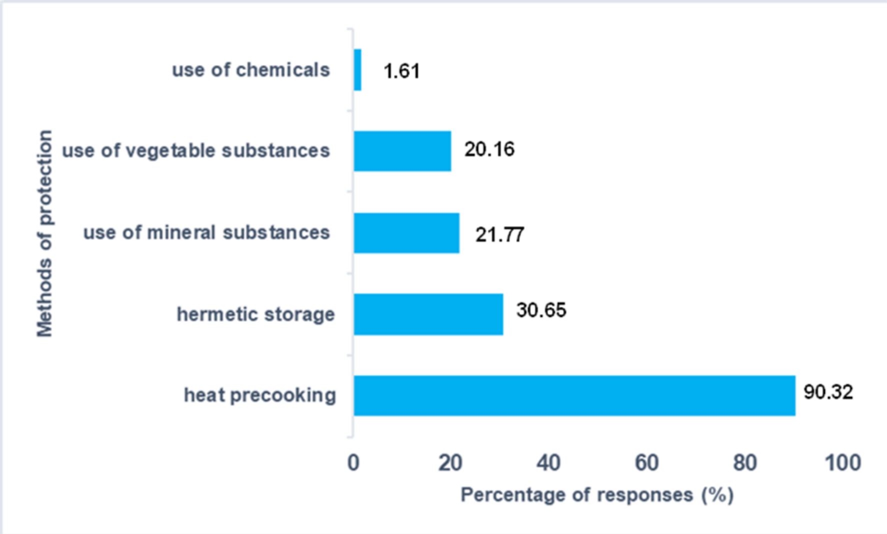

Fig. 5. Respondents' answers on methods of protection of S. macrostachya seeds

Fig. 5 illustrates the various protection methods used.

Tableau 4. Respondents' uses of Seeds after storage

Purpose of seed storage	Percentage %
sell to satisfy specific needs	67.74
Marketing when selling prices rise	46.77
Year-round consumption	41.13
Use during ceremonies	30.65
Consumption during the lean season	3.23

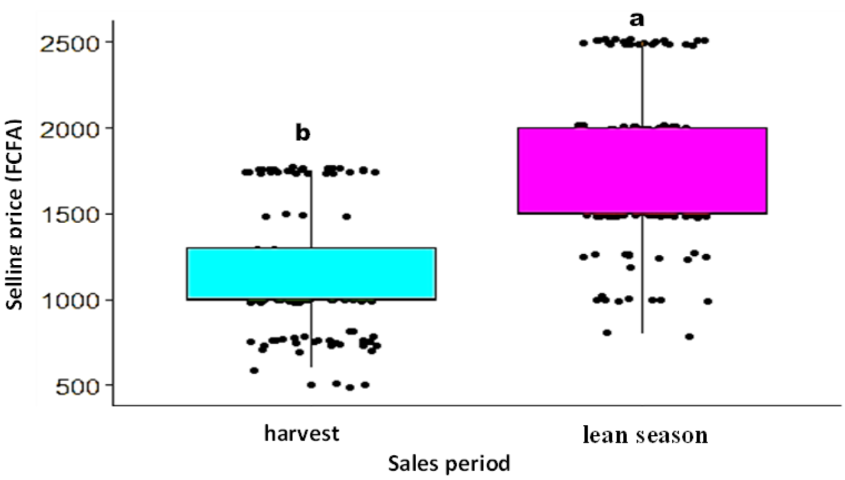

Fig. 6. Average price by sales period

Fig. 6 shows the market price of *S. macrostachya* seeds over time.

4 DISCUSSION

The results of this study provided valuable insights into the collection methods and storage conditions of *Senegalia macrostachya* seeds in the Boucle du Mouhoun province. These results revealed that women were the most involved in the *zamnè* value chain, which explains their high representation among respondents (95.97%). Most farmers (55.65% of respondents) reported shelling the pods immediately after harvest and storing the seeds without any additional drying. According to the collectors, the seeds should be left to dry properly on the tree to reduce moisture content, thereby preserving their nutritional value and germination capacity. This aligns with findings by [20], who noted that pods drying aims to retain nutritional value and germinative potential, while protecting from bacteria and fungi by reducing moisture levels. Shelling is typically done manually using sticks or by hand, primarily to eliminate impurities and potential insect infestations. A significant proportion of respondents (87.90%) preferred to store seeds in 50 or 100 kg polypropylene bags. These results are consistent with those of [15], who reported that 52.13% of participants also favored 50 kg polypropylene bags for *S. macrotachya* seed storage. Similarly, a study by [18] in central Benin also showed that 59.17% of respondents stored legume seeds in jute bags ranging from 50 and 100 kg, citing ease of monitoring and accessibility as major advantages. Other storage container such as 20-liter plastic drums and terracotta pots are commonly used for small quantities of *S. macrostachya* seeds, particularly when avoiding mixing with other food items. In cases of mixed storage, some respondents used banco granaries or barrels, which enable co-storage of *S. macrostachya* seeds with other products, especially groundnuts. Similar practices were observed by [15]. However, this type of mixed storage may facilitate pest transfer between products [21], [22]. Insects are frequently cited as the primary cause of damage to *S. macrostachya* seeds, typically infested through seeds perforation. Post-harvest losses caused by insect pests are both quantitative (e.g., weight loss) and qualitative (e.g., reduced nutritional value and germination rate) [23]. According to [15], insect infestations are the leading cause of degradation of *S. macrostachya* seeds in the Boulkiemdé province. Similar infestations have also been reported for cowpea and *voandzou* in the Hauts Bassins region [24], and for cereal stocks in the southern Sudanese zone of Burkina Faso [25]. Further, reference [15] noted that *S. macrostachya* seeds are often infested while still in the field, even before harvest and storage. Such early infestations have also been documented in order Acacia species, including *Acacia raddiana* in Senegal [26] and *Acacia tortilis* in Tunisia [27]. These primary infestations typically persist during storage and, according to 69.35% of respondents, can result in damage within less than a month somtimes even a week. To mitigate these losses, the most commonly used protection method was thermal precooking. This process eliminates visible adult insects at harvest and destroys larvae, halting their development. In [15] 's study in Boukiemdé, respondents similarly relied on heat pre-cooking. Additional protective methods mentioned by respondents included hermetic storage, botanical extracts, and the use of ash. [28] highlighted that ash, like other mineral substances, acts as a physical barrier that impedes females oviposition by filling the spaces between seeds. Hermetic storage works by inducing anoxia, which kills adult insects and larvae [29]. Some respondents also reported using botanical insecticides particularly neem oil, to control pests in *S. macrostachya* stocks. These preservation methods reportedly alow for safe seed storage over period ranging from 12 to 36 months. However, traditional methods such as hermetic storage in cans, thermal pre-cooking, and ash application are often challenging to scale up for large quantities [29]. *S. macrostachya* seeds are preserved for various purposes. While many producers store them for commercial reasons often selling in local market during the lean season in August when prices peak, others preserve them for household consumption. At harvest time in December, seeds prices are relatively low. As [15] indicated, the average selling price of *S. macrostachya* seeds was low 1260 FCFA per 2.45 kg, in December and increased to 1800 FCFA during the August lean season. These seeds are also prepared for special occasions such as weddings, baptisms, and engagement, and are consumed regularly throughout the year prior to the next harvest. Given their nutritional and economical, improving post-harvest managementn could position the zamnè sector as a promising avenue in the fight against poverty.

5 CONCLUSION

In summary, after harvest, *S. macrostachya* pods are threshed and sifted before being stored in various containers, with polypropylene bags being the most commonly bags due to their praticality. Storage aims to multiple purposes, primarily income generation through seed sales. According to the collectors interviewed, insect pests are the main cause of post-harvest seed losses. The most widely adoptive protective measure is thermal pre-cooking. To ensure optimal benefits from *S.macrostachya* seeds, it is crucial to implement effective pest management strategies. Addressing this challenge requires a comprehensive understanding of the insects species responsible for the observed damage.

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