Farmers’ management of peanut (Arachis hypogaea L.) diversity, their varietal preference traits and uses in Southern and Central Benin

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Abstract
Peanut (Arachis hypogaea L.) is one of the major oilseed legumes contributing to food security in Benin. Unfortunately, several constraints hamper its production leading to a low yield. A good knowledge of on-farm management of peanut diversity and uses that allow its maintenance in traditional Beninese agriculture are prerequisites to establish an efficient breeding programme. Therefore, this study aims to document peanut varietal diversity, folk nomenclature, seed system, storage constraints, pest management practices, varietal preference criteria, cultural taboos and uses in southern and central Benin. Two hundred and sixteen farmers were surveyed through 32 villages in southern and central Benin using rural appraisal tools. Fifty-four peanut local varieties grouped into eight morphotypes based on the seed characteristics were registered. The number of local varieties maintained per village ranged from 1 to 11 and varied between 1 and 4 per household. The drop in yield was the main reason of peanut varietal abandonment. Rodent attacks were the most important constraints of peanut production. Varietal preference criteria varied from ethnic groups with seed size and many pod/seeds per plant as the main preferred traits. Peanut seed system was mainly informal. To alleviate pest problems in stored peanut, producers used biocidal plants and synthetic chemicals. Some cultural taboos and various uses of peanuts have been recorded. Our results suggest that for boosting peanut production in central and southern Benin, breeders must create high-yielding peanut varieties. However, it is important to take into account the preference varietal criteria of each ethnic group for their adoption. For a good estimation of peanut diversity in the study area, morphological and molecular characterizations were recommended.

Keywords Groundnut · Seed system · Seed conservation · Traditional prohibitions · Uses · Varietal diversity

Introduction
Peanut (Arachis hypogaea L.) also called groundnut is one of the major oilseed, feed and food crops contributing to food security and poverty reduction in Benin. Cultivated for its seeds, peanuts are produced throughout the country with high production in the South and Central Benin. With a national production of 225,744 tons in 2018 (FAO 2018), peanut cultivation in Benin is used to satisfy the food needs of population and supply the local artisanal processing market with oils and cake products (Adjou et al. 2012). The seeds of this oilseed are very rich in edible oil, and proteins (Sebei et al. 2013; Gulluoglu et al. 2016). In addition, peanut seeds are good source of some nutrients such as calcium, phosphorus, and essential vitamins (Zahran and Tawfeuk 2019). It is consumed in many forms (fresh, boiled or roasted), and usually intended for the production of oil used in cooking and soap making (Adjou and Soumanou 2013). In Benin, peanut farming represents an important source of income through the sale of peanut-based products (Videgla et al. 2016a, b). In addition, cakes from oil extraction are used for livestock feed (Okello et al. 2010).
Despite its food and economic importance, peanut production has evolved in a sawtooth way in Benin, decreasing from 154,403 tons in 2010 to 140,135 tons in 2017 with an increase of 225,744 tons in 2018 (FAO 2018). This variation in peanut production results from various constraints related to its production and conservation. These constraints remain very little documented in Benin, while their knowledge is an important step for the proposal of sustainable solutions to boost peanut production. Indeed, despite its relative importance in Benin agriculture, peanuts have received little attention from research. As a result, peanut yield in Benin remains very low (998.3 kg/ha) compared to global yield (1611.4 kg/ha) in 2018 (FAO 2018). This low yield could be explained by the poor quality of seeds grown in Benin (Didagbe et al. 2015) and, the lack of improved varieties (Adomou et al. 1997) as is the case in Tanzania (Bucheyeki et al. 2008). However, very little information exists on the diversity of peanuts grown in Benin agriculture. While this information is necessary for breeders as a prerequisite for establishing a good peanut breeding programme (Banla et al. 2018). It is therefore important to document the diversity of peanuts grown in Benin, but also the farmers’ criteria of varietal preferences to ensure adoption of improved cultivars by farmers (Daudi et al. 2018). Moreover, knowing that seed is important to increase agricultural productivity, the documentation of the peanut seed dispersal systems is a necessity.

Attack of peanut stocks by insects is among main constraints of peanut seed conservation (Baributsa et al. 2017). Indeed, seed are very susceptible to insect attacks because of their fragile seed coat and brittle cotyledons (Santos et al. 2016). The losses due to these pests can reach more than 50% of the harvests after 4 months of peanut storage (Thiaw et al. 2007). However, very little attention has been given to storage insect pests associated with peanut and their management in Benin. Consequently, farmers’ knowledge, damage perception, and traditional management of these storage insect pests are not yet documented. These information are important for the development of integrated pest management strategies that meet farmer needs.

Peanut is a multipurpose oilseed legume, which can be used, as medicine, fodder, and cash crop (Lim 2012). The production of this legume in Benin is mainly done for local artisanal processing, which develop some peanut derivative products (Videgl et al. 2016a, b). It is important to evaluate the pattern of use of peanut through ethnic groups of south and central Benin for the development of conservation strategies of this crop. Therefore, the objectives of this study are to (i) document local nomenclature, production constraints, farmers varietal preference criteria, seed system, cultural taboos, storage pest management practices, traditional uses of peanuts and reasons of abandonment of peanut varieties grew in south and central Benin; (ii) evaluate peanut varietal diversity and abandoned varieties in the study area.

### Material and methods

#### Description of the study area

This study was conducted, respectively, in 33 villages of southern and central Benin in a chosen manner to cover all ethnic groups and provide good coverage of the study area (Fig. 1). The average temperature in the study area is between 26 and 28 °C and the annual rainfall varies from 800 to 1400 mm in the South and, 800 to 1200 mm in the central region. Vegetation is composed of deciduous or moist forests and wooded savannahs. The South is one of the most complex areas and dominated by ferrallitic soils. In the study area, farmers practise continuous cultivation or short fallows. The main ethnic groups encountered are Adja, Aízo, Holli, Wémènou (Ouémenou), Tori, Watchi, Xwla, Yoruba, Fon, Mahi, Idaasha, Ifê and Tchabè.

#### Collection of data

The data were collected in the 32 villages selected through the application of participatory research tools and techniques such as individual interviews and field visits using a questionnaire. The interviews were conducted with the help of guides to facilitate discussions with farmers. After presenting the objectives of the survey to the head of each village and the leaders of farmers organization and obtaining their agreement, ten households were selected in each village by the transect method described by Dansi et al. (2010). A total of 216 peanut farmers belonging to 10 ethnic groups (Mahi, Fon, Idaasha, Nago, Holli, Goun, Adja, Aïzo, Tori and Wémènou) were surveyed. The majority of surveyed farmers (137) were men, and illiterate (149) with an average age of 42.6 ± 0.9 years (Table 1). The years of experience of surveyed farmers in peanut production range from 2 to 68 years with surveyed farmers of central Benin having more experience (Table 1). Household size ranged from 1 to 21 people with an average of 15 persons per household. Farmers of central Benin planted larger areas (an average 1.7 ha) in peanut production compared to those in the South (an average of 1.4 ha). Peanut production is done on small plots (1.4 ± 0.1 ha on average). The data collected based on a semi-structured questionnaire concerned the varietal diversity maintained at the household level, the local nomenclature of peanut local varieties, abandoned local varieties, the reasons for their abandonment, the constraints related to peanut farming, the seed system, uses, pests and control methods. After interview, peanut local varieties listed by farmers were collected and classified using seed’s morphological descriptors (coat...
Fig. 1  Map of the study area showing the surveyed villages
colour, size, coat pattern, and hilum colour) published by the International Board for Plant Genetic Resources (IBPGR) and ICRISAT (1992).

Data analysis

The data were analysed from the descriptive and multivariate statistics and the results were presented in the form of tables and graphs. Chi-square analysis was used to compare the socio-demographic profile (education and sex parameters), farmer varietal preference criteria, and peanut culinary uses between regions. Before multivariate analysis, the data normality was tested using Levene’s test. To achieve normality and homogeneity of variances, data were log-transformed \[ \log(x + 1) \]. The transformed data were then subjected to one-way ANOVA analysis to compare age, experience, land size and household size of farmers between the two prospected regions, using the Statistical Package for Social Sciences (IBM SPSS version 23.0). The level of significance was set at 0.05, and means were separated by Student–Newman–Keuls (SNK) test. To describe the relationship between the culinary uses of peanuts and the ethnic groups of the study area, corresponding data were subjected to principal component analysis (PCA) using Minitab 17 software.

Results

Local nomenclature

Across the 10 ethnic groups surveyed in the study area, 54 peanut local names were recorded. All local names given to peanut local varieties have meaning (Table 2). The majority of these names correspond to the pod length (38.5% of producers), seed size (21.6%), number of grains per pod (14.7%), seed origin (12.5%), seed colour (4.7%), growing season (4.5%) and susceptibility to pests (3.5%).

Varietal diversity

The number of peanut local varieties per village ranged from 1 to 11 with an average of 4. The village Hountongon recorded the smallest number (1) of peanut local varieties while the village Atchédiégbé showed the greatest varietal diversity (11). The peanut diversity maintained in the household level varied from 1 to 4 in the study area; it varied from 1 to 3 in the South and from 1 to 4 in the Central Benin. The number of peanut local varieties subject to synonymy also varied within ethnic group. The greatest diversity was observed in the Fon ethnic group (25 local
| Denomination criteria | Percentage of responses | Local name | Ethnic groups | Meaning of name |
|-----------------------|-------------------------|------------|---------------|-----------------|
| Pod length            | 38.5                    | Aloga, Fonkoun, Fonkouin | Fon | Peanut with long pod |
|                       |                         | Azi Korga | Fon, Aizo, Tori, Goun, Ouéménou |
|                       |                         | Koundaho  | Tori, Ouéménou, Goun |
|                       |                         | Olomon lakoun | Nago, Yoruba, Holli, Fon |
|                       |                         | Azi korgri | Mahi |
|                       |                         | Korgli     | Fon, Tori, Goun, Aizo, Ouéménou |
|                       |                         | Kounkpèvi  | Tori, Ouéménou, Goun |
|                       |                         | Olomon kékéré | Holli |
| Seed size             | 21.6                    | Tchokotoukou, Azi alloga | Mahi | Long-seeded peanut |
|                       |                         | Ayossi lakoun | Nago |
|                       |                         | Azi winiwini | Mahi, Fon, Adja |
|                       |                         | Azi Kpékpéhoun | Mahi, Fon |
|                       |                         | Alokpèvi, Aloglivi, Azi kpéhoun | Fon |
|                       |                         | Azi allogri | Mahi |
|                       |                         | Azi kloklo   | Fon, Goun |
|                       |                         | Gbohoungbho, Konkloklo, Vénon | Fon, Goun |
|                       |                         | Atcholouga  | Fôn, Mahi |
|                       |                         | Agbodjougba | Holli |
|                       |                         | Awozi Olomon médji | Idatcha |
|                       |                         | Tondoun     | Adja |
|                       |                         | Awozi Olomon meta | Idatcha |
| Number of grains per pod | 14.7                  | Epka CARDER | Nago | Peanut with 2 seeds per pod |
|                       |                         | Azi CARDER  | Fôn, Adja, Mahi |
|                       |                         | Awozi Congo | Idatcha |
|                       |                         | Azi Congo   | Mahi, Fon |
|                       |                         | Ekpa Congo  | Nago |
|                       |                         | Togo zi     | Fôn |
|                       |                         | Agonli zi   | Fôn |
|                       |                         | Djougou zi  | Fôn |
|                       |                         | Glazouézi   | Fôn |
|                       |                         | Mahi zi     | Fôn |
|                       |                         | Liza zi     | Fôn |
|                       |                         | Azino fonton | Fôn |
|                       |                         | Yovozi      | Fôn |
| Origin of seeds       | 12.5                    | Epka CARDER | Nago | Peanut from Carder |
|                       |                         | Azi CARDER  | Fôn, Adja, Mahi |
|                       |                         | Awozi Congo | Idatcha |
|                       |                         | Azi Congo   | Mahi, Fon |
|                       |                         | Ekpa Congo  | Nago |
|                       |                         | Togo zi     | Fôn |
|                       |                         | Agonli zi   | Fôn |
|                       |                         | Djougou zi  | Fôn |
|                       |                         | Glazouézi   | Fôn |
|                       |                         | Mahi zi     | Fôn |
|                       |                         | Liza zi     | Fôn |
|                       |                         | Azino fonton | Fôn |
|                       |                         | Yovozi      | Fôn |
| Seed colour           | 4.7                     | Olomon wèwè | Nago | White seed peanut |
|                       |                         | Ayossi wèwè | Nago, Idatcha |
|                       |                         | Azi wèwè | Adja, Fon |
|                       |                         | Olomon founfoun | Holli |
|                       |                         | Azivo vo  | Mahi, Fon, Aizo |
|                       |                         | Ekpa djodjo | Nago |
|                       |                         | Yinbo      | Holli |
| Growing season        | 4.5                     | Houéton     | Fôn |
|                       |                         | Zoton      | Fôn |
| Susceptibility to pests | 3.5                   | Ahouahodou, Assozi | Fôn | Partridge peanut |
|                       |                         | Agonmadou  | Mahi |
|                       |                         | Agonmami   | Mahi | Partridge cannot eat |
varieties) followed by the Mahi (11), Nago (7), Goun (6), Adja (5), Holli (5), Idaasha (4), Wéménou (4), Tori (4), and Aïzo (3) ethnic groups. Based on the morphological characteristics of the peanut seeds, the 54 local varieties listed were grouped into 8 morphotypes (Table 3).

Five and fourteen farmers reported the abandonment of some peanut local varieties in southern and central Benin, respectively. The reasons for abandonment listed by the peanut producers were the drop in yield (47.1%), the lack of rain (5.9%), the drop in the market price (11.7%) and the lack of financial means (35.3%).

Production constraints

Farmers in southern and central Benin face several difficulties related to the peanut production. A total of nine constraints were recorded in the study area and all of them have been listed by farmers of south Benin (Table 4). While, only five production constraints were listed in central Benin. The most important constraints in both regions were the rodent attacks (82.6%) followed, respectively, by the lack of workforce in southern Benin and the difficulties related to the maintenance of fields in central Benin. Only peanut producers in southern Benin have listed transhumance, seed price increases, and decrease in yield as constraints (Table 4).

Thirteen pests were listed by farmers as causing significant damage to the peanut fields in the study area (Table 5). Rats, partridges, centipedes and rabbits were the most important pests registered in the south and central of Benin. However, termites are also reported as major pests in central Benin. Eight pests (rats, partridges, centipedes, greater cane rats, red ants, termites, caterpillars and monkeys) were identified as more damaging during the peanut ripening stage by attacking the pods, while rabbits, grasshoppers, crickets, snail and sheep have been identified by farmers as attacking the leaves during the vegetative stage. Monkeys have been listed as pests only in central Benin while snail and sheep have been listed only in southern Benin.

Farmers’ preference varietal criteria

Surveyed peanut producers reported nine varietal preference criteria (Table 6). These various criteria listed have been grouped into three categories: agronomic (68.9% of responses), culinary (20.1%) and economic (11.0%). The most important are: the seed size (35.2% of responses), the abundance of pods and seeds per plant (29.3%) and the capacity of the seeds to produce large amount of oil (19.2%).

The number and importance of farmers’ varietal preference criteria also varied according to ethnic groups (Table 6). For example, the peanut producers of the Fon ethnic group listed nine preference criteria against five preference criteria listed by the Adja, Tori, Nago and Mahi ethnic groups.

The Aïzo, Goun, Holli and Wéménou ethnic groups listed only two varietal preference criteria. The production of a large amount of oil is the quality sought by producers of the Idaasha, Mahi and Nago ethnic groups to adopt a variety of peanuts. While for producers of Aïzo, Holli, and Tori ethnic groups the great number of pods and seeds per plant was the main criteria. The peanut seed size was the main varietal preference criteria of farmers of Adja, Fon, and Goun ethnic groups. For farmers of Wéménou ethnic group the peanut seed size and the abundance of pods and seeds per plant were the only most important criteria for the adoption of a variety (Table 6).

Seed system

The peanut seed system in the study area was informal and seed supply structures were not widespread. The majority of producers surveyed (59.1%) were content to buy seeds in local markets from other producers or small traders. Others producers (23.3%) used seeds from previous crops stored. The local extension service ATDA (Territorial Agricultural Development Agencies) represents the only structure dealing with the sale of peanut seeds where some producers (8.3%) get their supplies. In addition, a small number of producers obtained peanut seeds from other countries including the Congo (5.1%), Nigeria (3.2%) and Senegal (1.0%).

The main criteria used by surveyed peanut producers (86.1%) in seed selection were the healthy seed (39.3% of responses), seed colour (27.6%), seed size (14.8%), seed shape (14.5%), seed maturity (2.8%), germination test (0.7%), and seed hardness (0.3%).

Producers have listed three constraints: limited access to quality seed (75.6% of responses) was notified as the main constraint followed by increased seed prices (21.3%), and seed conservation (3.1%) during the study area, peanut was preserved mainly in the unshelled form (90.7% of responses). Only a few producers (9.3%) stored peanut as seeds after shelling. In the study area, 8 different storage tools are used by producers to store seeds. The majority of producers (77.5%) keep the peanut in polyethylene bags. A number of producers have kept peanuts in baskets (10%), cans (5.9%), knitted loin-cloths (2.7%), calabashes (2.5%), granaries (0.9%), and on the plywood used as ceilings on their roofs where they spread them (0.5%).

The peanut storage locations varied from one producer to another. According to the majority of producers (72.3%), they prefer to store their peanuts at home. The other producers keep peanuts in stores (18.5%) and granaries (9.2%). For the majority of the surveyed producers (76.5%), the shelf life of the peanut is between 3 and 6 months (Fig. 2a). Majority of producers (96.6%) of
Table 3  Photo showing the aspects of the local varieties from the South and Center collected

| Villages                          | Local names            | Characteristics                                      | Pictures            |
|----------------------------------|------------------------|------------------------------------------------------|---------------------|
| Aklankpa, Atchédigbé, Keouss-Zà, Toffo-gare, Zakémondji | Agonmadou             | Erected port                                        | Pale pink seed     |
|                                  | Agonmami               |                                                      | Two seeds per pod   |
|                                  | Ahounahdou, Assozi     |                                                      | Round shape         |
|                                  | Djougouzi              |                                                      |                     |
|                                  | Glazoué zi             |                                                      |                     |
|                                  | Fonkou                 |                                                      |                     |
|                                  |                        | - Semi creeping port                                 |                     |
|                                  |                        | - Sequential flowering                               |                     |
|                                  |                        | - Variegated seed with purple dominance             |                     |
|                                  |                        | - Three seeds per pod                                |                     |
|                                  |                        | - Oblong shape                                       |                     |
|                                  |                        | - Rectangular pod                                     |                     |
|                                  |                        | - Azi green seed                                       |                     |
|                                  |                        | - Azi kogri                                            |                     |
|                                  |                        | - Kogklé                                              |                     |
|                                  |                        | - Gbounboun                                            |                     |
|                                  |                        | - Kounkloklo                                           |                     |
|                                  |                        | - Azi kélé                                              |                     |
|                                  |                        | - Azi Kpéléhoun                                       |                     |
|                                  |                        | - Alospévi                                            |                     |
|                                  |                        | - Alogiivi                                            |                     |
|                                  |                        | - Azi kéléhoun                                         |                     |
|                                  |                        | - Azi allagri                                          |                     |
|                                  |                        | - Rectangular pod                                     |                     |
|                                  |                        | - Brownish pink seed                                  |                     |
|                                  |                        | - Two seeds per pod                                   |                     |
|                                  |                        | - Oblong shape                                         |                     |
|                                  |                        | - Rectangular pod                                     |                     |
|                                  |                        | - Brownish pink seed                                  |                     |
|                                  |                        | - Two to three seeds per pod                          |                     |
|                                  |                        | - Oblong shape                                         |                     |
|                                  |                        | - Rectangular pod                                     |                     |
|                                  |                        | - Brownish pink seed                                  |                     |
|                                  |                        | - Two to three seeds per pod                          |                     |
|                                  |                        | - Oblong shape                                         |                     |
|                                  |                        | - Rectangular pod                                     |                     |
responses) indicated the favourable period for peanut seeds to be attacked by storage insects is from the first month of storage (Fig. 2b). Seed moisture (61.6% of responses), lack of insecticide (24.2%), seed immaturity (7.1%), storage time (5.1%), seed oil content (1.0%), and soil moisture (1.0%) were considered by surveyed producers as factor allowing peanut insect attacks.

Table 4  Constraints of peanut production in the study area

| Constraints          | South (N=153) | Centre (N=49) | Study area (N=202) |
|----------------------|---------------|---------------|-------------------|
| Rodent attacks       | 72.9          | 67.8          | 71.6              |
| Lack of workforce    | 12.9          | -             | 9.6               |
| Field maintenance    | 3.5           | 20.3          | 7.9               |
| Drought              | 2.4           | 8.5           | 3.9               |
| Lack of funding      | 4.1           | 1.7           | 3.5               |
| Poor seed quality    | 1.2           | 1.7           | 1.3               |
| Transhumance         | 1.2           | -             | 0.9               |
| Seed price increases | 1.2           | -             | 0.9               |
| Decrease in yield    | 0.6           | -             | 0.4               |

N: number of interviewed farmers

Management of peanut storage insect pests

To alleviate pest problems in stored peanut, producers use plant biocides and synthetic chemicals. In the study area, only 13.9% of producers reported that they use biocidal plants to control pests. A total of four plants insect repellents or insecticides were mixed with peanut for their protection. These are fruit of pili pili pepper (53.3%), leaves of neem (20.0%), orange peel (20.0%) and leaves of tobacco (6.7%).

Among the surveyed producers, only 11.1% use synthetic chemicals for peanut store protection. Most of the chemicals used are bought in market or in shops selling agricultural products. A total of four products are used by the surveyed producers whose three insecticides and one rodenticide. These are rodenticide (8.4% of producers), LAMBDA super (25.0% of producers), DD force (33.3% of producers) and Sofagrin (33.3% of producers).

Cultural taboos associated with peanut production

For some producers (11.6%), growing peanuts and have a good yield requires some conditions. These are prohibitions and recommendations. Regarding the bans, some producers (0.9%) of Adja ethnic group have indicated that you should

Table 5  Farmers’ perception and knowledge of peanut pests in southern and central Benin

| Pests                          | Local name                                                                 | Favourable Period | Organs attacked | South (%) | Centre (%) | Study area (%) |
|--------------------------------|---------------------------------------------------------------------------|-------------------|-----------------|-----------|------------|----------------|
| Rats                           | Okouté, Adjaka, Afin, Ihaa, Gbédja, glinzi, Ekouté, Edjin, Ador (Fon, Goun, Torri, Aïzo Ouéménou), Awassagbé (Fon, Goun, Torri, Aïzo, Ekoun) | Maturity          | Seeds           | 40.5      | 29.8       | 40.1           |
| Partridge                      | Akpao (Fon), Tikpa, Ehin (Adja) Agonkpata (Torri), Ahoua (Goun), Eyedaba (Fon), Hevi (Fon), Hinsouvo (Fon, Mahi), Yibou (Nago) Asson, Apkaro, Assoclé (Fon, Mahi) | Maturity          | Seeds           | 19.7      | 23.9       | 16.5           |
| Centipede                      | Djivi djivi, Dosso, Hanklo (Torri), Hannoukoun (Goun)                        | Maturity          | Seeds           | 16.9      | 5.1        | 14.9           |
| Rabbit                         | Azoui (Fon, Goun, Torri, Aïzo), Eworo (Nago)                                | Vegetative        | Leaves          | 10.5      | 8.7        | 10.6           |
| Greater cane rats              | Afin (Fon, Goun, Torri, Aïzo), Kokoro (Nago), Awata (Fon), Agbé (Fon)        | Maturity          | Seeds           | 4.5       | 1.4        | 4.1            |
| Red ants                       | Dorizihan (Idaatcha), Etoutou (Nago), Kpoupou (Adja)                        | Maturity          | Seeds           | 3.7       | 4.3        | 4.1            |
| Termite                        | Ehor (Nago), Etoutou (Nago), Kossoukossou (Fon, Goun, Torri, Aïzo), Orgain (Idaatcha) | Maturity          | Seeds           | 1.6       | 8.7        | 3.4            |
| Grasshoppers                   | Boclé (Fon, Goun, Torii, Aïzo), Aboclé (Fon)                                | Vegetative        | Leaves          | 1.4       | 2.2        | 1.7            |
| Caterpillars                   | Wanvou (Fon, Goun, Torii, Aïzo), Kokoro (Nago), Do (Mahi, Fon)              | Maturity          | Seeds           | 0.2       | 5.8        | 1.5            |
| Monkey                         | Ato vovo (Fon, Goun, Torri, Aïzo), Ozii (Fon, Goun, Torri, Aïzo), Kakougokou (Idaatcha) | Maturity          | Seeds           | 0.0       | 5.8        | 1.3            |
| Crickets                       | Gbossaulé (Fon, Goun, Torri, Aïzo), Boclé (Fon, Goun, Torri, Aïzo), Atré (Idaatcha), Cléssou (Mahi, Fon) | Vegetative        | Leaves          | 0.2       | 4.3        | 1.2            |
| Snail                          | Akouété (Fon, Goun, Torri, Aïzo)                                            | Vegetative        | Leaves          | 0.4       | 0.0        | 0.3            |
| Sheep                          | Gbo (Fon, Goun, Torri, Aïzo)                                                | Vegetative        | Leaves          | 0.4       | 0.0        | 0.3            |
not wear shoes in peanut fields. While for some producers of Fon ethnic group, it is prohibited to sow just after sex (2.8%) and expose grains or pods on cement floors (0.9%). For producers belonging Fon, Wéménou, and Goun ethnic groups it is ban to put salt in contact with the seeds (3.2%). Fon, Goun and Tori ethnic group do not allow women during menstruation to approach the seeds or go into the peanut field (2.3%). Other producers of Fon ethnic group recommend that storage be done by postmenopausal women to reduce insect attacks (0.5%), leave 4–6 lines in the field so that the ancestors’ blessings are on their field (0.5%), and pour the hulls on the road for good profitability (1.4%).

**Uses**

Four reasons justified peanut production in the study area. These are the marketing, consumption, processing and soil fertilization. The main reason is marketing followed by consumption in both south and central Benin (Table 7). In southern Benin, soil fertilization justifies peanut production while the main reason of its production in central Benin is processing.

Eight culinary uses of peanuts were identified in the study area. Peanut patty or peanut wafers (21.2% of response), peanut confectionery (17.6%), boiled peanut (14.6%), grilled peanut (14.2%), and peanut donuts (12.4%) were the main culinary uses in the study area. Peanut oil (9.9%), peanut sauce (8.4%), and peanut paste (1.7%) were the less culinary use forms in the study area. Principal component analysis was used to determine the links between culinary habits and the surveyed ethnic groups. The analysis reveals that the first and second components explain 49.8% and 22.2% of the information, respectively. The projection of the different food uses on the two axes shows that the Adja, Aïzo and

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**Table 6** Farmers’ preference criteria of peanut varieties in the study area

| Categories        | Criteria of preference                  | Adja | Fon  | Aïzo  | Goun  | Holli | Idaatcha | Mahi  | Nago  | Ouéménou | Tori  | Total |
|-------------------|----------------------------------------|------|------|-------|-------|-------|----------|-------|-------|----------|-------|-------|
| Agronomics        | Seed size                              | 48.8 | 46.0 | 33.3  | 75.0  | 20.0  | 10.1     | 30.3  | 50.0  | 28.6     | 35.2  |       |
|                   | A lot of pod and seeds per plant       | 7.3  | 27.4 | 66.7  | 25.0  | 80.0  | 30.0     | 33.9  | 24.2  | 50.0     | 42.9  | 29.3  |
|                   | Resistant to diseases and pests        | –    | 3.2  | –     | –     | –     | –        | 5.1   | 15.2  | –        | 7.1   | 4.1   |
|                   | Precocity                              | –    | 0.8  | –     | –     | –     | –        | –     | –     | 0.3      |       |       |
| Economics         | Beauty of grains                       | 9.8  | 11.3 | –     | –     | –     | –        | 13.6  | –     | –        | 14.3  | 6.3   |
|                   | Seed colour                            | 4.0  | 0.8  | –     | –     | –     | –        | –     | –     | –        | –     | 0.6   |
| Culinary          | Production of high amount of oil       | 31.7 | 50.0 | –     | –     | –     | –        | 37.3  | 30.3  | –        | 7.1   | 19.2  |
|                   | Good taste                             | 2.4  | 0.8  | –     | –     | –     | –        | –     | –     | –        | –     | 0.6   |
|                   | Finesse of the seed coat                | 0.0  | 0.0  | –     | –     | –     | –        | –     | –     | –        | –     | 0.3   |

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**Table 7** Importance of the reasons for peanut production in the study area (N=216)

| Reasons for production | South     | Centre    | Study area |
|------------------------|-----------|-----------|------------|
|                        | Number    | Percentage| Number     | Percentage| Number  | Percentage|
| Marketing              | 157       | 73.0      | 50         | 76.9      | 207     | 73.9      |
| Consumption            | 50        | 23.3      | 7          | 10.8      | 57      | 20.4      |
| Processing             | 2         | 0.9       | 7          | 10.8      | 9       | 3.2       |
| Soil fertilization     | 6         | 2.8       | 1          | 1.5       | 7       | 2.5       |
Goun ethnic groups consume peanuts mainly in the boiled form (Fig. 3), while Tori and Wéménou ethnic groups consume peanut mainly in the roasted form. For the Nago and Idaasha ethnic groups, they consume peanuts mainly in the form of pancakes. The consumption of peanuts in the form of sauce and oil is mainly in the Mahi ethnic group. In Fon and Holli ethnic groups, peanuts are eaten, respectively, in the form of dough or donuts.

In the study area, some farmers use the peanut leaves to feed animals such as sheep (77.1%) and rabbits (5.7%). The seeds destroyed by the storage insects are used to feed pigs (5.7%) and chickens (11.5%). Among the surveyed farmers, only 10.2% use the peanut plant in traditional medicine for the treatment of ailments such as malaria (50.0%), to revitalize children (27.3%) and to regulate blood pressure (22.7%). These ailments were treated with a decoction of peanut leaves and shells consumed in the form of herbal tea.

**Discussion**

At the community level, each peanut local variety has a local name by which it is identified as a unit of diversity by farmers. Analysis of the meanings of the vernacular names given to peanut local varieties in the study area confirms the existence of various scenarios (synonymy, and homonymy).
is common to the local nomenclature of many grain legumes in Benin such as cowpea (Gbagueyi et al. 2013), voandzou (Gbagueyi et al. 2015), Kersting groundnut (Assogba et al. 2015), and common beans (Loko et al. 2018). Based on the morphological criteria of peanut seeds, 8 morphotypes were identified corresponding to 54 local names. This shows that there are synonymy problems, which will have to be resolved through agro-morphological and molecular characterizations.

The study revealed the existence of 8 peanut local varieties across the study area. This diversity is found to be very low compared to that found in Bolivia (62 distinct landraces) area of peanut origin (Krapovickas et al. 2009) and higher than those encountered in Togo (4 varieties) (Banla et al. 2018) and Tanzania (8 varieties) (Daudi et al. 2018). The loss of peanut diversity in the study area is not alarming. However, it is urgent to set up a national programme of in situ and ex situ conservation of peanut genetic resources in order to protect the low productivity varieties, which are likely to be abandoned by producers. The villages of the Fon ethnic groups are recommended for the implementation of in situ conservation programmes for peanut varieties. The documented reasons of peanut variety abandonment will orient the breeders to the type of variety to be created. They suggest the creation of high-yielding peanut varieties, which are drought resistant.

Contrary to peanut farmers of Uganda (Okello et al. 2010), Tanzania (Daudi et al. 2018), Ghana (Tanzubil 2016), Niger (Bakoye et al. 2019), Malawi (Tsusaka et al. 2016), and Togo (Banla et al. 2018) for whom insect pests and diseases were the main constraints of peanut production, rodent attacks were perceived by Beninese farmers as the biggest constraint. This perception is shared by Pakistan farmers, who also mentioned rodents as the main constraint for peanut production (Khan et al. 2012a). Adarsh (2016) and Naik et al. (2017) notified that rodents could cause 30–40% of damage to peanut seeds at germination, 6–9% of damage at pod maturation and 4–9% of damage to mature pods besides their hoarding. Several rodent species such as Bandicota bengalensis (Gray), Tatera indica (Hardwicke), Mus booduga (Gray) and Mus melaada (Gray) have been identified in Asia as important pest of peanut (Sridhara and Tripathi 2005). Rats, rabbits and greater cane rats were the most important peanut rodent pests in south and central Benin. For the development of efficient rodent management strategies, it is important to identify rodent species and evaluate their population density in peanut fields.

As peanut farmers in India (Hemendra et al. 2014; Veeraiah et al. 2019) and Malawi (Tsusaka et al. 2016), Beninese farmers mentioned the lack of workforce, lack of funding, and the difficulties related to the maintenance of fields as other important constraints. Indeed, the harvesting and post-harvest operations such as shelling, lifting, and stripping are labour-demanding and time-consuming operations. The conception and dissemination of harvest and post-harvest machines for smallholder farmers configured for local varieties and the existing farm conditions are recommended.

Our study identified the preferred traits important for peanut farmers that will have to be integrated into future breeding programmes. For instance this study showed that peanut seed size, the abundance of pods and seeds per plant and the capacity of the seeds to produce large amount of oil are the most important traits. Peanut farmers in Togo (Banla et al. 2018) and Ethiopia (Abady et al. 2019) also mentioned similar preference criteria. It appears from our results that peanut preferred traits varied among ethnic groups. Those differences in peanut preference traits should be taken into account in any further peanut improvement or varietal introduction programme.

As in Uganda (Okello et al. 2010), Tanzania (Daudi et al. 2018), and Togo (Banla et al. 2018) peanut seed system in southern and central Benin is mostly informal. Most of farmers buy peanut seed in the local market or select their own seed for the next planting. In this context, the seed quality is often of poor quality due to various stresses and poor storage conditions (Ndjeunga et al. 2006). A grouping of peanut producers in a peasant association and a specialization of certain producers in seed production would boost peanut production in southern and central Benin. The government structures such as CARDER (Centre d’action régionale pour le développement rural) were the source of seed supply for few producers. This is probably due to the increased seed prices notified by farmers in the study area. In order to further enhance the performance of the seed sector, a subvention of peanut seed price by the Beninese government is recommended.

Like most producers in Niger (Bakoye et al. 2019) and Senegal (Cisse et al. 2018), peanut is stored mainly in the unshelled form by surveyed farmers. This form of peanut conservation has proven to be an effective approach in reducing insect infestations during storage (Baributsa et al. 2017). In fact, peanut shell can be destroyed by only few insect species (Cisse et al. 2018). This good storage practice should be promoted in the study area. Several peanut conservation tools have been identified in the study area, of which polyethylene bags being the most used. However, their effectiveness against attacks by storage insects is very limited (Fu et al. 2018). Knowing that storing shelled and unshelled groundnuts in hermetic triple layer (Purdue Improved Crop Storage- PICS) bags PICS bags reduce insect pest attacks (Baributsa et al. 2017), the promotion of these storage tools is highly recommended. The surveyed farmers have a good perception of the lifespan of the stored peanut and the appearance of insects in stocks. The grain moisture identified by farmers as the main factor
favouring the attack of storage insects is corroborated by Santos et al. (2016).

In an effort to properly store peanuts, some peanut producers use chemicals that are very dangerous to health and the environment. In fact, the commercial insecticide called DD force used by certain farmers has as active ingredient the dichlorvos, which is an organophosphorus classified as highly toxic by the World Health Organization (WHO 2004). In addition, the commercial insecticide Lambda super used by some farmers is an aberration because it is dedicated to the vegetable crops protection. It is therefore important to find alternatives to the use of chemical pesticides in the protection of groundnut stocks. The use of biocidal plants for stored peanuts protection is an alternative to the use of pesticides and is practised by some peanut producers in the study area. All of the plants used by peanut farmers in the study area for protect stored peanuts against pests have proven insecticidal or repellent properties. Indeed, Allotey and Goswami (1994) demonstrated the insecticidal effect of neem (Azadirachta indica) against Plodia interpunctella (Hubn.) and Ephestia cautella (Wlk.) infesting peanuts. In addition, neem plant extracts have showed a negative impact against Trogoderma granarium Everts, a pest of stored groundnuts (Odeyemi and Ashamo 2016). Aguoru et al. (2015) demonstrated biocidal effect of species of pepper against storage pests of peanut. Tobacco powder significantly affected egg development of Carvedon serratus Olivier, the main pest of stored peanut (Delobel and Malonga 1987). Allotey and Azalekor (2000) showed the impact of orange peel powder on the reduction of population of Corcyra cephalonica Stainton. These biocidal plants must be popularized across the study area.

The cultural taboos associated with peanut production restrict production of peanut to men, because women are not allowed during menstruation to approach the seeds or go into the peanut field. This taboo associated with the female fertility cycle was also observed in South Africa in traditional leafy vegetables production, which has an impact on the availability of labour resources (Vorster et al. 2008). However, some surveyed farmers believed that the presence of postmenopausal women in peanut storage permit to reduce insect attacks. These ambiguous cultural taboos towards women were also observed in Malawi concerning Bambara groundnut production (Forsythe et al. 2015). Similarly to yam production in Nigeria (Obidiegwu and Akpabio 2017), some surveyed farmers believe that peanut productivity is influenced by ancestors. Some farmers prohibited the contact of seeds with salt while some studies showed the insecticidal activity of this inert dust (Golob 1997; Zekarias and Haile 2017). All the taboos related to peanut production must be taken into account in the development of strategies of peanut conservation diversity in southern and central Benin.

Contrary to Botswana where peanut is grown by small-scale farmers exclusively for household consumption (Kassa et al. 2009), in southern and central Benin several uses underpin peanut production. Our results show that the forms of peanut consumption vary according to ethnic groups. Contrary to farmers in Togo (Banla et al. 2018) for whom peanut sauce is one of the most frequent uses encountered in southern and central Benin, peanut wafers locally called “KliuKliu” were the main form of peanut consumption. The variation of peanut culinary forms in the function of ethnic groups must orient the breeder on the quality of the varieties to be created and should be introduced into each ethnic group. For example, farmers of Mahi ethnic group will easily adopt peanut varieties with high oil content.

Peanut is used as fodder for several pets, but mostly for sheep. A study showed that the fodder of peanut varieties is the good quality and permit a good growth of sheep (Khan et al. 2012b). The same authors showed that fodder yield and quality vary significantly in function of the peanut variety. It would therefore be interesting to assess the fodder quality and yield of peanut varieties grown in the southern and central Benin. Thus, peanut breeding programmes could consider fodder yield and quality as criteria of selection.

Some medicinal values were attributed to peanut in the study area. This grain legume is used by surveyed farmers mainly to treat malaria. However, in Southeast Nigeria principally in Enugu State, some people believe that the great groundnut consumption is the cause of malaria (Ndibuagu et al. 2016). It would therefore be interesting to evaluate the effect of peanut infusions on subjects suffering from malaria in order to validate or absolve this use. The bioactive compounds and nutraceuticals in peanuts could explain their use in medicine for the prevention of illnesses such as cardiovascular disease, osteoporosis, and other degenerative diseases (Isanga and Zhang 2007). Peanut can be also used for cancer inhibition (Awd et al. 2000). The peanut plant is used in Nasarawa state of Nigeria as infusion to treat HIV/AIDS opportunistic infections such as gonorrhoea (Borokini et al. 2013). The use by surveyed farmers of peanut to revitalize children and to regulate blood pressure deserves to be investigated.

**Conclusion**

The present work has shown the existence of a variety of peanuts grown in southern and central Benin. These peanut local varieties were designated by local names, which varied through ethnic groups and led to synonymy problems. The seed system remains traditional and the sector is less organized. Peanut production is faced with several constraints and cultural taboos which hinder its production. Faced with these constraints, agricultural research
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References

Abady S, Shimelis H, Janila P (2019) Farmers’ perceived constraints to groundnut production, their variety choice and preferred traits in eastern Ethiopia: implications for drought-tolerance breeding. J Crop Improv. https://doi.org/10.1080/15427528.2019.1625836

Adarsh KK (2016) Estimation of population density of different species of rodents in groundnut. Adv Life Sci 5(6):2356–2365

Adjou ES, Soumanou MM (2013) Efficacité des extraits de plantes contre les moisissures toxinogènes isolées da l’arachide. J Appl Biosci 70:5555–5566

Adjou ES, Yehouenou B, Sossou CM, Soumanou MM, de Souza CA (2012) Occurrence of mycotoxins and associated mycflora in peanut cake product (kulikuli) marketed in Benin. Afr J Biotechnol 11(78):14354–14360

Adomou M, Ntare BR, Williams JH (1997) Stability of pod yields and parameters of a simple physiological model for yield among peanut lines in Northern Benin. Peanut Sci 24:107–112

Aguoru CU, Kombur DS, Olasan JO (2015) Comparative efficacy of different species of pepper (Capsicum spp.) in the control of stored groundnut (Arachis hypogaea L.) damage by pest of groundnut amongst the TIV speaking people of the north central Nigeria. Int J Curr Microbiol Appl Sci 4(3):1018–1023

Alletoy J, Azalekow W (2000) Some aspects of the biology and control using botanicals of the rice moth, Corcyra cephalonica (Stainton), on some pulses. J Stored Prod Res 36(3):235–243. https://doi.org/10.1016/s0022-474x(99)00045-4

Alletoy J, Goswami L (1994) Damage caused to maize and groundnuts by the moths Plodia interpunctella (Hbn.) and Ephesia cautella (Wlk.) and control using local plant materials. Int J Trop Insect Sci 15(03):323–329. https://doi.org/10.17159/1734-75840001763x

Assogba P, Ewedje E-EBK, Dansi A, Loko YL, Adjatia A, Dansi M, Sanni A (2015) Indigenous knowledge and agromorphological evaluation of the minor crop Kersting’s groundnut (Macrotlyloma geocarpum) (Harms) Maréchel et Baudet cultivars of Benin. Genet Resour Crop Evol 63(3):513–529

Awad AB, Chan KC, Downie AC, Fink CS (2000) Peanuts as a source of B-sitosterol, a sterol with anticancer properties. Nutr Cancer 36:238–241

Bakoyo O, Baoua I, Sitou L, Moctar RM, Amadou L, Njoroge AW, Murdock LL, Baributsa D (2019) Groundnut production and storage in the sahel: challenges and opportunities in the Maradi and Zinder Regions of Niger. J Agric Sci 11(4):25–34

Banla EM, Dzdzienyko DK, Beatrice IE, Offei SK, Tongoona P, Desmae H (2018) Groundnut production constraints and farmers’ trait preferences: a pre-breeding study in Togo. J Ethnobiol Ethnomed 14:75. https://doi.org/10.1186/s13002-018-0275-y

Baributsa D, Baoua IB, Bakoyo ON, Amadou L, Murdock LL (2017) PICS bags safely store unshelled and shelled groundnuts in Niger. J Stored Prod Res 72:54–58. https://doi.org/10.1016/j.jspr.2017.03.007

Borokini TI, Ighere DA, Clement M, Ajiboye TO, Alouwonle AA (2013) Ethnobotanical survey of traditional medicine practices in Oyo State. J Med Plants Stud 1(5):1–16

Bucheyeki TL, Shenkalwa EM, Mapunda TX, Matata LW (2008) On-farm evaluation of promising groundnut varieties for adaptation and adoption in Tanzania. Afr J Agric Res 3(8):531–536

Cisse A, Kane A, Souleymane DIA, Sembene M (2018) Evaluation of groundnut (Arachis hypogaea L.) storage methods and Caryedon serratus (Oliver) pest management in the Senegalese groundnut Basin (Fatick, Kaolack and Kaffrine). J Entomol Zool Stud 6(2):307–308

Dansi A, Adoukonou-Sagbadja H, Vodouhe R (2010) Diversity, conservation and related wild species of Fonio millet (Digitaria spp.) in the northwest of Benin. Genet Resour Crop Evol 57(6):827–839

Daudi H, Shimelis H, Laing M, Okori P, Mponda O (2018) Groundnut production constraints, farming systems, and farmer-preferred traits in Tanzania. J Crop Improv. https://doi.org/10.1080/15427528.2018.1531801

Delobel A, Malonga P (1987) Insecticidal properties of six plant materials against Caryedon serratus (OL.) (Coleoptera: Bruchidae). J Stored Prod Res 23(3):173–176

Didagbe OY, Houngnandan P, Dedeheouanou H, Sina H, Bello DO, Toukourou F, Baba ML (2015) Characterization of the peanut production systems in their agroecological regions in Benin. Eur Sci J 11(33):1857–7881

dos Santos F, Medina PF, Lourençã AL, Parisi JJD, de Godoy JI (2016) Damage caused by fungi and insects to stored peanut seeds before processing. Bragantia 75(2):184–192. https://doi.org/10.1590/1678-4499.182
FAO (2018) FAOSTAT database Roma: food and agriculture organization. www.fao.org. Accessed 20 Dec 2019

Forsythe L, Nyamanda M, Mwangwela AM, Bennett B (2015) Beliefs and motivations: a tool for improving agricultural practices in sub-Saharan Africa. Food Agric Low Dev Econ 15(2):109–132. https://doi.org/10.1080/1461706X.2015.1023484

Fu X, Xing S, Xiong H, Min H, Zhu X, He J, Feng J, Mu H (2018) Effects of packaging materials on storage quality of peanut kernels. PLoS ONE 13(3):e0190377. https://doi.org/10.1371/journal.pone.0190377

Gbagnou DI, Aaouzi S, Orobii A, Dansi M, Akouègninou BA, Dansi A (2015) Connaissances endogènes et perceptions paysannes de l'impact des changements climatiques sur la production et la diversité du niébé (Vigna unguiculata (L.) Walp.) et du vunzdrou (Vigna subterrenea (L.) Verdc.) au Bénin. Int J Biol Chem Sci 9(5):2520–2541

Gbagnou DI, Dansi A, Loko LY, Dansi M, Sanni A (2013) Diversity and agronomic performances of the cowpea (Vigna unguiculata Walp.) landraces in Southern Benin. Int Res J Sci Soil Sci 3(4):12113

Golob P (1997) Current status and future perspectives for inert dusts for control of stored product insects. J Stored Prod Res 33(1):69–79. https://doi.org/10.1016/S0022-474X(96)00031-8

Gulluoglu L, Bakal H, Onat B, El Sabagh A, Arioglu H (2016) Characterization of peanut (Arachis hypogaea L.) seed oil and fatty acids composition under different growing season under Mediterranean environment. J Exp Biol Agric Sci 4(5):564–571

Hemendra S, Singh NK, Kardam DK (2014) Economic analysis of peanut hay (Arachis hypogaea L.) as an alternative forage source for sheep. Trop Anim Health Prod 45(3):849–853. https://doi.org/10.1007/s11250-012-0297-8

Khan MT, Khan NA, Bezabih M, Qureshi MS, Rahman A (2012b) The geographical and agronomic performances of the cowpea (Vigna unguiculata Walp.) landraces in Botswana. Euphytica 167:293–301

Kappa MT, Yeboah SO, Beazib M (2009) Profiling peanut (Arachis hypogaea L.) accessions and cultivars for oleic acid and yield in Botswana. Euphytica 167:293–301

Khan AA, Munir S, Hussain I (2012a) Evaluation of in-burrow baiting technique for control of rodents in groundnut crop. Pak J Zool 44(4):1035–1039

Khan MT, Khan NA, Beazib M, Qureshi MS, Rahman A (2012b) The nutritional value of peanut hay (Arachis hypogaea L.) as an alternate forage source for trop. Trop Anim Health Prod 45(3):849–853. https://doi.org/10.1007/s11250-012-0297-8

Krapovickas A, Vanni RO, Pietrarrelli JR, Williams DE, Simpson CE (2009) The peanut landraces from Bolivia. Bonplandia 18(2):95–189

Lim TK (2012) Edible medicinal and non-medicinal plants: fruits, vol 2. Springer Science & Business Media, New York, p 1100

Loko YLE, Toffa J, Adjatin A, Akpo AJ, Orobii A, Dansi A (2018) Local taxonomy and traditional uses of common bean (Phaseolus vulgaris L.) landraces by the sociolinguistic groups in the central region of the Republic of Benin. J Ethnobiol Ethnomed 14:52

Naik MI, Adarsh KK, Hugar SV (2017) Burrow ecology of rodents in and around Groundnut field. J Soil Biol Ecol 37(1):263–280

Ndibuagu EO, Arinze OSU, Igweagu PC (2016) Knowledge of causes and complications of malaria, among residents of a rural community in Enugu state, southeast Nigeria. Int Res J Med Sci 4(11):1–5

Ndjeunga J, Ntare BR, Waliyar F, Ramouch M (2006) Groundnut seed systems in West Africa: current practices, constraints and opportunities. Technical Report. International Crops Research Institute for the Semi-Arid Tropics, Patancheru

Obidiegwu JE, Akpabio EM (2017) The geography of yam cultivation in southern Nigeria: exploring its social meanings and cultural functions. J Ethn Foods 4(1):28–35. https://doi.org/10.1016/j.jef.2017.02.004

Odeyemi AO, Ashamo MO (2016) Efficacy of neem plant (Azadirachta indica) extracts in the control of Trogoderma granarium, a pest of stored groundnuts. J Plant Dis Prot 112:586–593

Okell DO, Biruma M, Deom CM (2010) Overview of groundnuts research in Uganda: past, present and future. Afr J Biotechnol 9(39):6448–6459

Sebei K, Gnounou A, Herchi W, Sakoufi H, Boukhchina S (2013) Lipids, proteins, phenolic composition, antioxidant and antibacterial activities of seeds of peanuts (Arachis hypogaea L.) cultivated in Tunisia. Biol Res 46(3):257–263

Sridhara S, Tripathi RS (2005) Recent trends in coordinated research on rodent control. Rodent Newslett 34:2–4

Tanzubil PB (2016) Incidence of arthropod pests and diseases of groundnut (Arachis hypogaea L.) in Northern Ghana. J Entomol Zool Stud 4(4):29–32

Thiaw C, Gueye S, Gueye A, Samb A, Sembène M (2007) Ovicidal and adulticidal effect of powders and extracts of Calotropis procera AIT. and Senna occidentalis L. on Caryedon serratus (OL.) destroyer of groundnuts stocks. J Sci 7(3):1–15

Tsusaka TW, Mseke HW, Gondwe L, Madzonga O, Clarke S, Siambi M, Okori P (2016) Assessing the post-harvest constraints in smallholders’ groundnut production: a survey in central Malawi. Agric Sci Res J 6(9):213–226

Veeriah A, Shilpakala V, Ramalakshmi Devi S, Ankaiah Kumar K (2019) Constraint analysis of groundnut cultivation in YSR District of Andhra Pradesh, India. Int J Curr Microbiol Appl Sci 8(07):1488–1493

Videga EG, Floquet A, Mongbo RL, Tossou HS, Adjovi G (2016a) Prospects for a geographical indication (GI): evaluation of the willingness to pay (WTP) of two food products: peanut oil (Alognlini) and waters (Khwkwiti) of the agolin areas of Benin. Bus Manag Econ Res 2(3):46–55

Videga EG, Floquet A, Mongbo R, Garba K, Tossou HS, Toukourou F (2016b) Liens à l'origine et qualité spécifique d'un produit de linmi) and wafers (Kwlikwli) of the agonlin areas of Benin. J Food Res J 6(9):213–226

Videga EG, Floquet A, Mongbo R, Garba K, Tossou HS, Toukourou F (2016b) Liens à l'origine et qualité spécifique d'un produit de agoglin. Int Res J Agric Sci Soil Sci 9(5):2520–2541

Videga EG, Floquet A, Mongbo R, Garba K, Tossou HS, Toukourou F (2016b) Liens à l'origine et qualité spécifique d’un produit de la artisanat agroalimentaire du Bénin—le kluiklui d’Alogonl. Cah Agric 25:35003

Vorster HJ, Stevens JB, Steyn GJ (2008) Production systems of traditional leafy vegetables: challenges for research and extension. S Afr Tydskr Landbouvoort/S Afr J Agric Ext 37:85–96

World Health Organization [WHO] (2005) The WHO recommended classification of pesticides by hazard and guidelines to classification: 2004. World Health Organization, Geneva

Zahran HA, Tawfeuk HZ (2019) Physicochemical properties of new peanut (Arachis hypogaea L.) varieties. OCL 26(19):1–7

Zekarias E, Haile A (2017) Effect of some botanicals and table salt against Zabrotes subfasciatus (Coleoptera: Bruchidae) on stored field pea (Pisum sativum L.). grain. Int J Crop Sci 38(01):16–25. https://doi.org/10.1017/S17427584170000194