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# Socio-Economic Values and Ecological Importance of *Balanites aegyptiaca* (L.) Del. in Sahelian Agrosystems in western Niger

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**Abstract**

*Balanites aegyptiaca* contributes strongly to the resilience of Sahelian populations. All the organs of *B. aegyptiaca* are used either for food, medicinal purposes or for other services. However, very few studies on the socioeconomic importance of *B. aegyptiaca* have been conducted in Niger. The main objective of this study was to valorize the knowledge of the populations on the uses of *B. aegyptiaca* in the Sudan-Sahelian agrosystems of Niger. The study was conducted in the Dosso region. The region was chosen based on its two main agro-climatic zones, characterized by the scarcity of the species in the south and its abundance in the north. A survey was carried out in February 2021 to assess the diversity of uses. The findings revealed that the uses of *B. aegyptiaca* products are very diversified and varied considerably accross agro-ecological zones. The types of use varied significantly among ethnic groups. The Hausa possessed 88.26% of the use, the Zarma 14.47%, the Peulh 2.63%, the Songhai 1.32%, and Touareg 1.32%. All parts of *B. aegyptiaca* are used in traditional pharmacopoeia to threat various human and animal illnesses. 68.00% of respondents reported the interaction between Balanites and crops as very beneficial. *B. aegyptiaca* is prone to a variety of threats. Hence, 97.30% of respondents acknowledged the existence of several diseases and/or insect pests that affect Balanites' organs. Given the importance of this species in the region, more research is required to quantify its contribution to rural household food security and resilience.

**Keywords**: *Balanites aegyptiaca*, socio-economic values, ethnobotany, agro-climatic zones, Niger

## 1. Introduction

*Balanites aegyptiaca is a* species that thrives in the Sahelian and Sudanian zone, particularly in areas where annual rainfall is between 300 and 500 mm (Kimba, 2014). Owing to its plasticity, it can grow even with an annual rainfall between 150 mm to more than 1000 mm. The tree therefore has a wide ecological range (Kimba, 2014). *B. aegyptiaca* is a deciduous plant with variable foliage, sometimes behaving as evergreen (bearing green leaves all year round), other times, or on other sites, as long- or short-leaved deciduous, when placed in extreme conditions (Hiernaux et al., 1994).

Several studies have reported the socio-economic importance of the desert date palm (Zida, 2009 ; Noubissié Tchiagam et al., 2011 ; Abdoulaye et al., 2017). *B. aegyptiaca* is the tree whose all organs are used either for food, medicinal purposes or for works services. Various parts of the tree have been used in folk medicine in many parts of Africa and Asia (Kipkore et al., 2014; Mohamed et al., 2002, 2000). Anti-appetant, anti-diabetic, molluscicidal, anthelmintic and contraceptive activities have been revealed in various Balanites extracts (Kamel et al., 1991; Liu & Nakanis, 1982). Bark and root extracts of *B. aegyptiaca* are laxative (Sereme et al., 2008). *B. aegyptiaca* showed a hypoglycaemic effect on rats studied in the laboratory comparable to the action of metformin (Al-thobaiti & Zeid, 2019). *B. aegyptiaca* extracts contain good antibacterial activity, which can be used in the treatment of various infectious diseases (Jahan et al., 2013). The economic activities about the products of the tree concern mainly the marketing of fruits, seeds, and wood, which constitute a definite socio-economic interest for the populations, especially for women (Abdoulaye et al., 2017). In addition, the oil extracted from the kernels is an edible oil used to prepare sauces (Abdoulaye et al., 2017; Kimba, 2014) and can be produced without any prior expenses for rural populations (Avakoudjo et al., 2013). Furthermore, *B. aegyptiaca* produces a very rich fodder for animals, which particularly appreciate the fruits and young shoots (Noubissié Tchiagam et al., 2011; Abdoulaye et al., 2017). It is particularly resistant to drought (Chevallier et al., 2003; Dao, 1993; Klorane, 2012; Sagna et al., 2014; Zida, 2009).

*B. aegyptiaca* litter improves the physical and chemical properties of the soil by increasing water availability under the canopy (Chambers, 2001). They also increase species diversity (Diallo et al., 2016; Doallo et al., 2015) providing the herbaceous biomass with a microclimate, thus protecting the soil from direct radiation and high temperatures (Lopez-Pintor et al., 2000). The carbon sequestration capacity of *B. aegyptiaca* parks can contribute to climate change mitigation (Adamou, 2020).

However, despite its multiple services, very few studies have been conducted on the socio-economic importance of *B. aegyptiaca* in Niger. Thus, the overall objective of this study was to enhance the current knowledge of rural populations on the uses of *B. aegyptiaca* products in the Sudan-Sahelian agrosystems of Niger. Specifically, the study aimed to: (1) identify the uses of *B. aegyptiaca* organs, (2) identify *B. aegyptiaca* - crop interactions and, (3) identify the types of attacks on *B. aegyptiaca*.

## 2. Methods

### *2.1 Study Area and Target Population*

The study area covered two agro-climatic zones of the Dosso region, the Sudanian zone and the Sudano-Sahelian zone. Four departments including Gaya, Dosso, Tibiri and Dogon Doutchi of the Dosso region were selected to conduct the survey. The survey targeted a category of populations carrying out one or more socio-professional activities related to *B. aegyptiaca*. These populations are endowed with a know-how that helped us to collect the data. The Dosso region abounds in various types of ecosystems (classified forest, savannah, dallols, Sudanian and Sahelian agrosystems). The Dosso region was chosen on the basis of its two major agro-climatic zones characterised by the rarity of the Balanites species in the south and its abundance in the north in order to compare the different uses of Balanites. In Dosso, Tibiri and Dogon-Doutchi, three villages from the same commune were selected for data collection while in the department of Gaya, due to the unavailability of *B. aegyptiaca* resources, three villages from three different communes were selected (Figure 1).

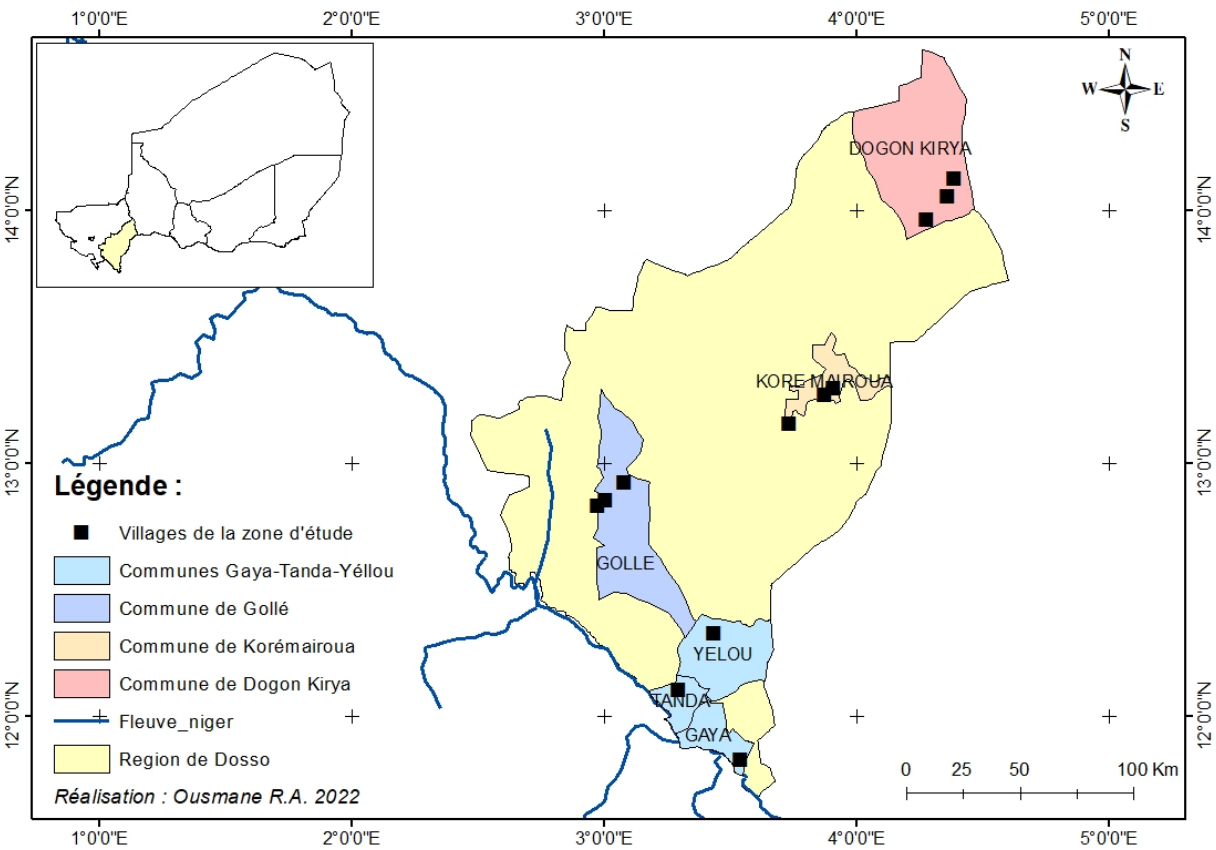


Figure 1. Study area

*2.2 Data Collection*

The survey was conducted in February 2021. It concerned people whose activities include: picking, selling fruit, traditional medicine, handicrafts and processing of wood products (fruit). A questionnaire that provided information on the identity of the site and the respondents, parts of *B. aegyptiaca* used including the processing of the fruits (oil extraction and soap making), the interaction between *B. aegyptiaca* and rainfed crops, and the diseases and pests of *B. aegyptiaca* was used. In each department, a commune was selected and from each commune, three villages were chosen to conduct the interviews. A quota-oriented sampling technique was used. Ten volunteers with professional activities related to *B. aegyptiaca* were identified and interviewed in each village, allowing us to gather relevant information from the local population. If the target number of interviewees could not be reached, the number of available volunteers would be used. In the study area, a total of seventy-six volunteers were interviewed.

*2.3 Data Analysis and Processing*

The frequencies of the modalities of the qualitative parameters including, socio-demographic characteristics of respondents, processing of the fruits, sale of *B. aegyptiaca* products, interaction between *B. aegyptiaca* and rainfed crops, diseases and pests affecting *B. aegyptiaca*, were determined using the following formula:

$$f = \frac{ni}{n} * 100 \quad \text{----------(1)}$$

*ni* = number of occurrences of a modality; *n* = total number.

The frequency of use of *B. aegyptiaca* products according to agro-climatic zones was calculated using the abovementioned formula (1). A Hierarchical Ascending Classification (HAC) was used to classify and characterise the respondents according to the different uses of *B. aegyptiaca*. The different uses of *B. aegyptiaca* organs identified during data collection were processed to highlight the frequencies of citation. A Discriminant Factorial Analysis (DFA) was used to discriminate *B. aegyptiaca* use groups by grouping variables: climatic zone and ethnicity. The analysis was carried out using "candisc" package of R 3.6.0 Software.

## 3. Results

*3.1 Socio-Demographic Characteristics of Respondents*

The distribution of respondents according to socio-demographic parameters is shown in Table 1. The results showed that 72.37% of the respondents were men and 27.63% were women. The respondents are divided into three age groups: young people under thirty-five years old (8.22%), adults between thirty-five and sixty years old (47.95%), and elderly over sixty years old (43.84%). The ethnic groups identified during these surveys are: Hausa (79.22%), Zarma (14.29%), Songhai (2.60%), Peulh (2.60%) and Touareg (1.30%) with the socio-professional activities indicated in Table 1. The respondents were gatherers (61.33%), handicrafts workers (17.33%), traditional practitioners (14.67%), fruit salers (2.67%), and women processors (4%).

Table 1. Socio-demographic characteristics of respondents in the Dosso region

| Status of respondents | Quote | Frequency (%) |
|---|---|---|
| **Department** | | |
| Gaya | 19 | 25.00 |
| Dosso | 5 | 6.58 |
| Tibiri | 24 | 31.58 |
| Dogon_Doutchi | 28 | 36.84 |
| **Gender** | | |
| Female | 21 | 27.63 |
| Male | 55 | 72.37 |
| **Age group** | | |
| < 35 | 6 | 8.22 |
| 35-60 | 35 | 47.95 |
| > 60 | 32 | 43.84 |
| **Ethnicity** | | |
| Hausa | 61 | 79.00 |
| Peulh | 2 | 3.00 |
| Songhai | 2 | 3.00 |

| | | |
|---|---|---|
| Tuareg | 1 | 1.00 |
| Zarma | 11 | 14.00 |
| **Profession** | | |
| Handicrafts | 13 | 17.33 |
| Picking | 46 | 61.33 |
| Traditional medicine | 11 | 14.67 |
| Resale of fruit | 2 | 2.67 |
| Transformation | 3 | 4.00 |

*3.2 Use of B. aegyptiaca Products*

The proportions of use of Balanites products by agro-climatic zone are 25% for the Sudanian zone and 75% for the Sudano-Sahelian zone. These proportions of use by ethnic group are 80.26% for the Hausa, 14.47% for the Zarma, 2.63% for the Peulh and 1.32% each for the Songhai and Tuareg.

Table 2. Frequency of use of Balanites products by agro-climatic zone and ethnic group

| **Use by agro-climatic zone** | **Quote** | **Frequency (%)** |
|---|---|---|
| Sudanese | 19 | 25% |
| Sudanese-Sahelian | 57 | 75% |
| **Use by ethnicity** | | |
| Hausa | 61 | 80.26% |
| Zarma | 11 | 14.47% |
| Peulh | 2 | 2.63% |
| Songhai | 1 | 1.32% |
| Tuareg | 1 | 1.32% |

3.2.1 Use of *B. aegyptiaca* Products According to Agro-Climatic Zones and Ethnicity

The results from the Discriminant Factorial Analysis about the use of different parts of *B. aegyptiaca* according to ethnic groups and agro-climatic zones (Figure 2) show a considerably different distribution of the respondents per zone (Figure 2a), and between the Hausa ethnic group and the other ethnic groups (Peulh, Zarma, Touareg and Songhaï) (Figure 2b). The area is the most discriminating criterion.

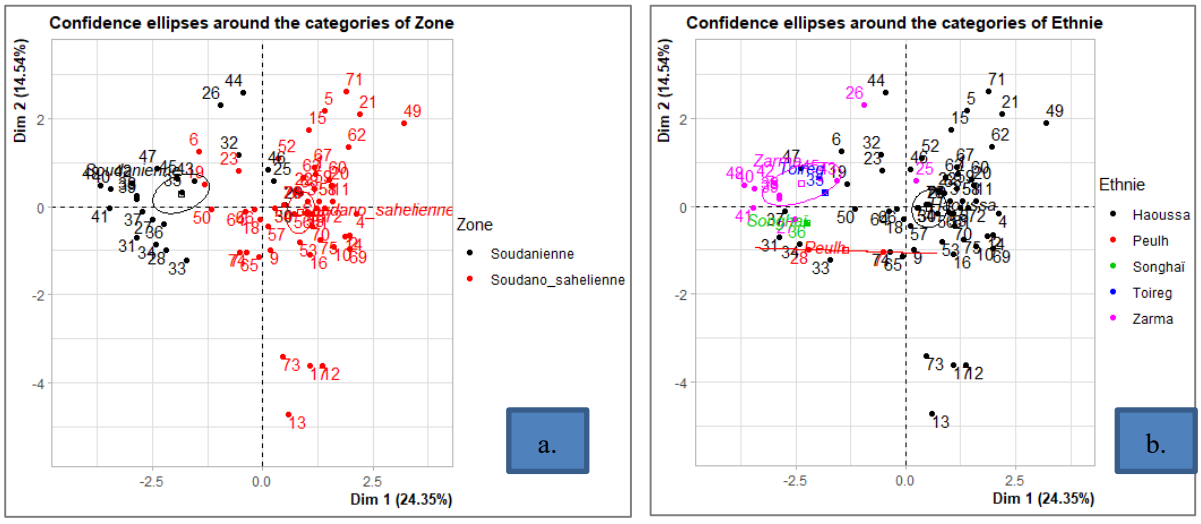


Figure 2. Uses of *B. aegyptiaca* products by area (a) and ethnicity (b)

3.2.2 Use Group of *B. aegyptiaca* Products

The Hierarchical Ascending Classification produced two groups of respondents who can be distinguished according to the types of use of *B. aegyptiaca* products (Figure 3). The first group (G1) is essentially Sudano-

Sahelian, composed of 50 respondents, mainly from Hausa ethnic group. The second group (G2) is Sudanese and consists of 26 respondents who are mainly of the Hausa and Zarma ethnic groups.

Description of Group 1

(Sudano-Sahelian group with *Hausa* as main ethnic group)

The Sudano-Sahelian group is marked by the highest frequency of use of Balanites products (Figure 3). Certain uses such as: cosmetic use of the fruits (3.95%) and roots (5.26%), energetic use of the bark (1.32%), medicinal use of the brandillae (3.95%), use of the trunks in masonry (7.89%) and fertilisation of the soil (5.26%) by piling up the thorns and brandillae on the clay armouring are specific to this group. 48.68% of the respondents in this group said they were aware of the processing of *B. aegyptiaca* fruits into paste, juice or cooking oil. For human consumption, three types of organs are used: leaves, flowers and fruits of *B. aegyptiaca*, which are used by the respondents at frequencies of 11.84%, 65.79%, and 64.47%, respectively. Leaves are mainly collected for animal feeding. This activity is practised by 56.58% of respondents in group 1. The most used organs for handicraft products (dabas handles, hoe and hilar handles, sticks etc.) by group 1 are stems (52.63%), trunks (40.79%), roots (11.84%), and branches (10.53%). For commercial uses, group 1 includes the following uses: flowers (19.74%), fruits (28.95%), stems (25%), and trunks (31.58%). The oil from the kernels of *B. aegyptiaca* is used as an ointment and the cake from these kernels is used for making soaps. The bark and roots are used to make macerations for skin care by 10.53% of respondents in this group. Energy use mainly concerns firewood used to prepare food. The most used organs are: branches (48.68%), trunks (44.74%), and stems (44.74%). For gardening (agronomic parks), branches are used exclusively to make enclosures (13.16% of respondents). Furniture uses mainly concern daily-used tools such as chairs or beds. The most used organs are: stems (14.47%) and trunks (7.89%). As for masonry use, all parts are used in construction. The most important used organ is the stem, which is used as a crossbeam for houses by 26.32% of respondents. Traditional medicine is one of the most important activities for treating illnesses in rural areas. The organs used by the respondents in this group are mainly bark (52.67%), fruit (23.68%), roots (23.68%), thorns (23.68%), and leaves (9.21%).

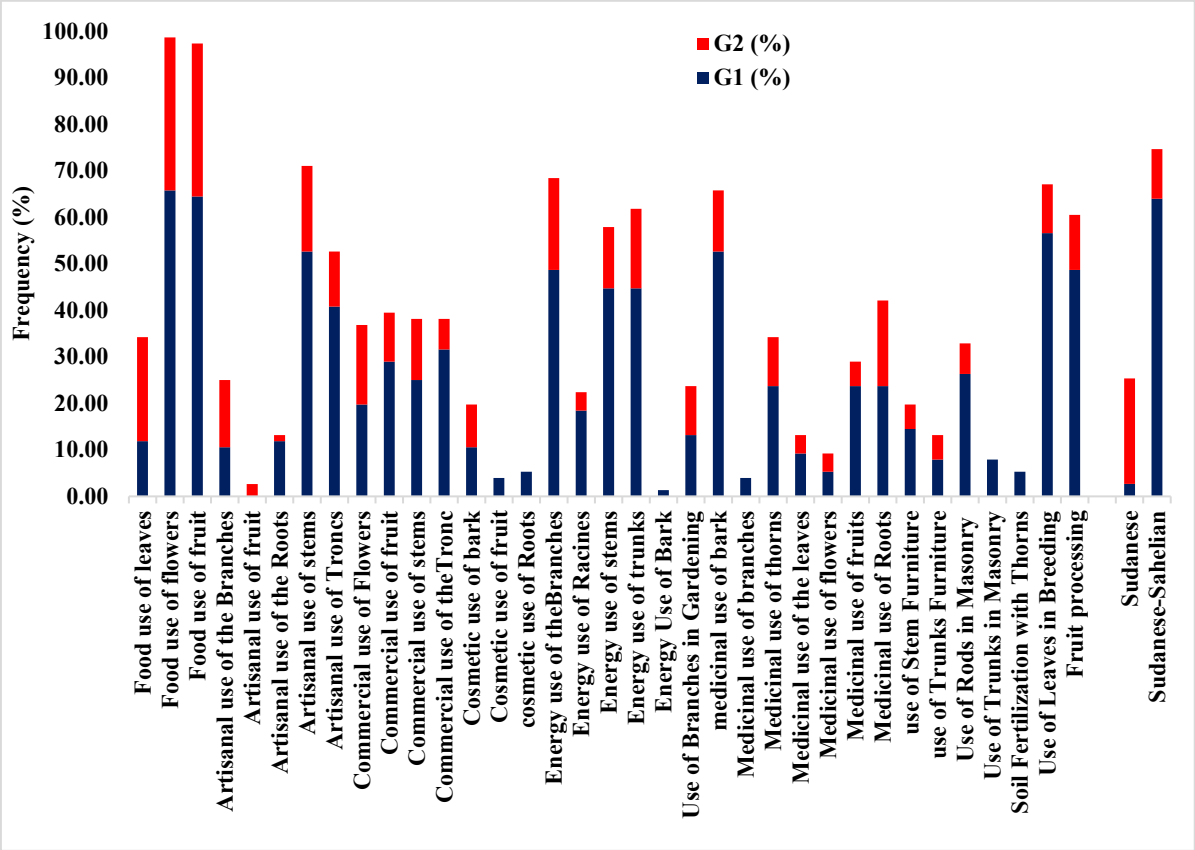


Figure 3. Frequency of use of *B. aegyptiaca* organs according to the two groups. (*G1=Group1 and G2=Group2*).

Description of Group 2

(Sudanese group with *Hausa* and *Zarma* as main ethnic groups)

The Sudanian group is marked by the lowest frequency of use of *B. aegyptiaca* products (Figure 3). This group is characterised by the artisanal use of fruits (2.63%). This group uses the special tiny and round fruit of some Balanites plants to make rosaries. 11.84% of the respondents in this group confirm that they process Balanites fruits into paste, juice or cooking oil. Three types of organs are used for human consumption: leaves, flowers and fruits, which are used by the respondents in this group at frequencies of 22.37%, 32.89%, and 32.89%, respectively. The dry leaves are mainly collected for feed. This activity is practised by 10.53% of the respondents. The most commonly used organs to make handicraft tools (dabas handles, hoe and coaming handles, sticks) by this group are stems (18.42%), trunks (11.84%), roots (1.42%), and branches (14.47%). For commercial use, the Sudanese group uses flowers (17.11%), fruits (10.53%), stems (13.16%), and trunks (9.21%). The use of bark in cosmetics is practised by 9.21% of the respondents. The organs used as firewood are mainly branches (17.74%), trunks (17.11%), stems (13.16%), and roots (3.95%). For gardening, 10.53% of respondents use branches to make animal pens and agronomic parks. Furniture uses mainly concern tools made from organs such as: stems (6.58%) and trunks (5.26%). Stem is the most commonly used organ in masonry (6.58% of respondents). To treat diseases in the farming environment, the organs used by the respondents in this group are: bark (13.16%), fruit (5.26%), roots (18.42%), thorns (10.53%), and leaves (3.95%).

*3.3 Processing of B. aegyptiaca Fruits*

*B. aegyptiaca* fruits are processed into several by-products for the needs of the population. Sixty-two percent (62%) of the respondents confirmed that *B. aegyptiaca* fruits are processed into several products (Figure 4a). Of these respondents, 74% reported processing the fruit into paste, 17% into oil, 8% into soap, and 2% into juice (Figure 4b).

3.3.1 *B. aegyptiaca* Oil

According to Fatchima Yacouba, president of women processors association of wood products, the steps of oil extraction from *B. aegyptiaca* oil consist of:

- Soaking the fruit overnight to wash, dry and peel the kernels;
- Toasting the almonds ;
- Crushing these almonds in a mortar and sieve (or grind them in a mill);
- Puting the almond flour back into the mortar and pestle, adding diluted tamarind or sorrel juice to break up the harsh taste of the almonds.

Then, the oil extraction could start a few moments later. From 2kg of the kernels, it is possible to extract more or less one litre of oil.

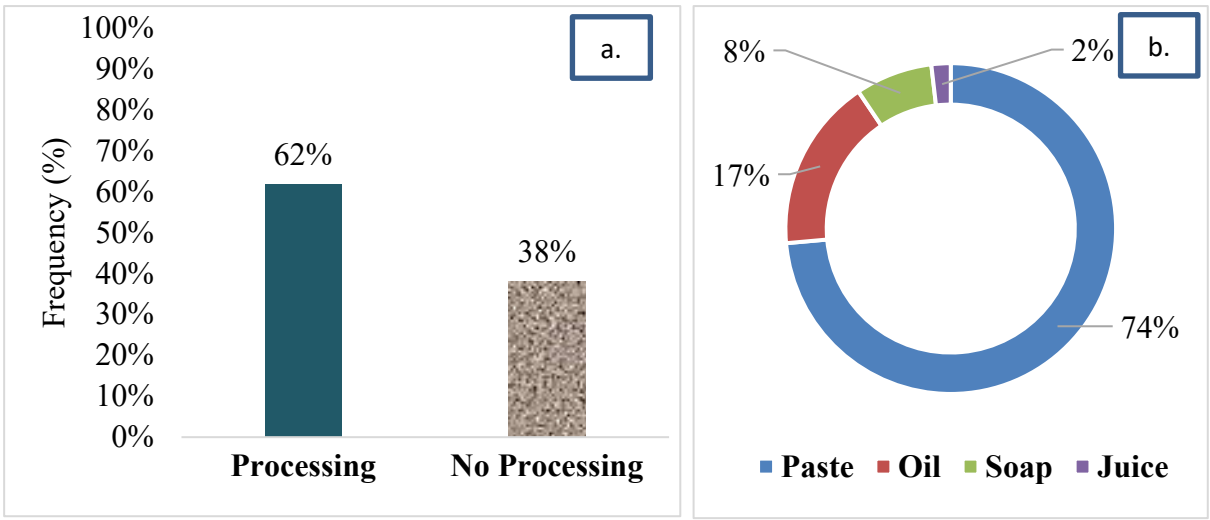


Figure 4. Processing of *B. aegyptiaca* fruits by local people

3.3.2 Soap Made from *B. aegyptiaca* Cake

The result of an interview with Akka Rabo, member of the women's association for the transformation of forest products in Dogon Kirya, who had been trained in Aguié (Maradi) revealed that, the process of making soap from *B. aegyptiaca* is as follows:

- After the extraction of Balanites oil, a residue (cake) remains which is dried in the sun.
- The cake is then dried and pounded (or more easily, ground into meal using a mill) to make use of half of its meal (as an example).
- The rest of the ingredients needed to make the soap are: water in a container, caustic soda in a bottle, and oil from the market (4 litres).
- After completing the soap making process, the final step is to shape the soap using a mould of your choice.

*3.4 Sale of B. aegyptiaca Products*

The organs of *B. aegyptiaca* used for commercial service are flowers (37%), fruits (39%), crossbeam (38%), and trunks (38%) (Figure 5a). The market price of fruits varies according to the quantity produced per season and the availability of these resources (Figure 5b). Indeed, 86.36% of the respondents confirmed that the price of *B. aegyptiaca* fruit varies according to the season and 13.64% of respondents said that the price of fruit remains uniform. According to the respondents, fruit is cheaper at harvest time and becomes expensive when it is scarce on the market.

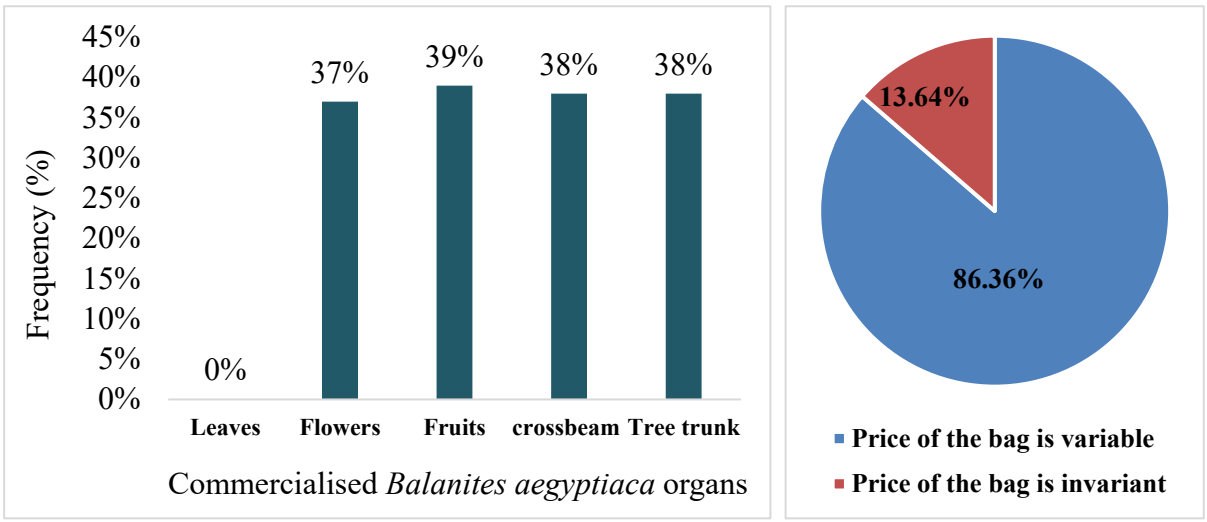


Figure 5. Commercially available organs of *B. aegyptiaca*

*B. aegyptiaca* products provide a significant amount of money to the population through activities such as: the sale of flowers, fruits, charcoal, firewood, and other items made from wood.

Table 3. Prices of *B. aegyptiaca* products.

| Price of tools (in FCFA) | Min | Average | Max | Standard Error |
|---|---|---|---|---|
| 27 kg Bag of flowers (*Dubagara*) | 1750 | 6348.21 | 10500 | 609.52 |
| Bag of 70-80 kg fruits | 2500 | 7307.43 | 10500 | 231.59 |
| 2 kg of Fruits measurement | 100 | 239.19 | 500 | 8.59 |
| 2 kg Coal measurement | 200 | 200 | 200 | 0 |
| Handle of the sowing daba | 1000 | 1000 | 1000 | 0 |
| Pestle | 500 | 750 | 1000 | 96.23 |
| Traverse (Shed and kitchen) | 500 | 1000 | 1500 | 353.55 |
| Hoe handle | 500 | 666.67 | 750 | 64.15 |
| Daba handle | 500 | 650.00 | 750 | 50.00 |
| Coaming handle | 1000 | 1083.33 | 1250 | 64.15 |
| Mortar | 5000 | 9062.5 | 12000 | 513.76 |

| | | | | |
|---|---|---|---|---|
| Wooden spatula | 750 | 875 | 1000 | 88.39 |
| Chair | 1000 | 1000 | 1000 | 0 |
| Spoon | 100 | 100 | 100 | 0 |
| Slate | 600 | 800 | 1000 | 141.42 |
| Bundle of wood | 750 | 750 | 750 | 0 |
| Dough (one ladle) | 50 | 50 | 50 | 0 |

3.5 Use of *B. aegyptiaca* organs in traditional medicine

*B. aegyptiaca* is an emergency plant for the health care of farmers. The plant is widely used in traditional medicine to cure various diseases. Twenty-two diseases (Appendix B: Table B1) were identified as being treated by *B. aegyptiaca* products, through various concentrations of active ingredients in its different organs. The most frequently cited diseases are: wounds (25.64%), haemorrhoids (19.23%), jaundice (11.54%), stomach ache (6.41%), and syphilis/gonococca (5.13%). The most used organs in the treatment of diseases are: barks (66%), roots (42%), and thorns (34%). The least used organs are: branches (4%) and flowers (9%) (Figure 6).

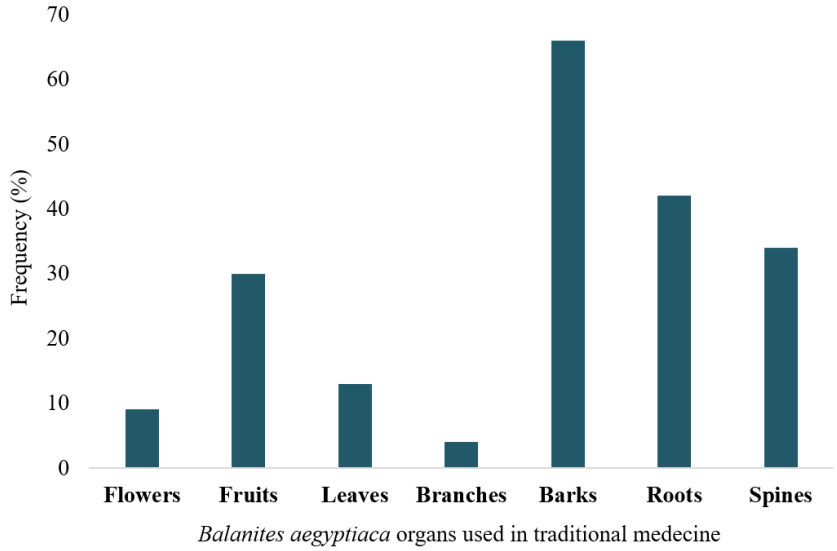


Figure 6. *Balanites aegyptiaca* organs used in traditional medicine

*3.6 Interaction with Crops and Threats from B. aegyptiaca*

Information on the quality of *B. aegyptiaca* interactions with rainfed crops (millet, sorghum) and those relating to the presence or absence of diseases or pests are recorded in Table 4. The interactions between *B. aegyptiaca* and crops were declared favourable by 68.42% of the respondents and unfavourable by 22.37% of the respondents. Nevertheless, some respondents (9.21%) thought that there were no significant interactions between rainfed crops and *B. aegyptiaca*. Regarding pests, 97.37% of the respondents said that they negatively impacted the development of *B. aegyptiaca*. Attacks are mainly directed at fruits and leaves but rarely at wood. However, 2.63% of the respondents claimed that they were not aware of any attacks or diseases related to *B. aegyptiaca*.

Table 4. *B. aegyptiaca* - rainfed crop interactions and pest attack

| | Quote | Frequency (%) |
|---|---|---|
| **Interactions** | | |
| Positive | 52 | 68.42 |
| Negative | 17 | 22.37 |
| No response | 7 | 9.21 |
| **Diseases / Pests** | | |
| Absence | 2 | 2.63 |
| Presence | 74 | 97.37 |

The main forms of attack recorded on *B. aegyptiaca* fruits and leaves are shown in Figure 7. The most frequent attacks are from insects (37%) and their larvae (46%) on the leaves. Some forms of attacks were also recorded on fruits by bat-bats (13%) and birds (4%).

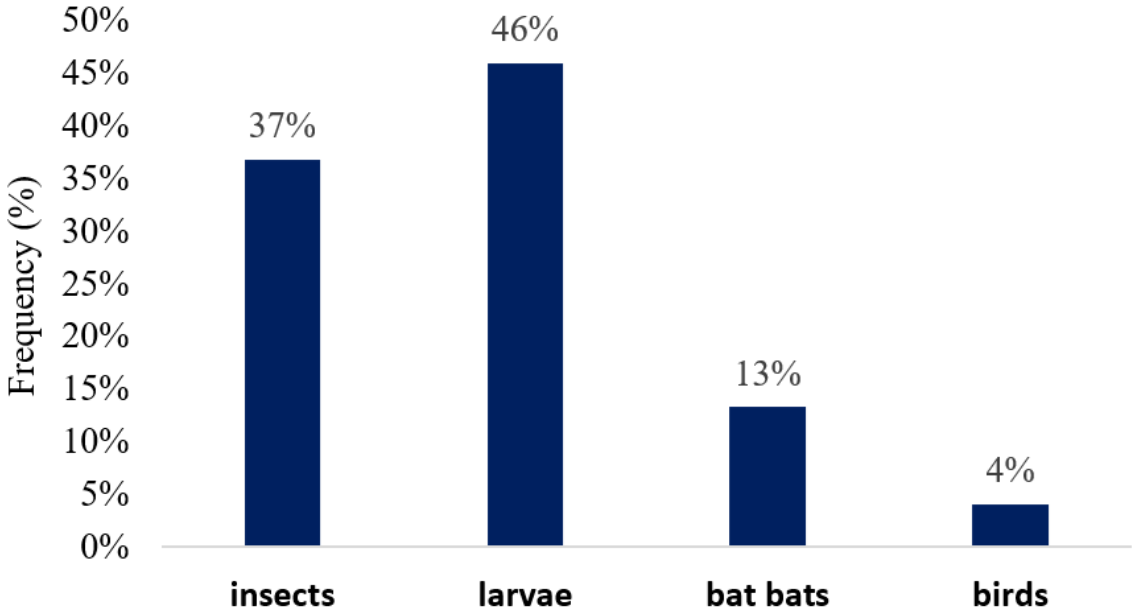


Figure 7. Pests affecting *B. aegyptiaca* production

## 4. Discussion

### *4.1 Socio-Demographic Characteristics of Respondents*

The majority of respondents were men 72% compared to 28% of women. This difference could be due to other socio-professional activities occupied by women such as the sale of henna, wood, and Moringa (Harouna et al., 2019).

### *4.2 Uses of Different Organs of B. aegyptiaca*

#### 4.2.1 Food uses of Fruits and Leaves of *B. aegyptiaca*

The uses of *B. aegyptiaca* products vary greatly from the Sudanian zone to the Sudano-Sahelian zone. The Sudanian zone is mainly composed of respondents from the Hausa and Zarma ethnic groups, while the Sudano-Sahelian zone is mainly composed of respondents from the Haussa ethnic group. Flowers, leaves, and fruits are commonly consumed in the study area. Kirikoshi (2017) states that *B. aegyptiaca* is mainly a food for the lean season. Almost all the respondents stated that they consume the flowers as vegetables and the fruits by sucking and sometimes as juice or paste in their daily diet. The fruits of *B. aegyptiaca are* highly valued by the population for many reasons: food, medicinal, commercial, and craft. The majority of people consume the fruits fully ripe, which was also reported by Adamou et al. (2020), Abdoulaye et al. (2017), and Kirikoshi (2017). Some respondents, particularly women and teenagers, cook immature fruits in order to make them edible. Some people even add a pinch of salt to make the food more appetizing. This practice gives the fruit the appearance of olive fruits. The collection of immatures, young fruits hinders the development and dissemination of *B. aegyptiaca* in the area (Adamou, 2020; Doamba, 2012). Young leaves are commonly mixed with flowers to prepare a special salad known as *Doubagara* in Hausa and Zarma. Besides, the population gathers and dries flowers putting them in bags to either conserve or sell at nearby or regional markets. This practice was also found in Burkina Faso (Zida, 2009) and Tillabérie in Niger (Adamou, 2020).

Livestock is a vital component of the rural economy (CNEDD, 2009). In the study area, livestock is mostly composed of goats and sheep, which have a strong appetite for fresh or dried *B. aegyptiaca* leaves and ripe fruits. The dried Balanites leaves are particularly collected to feed animals. These results corroborate those reported by Adamou (2020) in the Tillabérie region of Niger. Consistently, Kaboré-Zoungrana et al. (2008) revealed that *B. aegyptiaca* leaves are a potential source of nitrogenous matter and mineral elements. However, according to these authors, *B. aegyptiaca* has a high calcium content (55g/kg dry matter) and a low phosphorus content (3g/kg dry matter) (Kaboré-Zoungrana et al., 2008).

4.2.2 Processing and Sale of *B. aegyptiaca* Products

The organs of *B. aegyptiaca* are used in various manufactures. The very small kernels are used to make rosaries. Branches, stems, and roots are used to make handles: dabas, hoes and hilars. The trunks are used to make mortar and slates for Koranic studies. These various tools allow the craftsmen to generate income to meet the daily needs of their families and the users to have tools that facilitate their work (Creac'h, 1940; Adamou, 2020; Habou et al., 2020). In the Dosso region, *B. aegyptiaca* fruits are either transformed into pasta (associated with millet or sorghum) during the lean season (using the seed or pulp), juice (using the pulp), oil (using the seed) or soap using the cakes after oil extraction. This activity is one of the most promising on the market for generating incomes (up to 2500 FCFA per litre). Various non-governmental organisations and associations offer free trainings to women to help them become financially independent (as is the case in Dogon Kirya (Dogon Doutchi)). The majority of respondents do not sell *B. aegyptiaca* flowers and fruits, even though these organs are easily accessible and highly profitable as they are highly valued by the population.

4.2.3 Energetic and Cosmetic use of *B. aegyptiaca* Organs

For energy needs, people use branches, stems, bark, trunks, and even roots as firewood. In cosmetics, fruits are particularly used to produce skin care substances, such as the oil used as an ointment and the cake from which women make soaps with significant skin care benefits (Africajou, 2016; Lacasetik, 2020; Oléo-Sine, 2016; Tiétiambou et al., 2015). In addition, *B. aegyptica* oil can be used as a biofuel for diesel engines (Amadou, 2007; Barkat & Sebrani, 2021; Boukar, 2014).

4.2.4 *Balanites aegyptiaca* in Traditional Medicine

*B. aegyptiaca* is used in traditional medicine to treat human and animal diseases. The bark, roots, spines, and fruits are the main organs commonly used by traditional healers and the rest of the population., It was previously reported In Burkina Faso that barks are the most commonly organs used in traditional medicine (Zida, 2009) unlike in Tillabérie, where it is rather the leaves that are predominantly used (Adamou, 2020). In this study, twenty-two diseases have been identified as treated with *B. aegyptiaca* products. Wounds, haemorrhoids, jaundice, stomach ache, and syphilis/gonococca are the most frequently mentioned. These results are in line with those reported by Adamou (2020) in the Tillabérie region, where sores, haemorrhoids, and stomach ache were the most cited. Furthermore, wounds and hemorrhoids were also reported as the most frequently treated diseases in a similar study conducted by Habou et al (2020) in South-East Niger (Zinder region, Damagaram Takaya). These differences could be attributed to different populations' knowledge of traditional medicine or to the fact that certain diseases are rare in some geographical areas.

*4.3 Interaction with Crops and B. aegyptiaca Threats*

The interaction between Balanites and crops is very favourable according to most of the respondents. They report very good cereal yields around *B. aegyptiaca* plants due to the decomposition of organic matter into compost which is beneficial to all other plants. Tahar (2008), reported that millet grain yields under *B. aegyptiaca* were higher than those obtained under other trees and the control plot. However, the observations on the negative impact of Balanites on crops are always mentioned in the absence of agroecological practices. Also, over the years, the soil becomes denuded in the vicinity of *B. aegyptiaca*, making it difficult to use because of the change in soil texture caused by the gum produced by the tree. Similarly, the presence of urine from animals that graze or rest under the tree of *B. aegyptiaca* would produce the same effect. According to other respondents, cereals that grow under *B. aegyptiaca* trees encounter several obstacles at heading stage. The ears that reach the tree branches are pecked by the birds that nest on *B. aegyptiaca* and the surrounding trees, this is not the case for cowpea for example. Others explain that the constraint on cereal production is due to the shading caused by *B. aegyptiaca* trees.

The respondents confirm the existence of diseases and pests hindering *B. aegyptiaca* growth and dissemination. The main pests include insects and their larvae, as well as bats and birds. Dramé Yaye et al. (2021) studied the diversity of insect pests of *B. aegyptiaca* (8 orders, 27 families, and 43 species of insects) and found that most of the orders such as: Coleoptera, Lepidoptera, Orthoptera, and Heteroptera are polyphagous insects that attack several plant species. The most important threat is from insects that completely destroy the fruits and limit the reproduction and dissemination of *B. aegyptiaca*. However, it should be noted that most of the insects visit *B. aegyptiaca* at flowering stage, which is very beneficial to the plant for its reproduction. These results are in line with those of Ndoye et al. (2004) who also found that Hymenoptera, Diptera, and Coleoptera are the orders of insect pollinators of *B. aegyptiaca*.

## 5. Conclusion

The study was conducted in the Dosso region, which has two agro-climatic zones: the Sudanian zone in the south and the Sudan-Sahel zone in the north. *B. aegyptiaca* is very useful to the local population and to the population of the big cities from where the products of this plant are transported and sold, thus contributing to the resilience of the rural populations. The uses of *B. aegyptiaca* products are very diverse. *B. aegyptiaca* is effectively used in traditional medicine to treat various human and animal diseases. The wood of *B. aegyptiaca is* much appreciated for its use in energy and manufacture of farming tools. The interaction of Balanites and associated plants in rainfed agriculture is very beneficial as it improves the growth and yield of these associated crops. However, *B. aegyptiaca* development and dissemination are hindered by numerous pests. Currently, in the study area, Balanites trees are well protected both by environmental preservation agents and agroforestry parks owners who regularly prevent cuting of these trees, which are becoming increasingly rare. These findings confirmed also the wide range of knowledge about the uses of *B. aegyptiaca* products in western Niger. Given the importance of this plant in the region, further studies are needed to assess its contribution to rural household food security and resilience.

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**Appendix A**

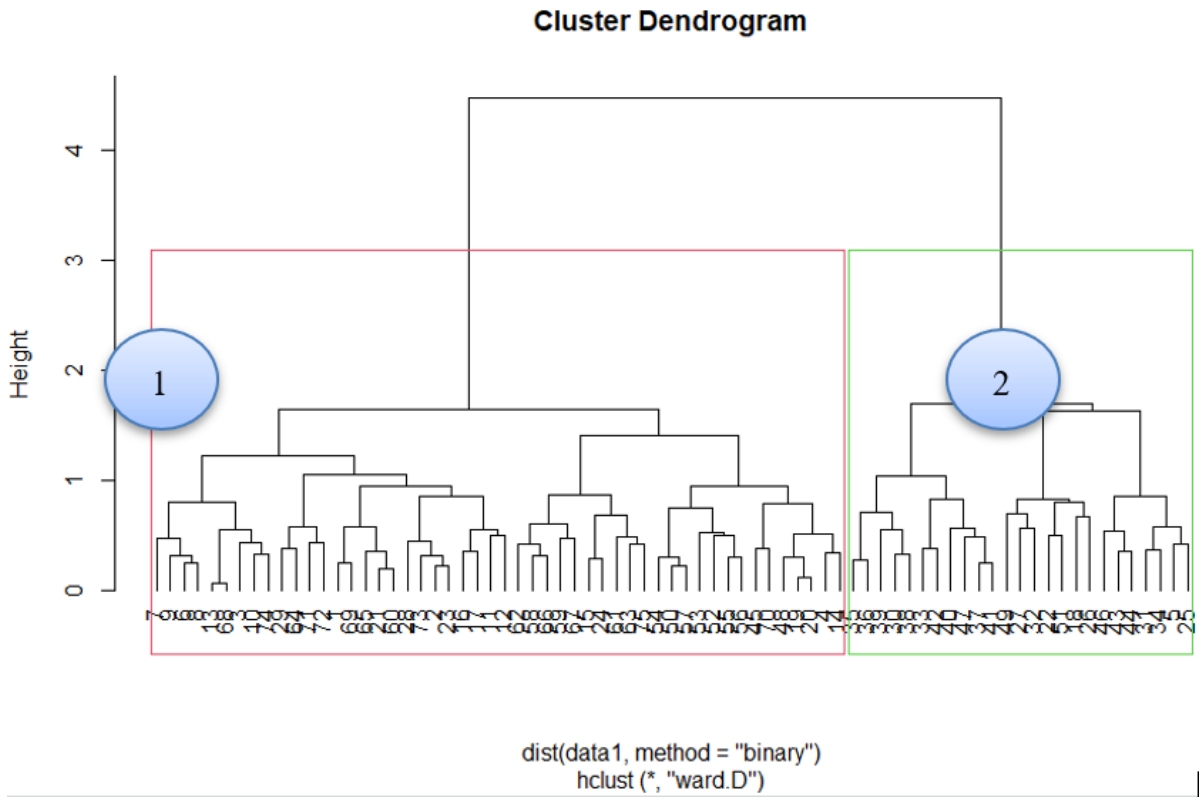


Figure A1. Group of respondents based on Balanites use

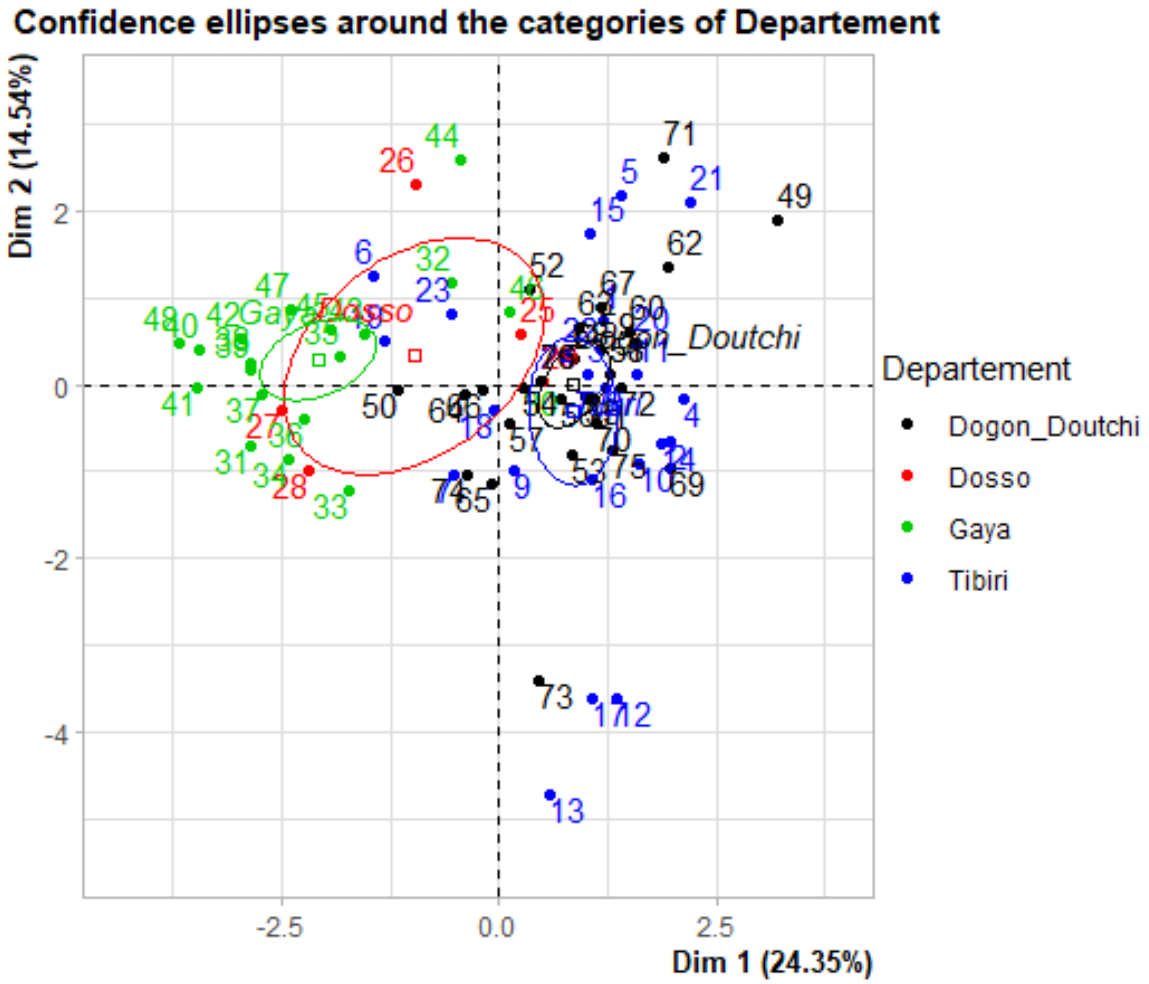


Figure A2. Discrimination of uses of *B. aegyptiaca* products according to departments in the study area

**Appendix B**

*Diseases treated with the organs of B. aegyptiaca*

The different forms of preparation used for treatment are decoction, maceration and fumigation. The most common mode of administration is orally and by skin application.

Table B1. Diseases and treatment with *B. aegyptiaca* products

| N° | Diseases | Preparation of the treatment | Quote | Frequency (%) |
|---|---|---|---|---|
| 1 | Jaundice | Decoction with the dry yellow leaves or bark of *B. aegyptiaca*. | 9 | 11,54% |
| | | Flour of the bark *B. aegyptiaca* + *Acacia nilotica* and spike of purple millet. To be eaten in porridge. | | |
| 2 | Hemorrhoid | Make a maceration of *B. aegyptiaca* bark + *Combretum nigricans* bark + traditional ancestral soap. | 15 | 19,23% |
| | | Decoction with leaves, bark of *B. aegyptiaca* and *Faidherbia albida* | | |
| | | Decoction of *B. aegyptiaca* roots + [*Datura inoxia*, *Grewia flavescens*, *Ximenia americana*, *Gardinia sokotensis*, *Prosopus africana* bark + *Senna siberiana* root]. | | |
| | | *B. aegyptiaca* flowers eat like legume. | | |
| 3 | *Animal tumour* | Fumigation of the flowers. | 1 | 1,28% |
| 4 | Bellyache | Flour from the bark of *B. aegyptiaca* with another plant (kept secret). | 5 | 6,41% |
| | | Make a maceration of the crushed raw Balanites flowers. | | |
| 5 | Ulcer | Flour of *B. aegyptiaca* leaves + millet seeds + red natron. | 3 | 3,85% |

| N° | Diseases | Preparation of the treatment | Quote | Frequency (%) |
|---|---|---|---|---|
| | | Bark decoction | | |
| 6 | Constipation | A spoonful of the flour from the bark. | 1 | 1,28% |
| 7 | Pests | Sucking on the fruit in the morning. | 1 | 1,28% |
| 8 | Syphilis/Gonococcus | Decoction with *B. aegyptiaca* bark + bark of other plants (kept secret). | 4 | 5,13% |
| | | Root of *B. aegyptiaca* towards the East + red natron and boil the mixture. | | |
| 9 | Colds | Sucking the fruits of *B. aegyptiaca* | 1 | 1,28% |
| 10 | Wound | Toast the seeds, rub them against a clean stone to extract the oily paste which heals wounds by application. Can be applied to the lips and the feet when it is cold. | 20 | 25,64% |
| | | Hand pain/wounding: crush the leaves of *B. aegyptiaca* and make a paste to apply by hand. | | |
| | | Flour from the bark and leaves of *B. aegyptiaca* cleans wounds. | | |
| 11 | Headache (*Jiri* in Hausa) | Flour from the bark of *B. aegyptiaca* with other plants (kept secret). | 2 | 2,56% |
| | | Toast the seeds and apply their paste (oil) to the head. | | |
| 12 | Blood pressure | Leaves of *B. aegyptiaca.* | 1 | 1,28% |
| 13 | Pain in the airways | Maceration with *B. aegyptiaca* leaf powder. | 1 | 1,28% |
| 14 | Vision problems | Toast the small branches, which will give off a kind of reddish, greasy liquid. Apply this liquid to the eye to correct the vision problem. | 1 | 1,28% |
| 15 | Scorpion bite | Toothpick from the bark of *B. aegyptiaca* treats scorpion bites. | 1 | 1,28% |
| 16 | Snake bite | Maceration with *B. aegyptiaca* bark. | 1 | 1,28% |
| 17 | Skin infection | Wash with the decoction of *B. aegyptiaca* roots. | 2 | 2,56% |
| | | To treat a newborn's navel: burn the bark of Balanites and then apply it to the navel. | | |
| 18 | Itching | Flour of the *B. aegyptiaca* bark to consume into the (millet) porridge. | 2 | 2,56% |
| | | Bark of (*B. aegyptiaca* + *Sclerocaria birrea* and *Albizzia chevalieli*). | | |
| 19 | Hip pain | Make a decoction of *B. aegyptiaca* bark with saline natron (*Balma* in local language). | 1 | 1,28% |
| 20 | Breast disease | Flour of *B. aegyptiaca* bark and consume it into (millet) porridge once a day. | 1 | 1,28% |
| 21 | Newborn constipation | Maceration with *B. aegyptiaca* bark. To given to the breastfeeding mother. | 1 | 1,28% |
| 22 | Earache | Decoction with *B. aegyptiaca* bark and apply to the ear once cooled. | 1 | 1,28% |