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Ethnoveterinary study of galactogenic recipes used by ruminant breeders to improve milk production of local cows in Benin Republic

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ABSTRACT

Ethnopharmacological relevance: In Benin, traditional recipes are used to improve livestock dairy performance, but they are not sufficient documented. The study aimed to inventory the galactogenic recipes used by herders to improve production in cow farming.

Aim of the study: The study aimed to inventory the galactogenic recipes used by herders to improve production in cow farming.

Material and methods: We conducted semi-structured interviews among 65 peuls camps, 4 bioclimatic zones, and 565 farmers dialogue partners, including agro-pastoralist, healers and pastoralists from the rainy season April and May 2019. Detailed information about homemade herbal remedies of galactogenic recipes (plant species, plant part, manufacturing process) and the corresponding use reports (dialogue partner, category of use and route of administration) was collected. Then other to classify the various recipes identified into homogeneneous groups according to their effectiveness in stimulating milk, a numerical classification was carried out on the recipes taking into account the milk gain.

Results: They showed that Peuls and Gandos sociocultural groups have a better knowledge of galactogenic recipes. Of the 295 recipes inventoried, 102 frequently cited recipes were divided into two groups. Group 2, consisting of 16 recipes, had a significantly ($p < 0.001$) higher milk yield than group 1. *Vigna unguiculata* (L.) Walp. and *Arachis hypogaea* L. were the main ingredients of the recipes (respectively 56 and 31% of incorporation rate). The composition of the recipes varied according to the agro-ecological zones. Herders in Northern Benin used more recipes based on *Bobgunnia madagascariensis* (Harms) J.H.Kirkbr. & Wiersema, *Saba comorensis* (Bojer ex A. DC.) Pichon and *Euphorbia balsamifera* Aiton. Those in Southern Benin mainly used recipes based on *Gardenia aqualla* associated with *Vigna unguiculata* (L.) Walp or *Arachis hypogaea* L.. To improve the effectiveness of galactogenic recipes, socio-cultural and magical-religious practices are used when procuring the plant material to be used, preparing the galactogen and administering the recipe to the animals. These include pronounced incantations or recited Koranic verses. The most commonly used route of administration is the oral route with an average treatment duration not exceeding 5 days.

Conclusion: The study reveals that the majority of breeders (90%) opt for the use of galactogenic plants rather than synthetic products to improve milk production.

1. Introduction

Health, well-being and economic growth are important in the overall development of a people (Mafimisebi and Oguntade, 2010). Africans, even in urban areas, often supplement the care they receive in clinics and hospitals with care from traditional healers (World Health

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Organization, 2002; Fasola et al., 2011). Traditional medicine is an important part of health care (Nunkoo and Mahomoodally, 2012; Sayeed et al., 2017). The use of plants to relieve ailments and diseases is a very old practice (Samouh et al., 2019). According to the World Health Organization (WHO), more than 80% of the world's population resort to the use of plant extracts or their active components (World Health Organization, 2001; 2003). In recent years, ethno-veterinary studies have been carried out in Africa, Asia and America and it emerges from these studies that in developing countries, animal health care is often based on the use of homemade preparations because access Western veterinary products is difficult and too expensive for agro-pastoralists (Nyamanga et al., 2008). Benin is no exception to this rule. Many studies (Dassou et al., 2014; Dassou et al., 2015; Houndje et al., 2016) focuss on it.

Indeed, the persistence of conflicts between farmers and herders, which leads to difficult access to pastures due to anthropogenic pressures (Lesse, 2011; Lesse et al., 2015; Zakari et al., 2015; Toko et al., 2016), the low genetic productivity of cattle whose production does not exceed on average 2L/day per cattle (Kassa et al.,2016). Faced with this situation, promising strategies have been put in place by integrating the exotic Girolando breeds to improve the milk production of local cattle in Benin. Despite these efforts for decades, the objectives of agro-breeders on the performance of animals, especially in milk, remain insufficient. However, milk in the peasant environment and especially in Fulani creates employment for women and generates significant income for households, hence the need for ruminant breeders and agro-breeders to find urgent and easy-to-adopt solutions; including the use of endogenous knowledge to improve milk production in cows. Several studies have been carried out on the endogenous knowledge used in the Fulani environment and recently, the work of Dassou et al. (2020) has shown that certain medicinal plants are used by the Fulani communities to treat animal diseases. It appears from the study that plants such as *Annona senegalensis* Pers., *Saba comorensis* (Boj.) Pichon, *Calotropis procera* (Aiton) WTAiton, *Adansonia digitata* L., *Anogeissus leiocarpa* (DC.) Guill. & Perr., Euphorbia unispina NEBr., Sorghum bicolor (L.) Moench, Vitellaria paradoxa CFGaertn., *Khaya senegalensis* (Desr.) A.Juss., *Prosopis africana* (GuilI. & Perr.) Taub., *Afzelia africana* Sm. and *Pterocarpus erinaceus* Poir., have antiviral, antimicrobial and antiparasitic properties. Subsequently, many of its species have already been studied in the sub-region and these have shown that these species and many others of the Beninese flora are used to induce or improve milk production women than ruminants (Koko et al., 2011; Akouedegni et al., 2012; Dassou et al., 2014; Salifou et al., 2017). But so far, no study has been seriously invested in testing the effectiveness of presumed galactogenic recipes by traditional breeders or in evaluating the action of these plants on the mechanism of milk secretion. In addition, the effects of these galactogenic preparations on milk yield in dairy ruminants, the minimum improving dose of milk production as well as the galenic form best suited to the socio-economic conditions of traditional breeders are all unknown phenomena. This knowledge is however necessary in order to improve the use of galactogenic recipes, to stimulate or increase milk production and perpetuate endogenous practices. To do this, it is specifically useful to identify the recipes used by breeders for improving milk production to identify the components entering into galactogenic preparations and the recipes presumed the best in milk yield according to these traditional breeders.

2. Material and methods

2.1. Study environment

This study was carried out in Benin in the departments of Atacora, Alibori, Borgou, and Zou between 6°15′ and 12°25′ North latitude and 0°40′ and 3°45′ East longitude. In southern Benin, the climate is Guinean characterized by two rainy seasons and two dry seasons: a long rainy season (March–July) followed by a short dry season (July–September); a short rainy season (September–October) followed by a long dry season (November–March). In northern Benin, the climate and vegetation are of the Sudano-Sahelian type with a rainy season (May–October) and a dry season (November–April). Rainfall varies between 700 and 1200 mm. The Fulani camps visited for this study are shown in Fig. 1. Several reasons motivated the choice of the above-mentioned zones, namely: the frequency of studies carried out by authors such as Adjanohoun (1989), Akouègninou et al. (2006), Koko et al. (2011), Djègo et al. (2011) and Dossou et al. (2012) on medicinal plants, as well as those used by traditional healers to improve milk production within lactating women. It is proven that these areas constitute floristic reserves because of the proximity of forests and water resources, the existence of watercourses and fodder reserves for livestock feed, the diversity of sociolinguistic groups, due to the availability of arable land and proximity to large markets for the sale of agricultural products, and the difficult access of the populations to synthetic medicines.

2.2. Pre-survey on the identification of dialogue partners

A pre-survey was carried out in February 2019 to inform the population about the study project following the methodology of snowball (Disler et al., 2014). Therefore, different methods were used to identify dialogue partners. As a first step, a letter containing detailed information on the study project was sent to the departmental management of livestock in the survey areas. Subsequently, a large population of pastoralists was informed about the research during the vaccination campaigns. In addition, the research project was presented during a meeting with the president of the National Association of Professional Organizations of Ruminant Breeders (ANOPER-Benin) in the presence of some representatives of breeders from each study area (Fig. 2).

2.3. Investigation proper

The ethno-veterinary survey was carried out at the start of the rainy season (April and May 2019) with 565 people (men and women) by snowball sampling. The number of respondents was determined on the basis of the importance of the practice of cattle breeding and according to the agro-climatic zone. Thus, the distribution was made as follows: 222 breeders in Alibori (39%); 227 breeders in Borgou (41%); 86 breeders in Atacora (16%), 21 breeders in Zou (4%) (Fig. 2). The surveys were carried out in 65 Fulani camps and 9 municipalities in the agro-climatic zones surveyed. The respondents were chosen with the help of officials from the Territorial Agency for Agricultural Development (ATDA) and District Heads according to the criteria defined by Eynden and Damme (1993) namely: availability and habit of working with livestock agents, celebrity in the practice of traditional medicine; the reputation or popularity of the village in traditional medicine; the exclusive or majority use of plant or natural products in the healing process. To these criteria is added another defined by Dassou et al. (2020) which is the high concentration of animals during the period of investigation. All people with an age range of 25 years–80 years having knowledge of the endogenous practices used to induce or improve milk production were taken into account. Data was collected through face-to-face interviews with users using semi-structured questionnaires.

2.4. Questionnaires and quantification of milk production after use of formulas

A total of 565 structured and semi-structured interviews were conducted by the first author (AZ) over seven weeks using questionnaires in cattle markets, on the rangelands with the herdsmen and the Fulani camps. They were carried out in French in the presence of a Peulh translator who masters both languages very well and the breeding technician of the area. The duration of each interview was 1 h to 2 h and the report was made on the consent of the respondents. The aspects on which the interview was made were as follows: the profile of the respondents (surnames; first names; sex; age; marital status; origin; level

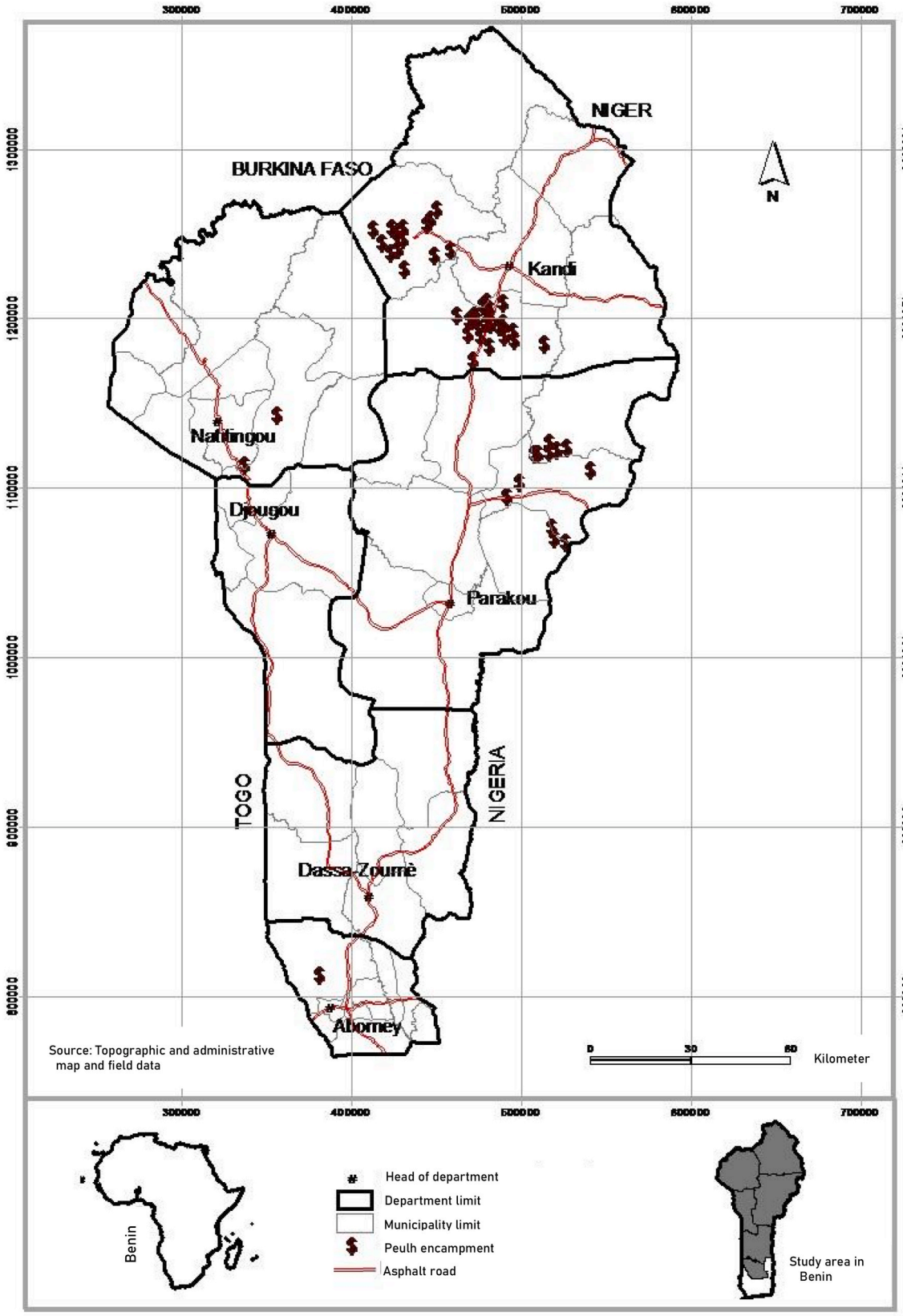
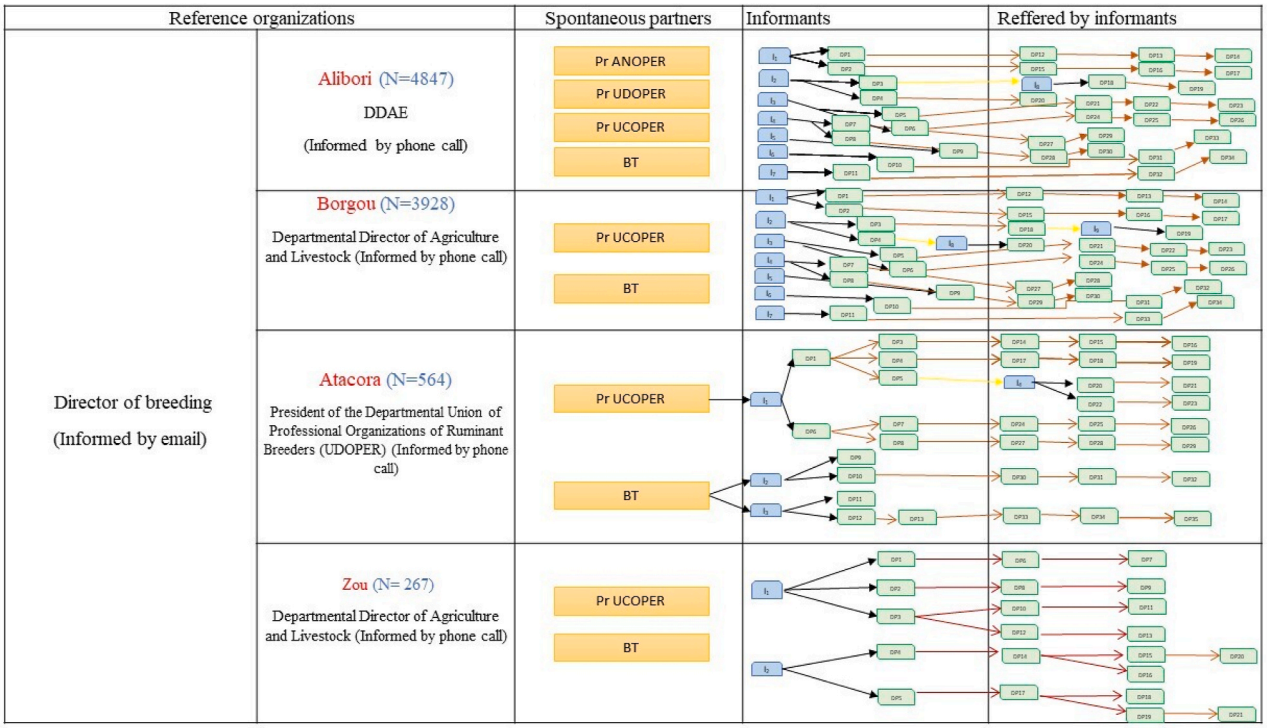


Fig. 1. Study area mapping.



N = population size ; Pr = President ; ANOPER = National Association of Professional Organizations of Ruminant Breeders ; UCOPER = Communal Union of Professional Organizations of Ruminant Breeders ; UDOPER = Departmental Union of Professional Organizations of Ruminant Breeders ; BT = Breeding technicians; I = Informant ; DP = Dialogue partner.

Fig. 2. Snowball sampling.

of education; seniority in the area; socio-cultural group and religion to which they belong and whether or not endogenous practices are used to improve the milk production of cows in their herds); if so, the local names of the different ingredients used in the preparation of galactogenic recipes, the organs of each plant, the method of using the recipes, the processing time, the ideal time of day for the administration of the preparations, the routes administration depending on whether it is internal (oral, intravaginal/intrauterine administration) or external (application to the skin); the milk yield following the use of these recipes the side effects that can produce the misuse of each ingredient and even the preparation; knowledge on the use of veterinary products to improve milk production and finally anthropogenic issues related to the use of each plant species or recipe. These data were recorded on KoBocollect version 2018 software. For each recipe cited, the quantities of preparations administered and the quantity of milk produced per animal were evaluated material (Salifou et al., 2017). The equipment used is a graduated cylinder with a capacity of 2 L and a precision of 10 ml. The technique consists in simulating with the water in the test tube, the quantities of preparations administered and of milk produced per day per animal. The respondents poured water into the graduated cylinder to simulate the quantity of milk before and after administration of galactogenic preparations. The difference of the two values gives the milk gain. The technique consists in simulating with the water in the test tube, the quantities of preparations administered and of milk produced per day per animal. The respondents poured water into the graduated cylinder to simulate the quantity of milk before and after administration of galactogenic recipes. The difference of the two values gives the milk gain.

Finally, the methodology proposed for the Tramil group in Caribbean Tramil 4 and used by Déléké-Koko et al., 2011 and Fagbohoun et al. (2014) was taken into account for more analyses. This method considers recipes that have been mentioned by multiple dialogue partners. In this study, recipes that were mentioned by at least five dialogue partners at different levels were considered.

2.5. Identification of plant specimens

The plant species mentioned during the interviews were look for with the help of the respondents. For each species, the spatial positions were determined using a GPS (Global Positioning System). Images and samples were taken from those available during the investigation period following the method of (Koko et al., 2011). This method consists of harvesting entirely, with flowers and fruits if possible. For trees and shrubs, a leafy twig with flowers and fruits is cut. The harvesting of a fragment of bark is often necessary to facilitate identification. When the samples are too long (example: Poaceae from savannahs), the fructified parts, the upper leaves and the lower leaves as well as the characteristic fragments of the roots are harvested. The delicate flowers are spread at harvest time between two pieces of damp paper. Aquatic species were collected in mass on wet paper. At the time of harvest, the date of harvest, the locality, the station (savannah, forest, meadow …), the color of the flowers, and if possible, the common name is listed; a number is then assigned to each sample. Some samples were determined in the field using Arbonnier (2002) and the Flore analytique in Benin (Akouègninou et al., 2006). It was not possible to collect all the herbarium reference specimens during the interviews, as they were carried out at the end of the drought. However, collection was only possible in September 2019 out of a total of 50 herbarium reference specimens in 7 different municipalities out of the nine surveyed. The specimens were dried, labeled and deposited in the botanical and zoological gardens of the University of Abomey-Calavi. The identification of other plant species was made at the national herbarium of Benin.

2.6. Statistical analysis

2.6.1. Galactogenic recipes

A galactogenic recipe was defined as a description of a preparation from a dialogue partner (breeder) containing one or more plants, parts of plants or other natural compounds more or less transformed into a finished product: [Dialogue partner] × [Plant species or other natural compounds] × [parts used] × [method of manufacture of the preparation].

2.6.2. Usage report (UR)

The list of species has been established. The botanical nomenclature used is that of Akouègninou et al. (2006) then confirmed on the site www.plantlist. To categorize the respondents, the age classes proposed by Assogbadjo et al. (2008) were used and are presented as follows: young people (23–29 years old); adults (30–59 years old); old people (60–72 years old).

Finally, in order to classify the various recipes identified into homogeneous groups according to their effectiveness in stimulating milk, a numerical classification was carried out on the recipes taking into account the milk gain. This classification presented in the form of a dendrogram was carried out using SAS v 9.2 software, taking into account the coefficient of determination $R^2 = 50\%$ (Sossa et al., 2014; Dah-Nouvlessounon et al., 2015). The groups obtained from this numerical classification were subjected to an analysis of variance followed by the 5% Student Newman Keuls test (Dagnelie, 1973) in order to identify the group of recipes inducing better milk production.

3. Results

3.1. Socio-professional characteristics of respondents

The survey on endogenous recipes used by traditional herders to improve milk production revealed that 93.6 percent of the respondents were male compared to 6.4 percent female (Table 1). The practice of using galactogenic recipes to improve milk production was much more prevalent among the Fulani (64.2% of respondents) than among other ethnic groups. Adults using galactogenic recipes were in the majority (57.7%) and are mostly illiterate. Very few of them had reached secondary school (5.6%). Agro-pastoralists were much more common in the Alibori and Borgou departments.

3.2. Endogenous knowledge of breeders on the efficiency and use of galactogenic plants to increase milk production

In the departments where the survey was carried out, breeders (92.2%) acknowledged that the acquisition of galactogenic knowledge is passed on from father to son, from one lineage to another in such a way that the secret does not cross family or tribe boundaries. For example, each family or tribe has plants that it uses to stimulate milk production. Concerning the prediction of the efficacy of a galactogenic recipe efficacy, breeders (73.4%) had admitted that they base their prediction on the colour and presentation of the supernatant of the preparation, which had a foamy appearance after homogenisation. Oral administration of the preparations was mostly done 48 h after calving if the animal did not produce enough milk.

3.3. Receipes galactognics reports and frequencly of agro-ecological zones

The results of the interviews showed that out of the 565 interviews, 295 reports of galactogenic recipes for a total of 119 plant species belonging to 41 families were mentioned by the dialogue partners (Supplementary data). More than 84% of reports of galactogenic remedies have been found in northern Benin (Atacora, Borgou and Alibori). The plant species involved in constituting the galactogenic recipes ranged from 2 to 7 with an average of 4 plant species freshly harvested from the wild for each report of homemade galactogenic remedy. Other ingredients (salt, sugar, monitor lizard or hedgehog fat and potash) from primary processing could be added to the heart of recipe preparation.

Tables 1–3 have shown that the most represented families of plant species are the Fabaceaes (60%); Euphorbiaceaes (20%); the Apocynaceaes (17.1%); Combretaceaes and Moraceaes (15%) and Malvaceaes. Species such as *Vigna unguiculata*, *Arachis hypogaea*; *Bobgunnia madasgariensis, Euphorbia balsamifera* and *Saba comorensis* were strongly represented in all agro-ecological zones except in Zou where an almost total absence of *Bobgunnia madasgariensis,* and *Euphorbia balsamifera* was noticed.

3.4. Parts of organs and method of use reports of galactogenic remedies

In the four areas the most heavily used parts of the plants were the leaves followed by the seeds, then the roots, bark and stems. It should also be noted that the plant organs involved in the usage reports were strongly related to the species. Seeds could be seen with *Vigna unguiculata*, and *Arachis hypogaea*; the root bark exclusively with *Bobgunnia madasgariensis*, *Gardenia aqualla* and *Saba comorensis* while with *Afzelia africana* and *Acacia* spp single leaves are mostly used regardless of the study area.

According to the dialogue partners, the use pattern varied depending on the species and the part of plants involved in the use reports. Thus, the seeds of *Vigna unguiculata*, and *Arachis hypogaea* are used after pounding. *Afzelia* spp leaves were used in powder form as were *Pterocarpus erinaceus*, *Acacia* spp; and *Khaya senegalensis* while the bark of the roots of *Bobgunnia madasgariensis* and the stems of *Euphorbia balsamifera* were used after pounding against an exclusive decoction of the roots of its two species. The solvent most used by dialogue partners was water (97%) orally and the rest was specifically butter from shea or cow's milk by massaging the udders a few days before calving. In short, pounding was the most used followed by maceration then decoction and powdering (supplementary data).

3.5. Effectiveness of presumed galactogenic recipes

In order to assess the effect of galactogenic recipes on milk production in local cows in Benin, a numerical classification of the recipes was carried out. The results of this classification were presented in the form of a dendrogram (Fig. 3). Taking into account the coefficient of determination $R^2 = 50\%$, two distinct groups of galactogenic recipes emerged from this dendrogram. Group 1 contains 86 recipes while group 2 contains 16 galactogenics recipes. A highly significant difference ($p < 0.001$) was found between the two groups with regard to milk production. With regard to the results in Fig. 4, the galactogenic recipes belonging to Group 2 had an average milk yield of 0.6 L that was

Table 1
Socio-professional characteristics of respondents.

Ethnicities	Number of men	Percentage	Number of women	Percentage
Gandos	**158**	**28.0**	**0**	**0**
Peulhs	**363**	**64.3**	**36**	**6.4**
Others	**8**	**1.4**	**0**	**0**
total	**521**	**93.6**	**36**	**6.4**
		Age classification		
Youth	**122**	**21.6**	**0**	**0**
Adults	**326**	**57.7**	**30**	**5.3**
Old	**81**	**14.3**	**6**	**1.1**
Total	**529**	**93.6**	**36**	**6.4**
		Education level		
Educated	**59**	**10.4**	**0**	**0**
Non-Educated	**475**	**84.1**	**31**	**5.8**
Total	**534**	**94.5**	**31**	**5.8**

Table 2
Lists of plants involved in the constitution of 16 galactogenic recipes.

Scientific name	Family	specimen number	Local names (Peulh)
Bobgunnia madagascariensis (Desv.) JHKirkbr. & Wiersema	Leguminosae-papilionoideae	Agbani 2415	Cocobi
Vigna unguiculata (L.) Walp	Leguminosae-papilionoideae	Agbani 2416	Yièbè
Balanites aegyptiaca (L.) Delile	Zygophyllaceae	Agbani 2417	Tanni
Anogeissus leiocarpa (DC.) Guill. & Perr.	Combretaceae	Agbani 2418	Kojoli
Pterocarpus erinaceus Poir.	Leguminosae-papilionoideae	Agbani 2419	Banoui
Khaya senegalensis (Desv.) A.Juss	Meliaceae	Agbani 2420	Kahi
Afzelia africana Pers.	Leguminosae-caesalpinioideae	Agbani 2421	Warrangni
Arachis hypogaea L.	Leguminosae-papilionoideae	Agbani 2422	Biridji
Euphorbia balsamifera Aiton	Euphorbiaceae	Agbani 2423	Tcholoui
Saba comorensis (Bojer ex A. DC.) Pichon	Apocynaceae	Agbani 2424	Bernine
Bombax costatum Pellegr. & Vuillet	Malvaceae	Agbani 2425	Rainiyor
Cucurbita pepo L.	Cucurbitaceae	Agbani 2426	Cobial
Calotropis procera subsp. hamiltonii (Wight) Ali	Apocynaceae	Agbani 2427	Corora
Gardenia aqualla Stapf & Hutch	Rubiaceae	Agbani 2428	Dihanli
Sorghum bicolor (L.) Moench	Poaceae	Agbani 2429	Gaoul
Raphionacme brownii Scott-Elliot	Apocynaceae	Agbani 2430	Dahiyohi
Cucurbita maxima Duchesne	Cucurbitaceae	Agbani 2431	Cobial
Ficus trichopoda Baker	Moraceae	Agbani 2432	Ilawadii
Euphorbia heterophylla L.	Euphorbiaceae	Agbani 2433	In-indè
Secamone afzelii (Roem.& Schult.) K.Schum.	Apocynaceae	Agbani 2434	Anonsi
Ficus vallis-choudae Delile	Moraceae	Agbani 2435	Ibi; Ibadania
Vitellaria paradoxa C.F. Gaertn.	Sapotaceae	Agbani 2436	Karé

significantly higher ($p < 0.05$) than those in Group 1 (Fig. 4).

The error bars represent standard errors. Bars with the same alphabetic letters are not significantly different according to the Student Newman Keuls test ($p > 0.05$).

At the end of the dendogram, two groups of galactogenic recipes were identified and group two composed of sixteen galactogenic recipes represents the reports of the most effective home remedies. Among these sixteen galactogenic remedies 5 were frequently mentioned by the dialogue partners of the study area. It is *Bobgunnia madagascariensis* (Desv.) J.H.Kirkbr. & Wiersema + *Vigna unguiculata* (L.) Walp (12.8%); *Arachis hypogaea* L. + *Euphorbia balsamifera* Aiton (5.7%); *Ficus trichopoda* Baker + *Euphorbia balsamifera* Aiton + *Ficus platyphylla* Delile + *Arachis hypogaea* L. (1.8%) *and Euphorbia balsamifera* Aiton + *Gossypium hirsutum* (L.) + *Cucurbita maxima* Duchesne + *Sarcocephalus latifolius* (Sm.) E. A. Bruce + *Vigna unguiculata* (L.) Walp; *Saba comorensis* (Bojer ex A.DC.) Pichon + *Bobgunnia madagascariensis* (Desv.) J.H.Kirkbr. & Wiersema + *Vigna unguiculata* (L.) Walp + *Cucurbita maxima* Duchesne 1.5% and 1.2% *respectively* (Table 3).

3.6. Socio-cultural and magical-religious practices in the preparation and use of galactogenic recipes

Socio-cultural and magical-religious practices were used by respondents to improve the effectiveness of galactogenic recipes. For example, recipes based on *Combretum adenogonium* Steud. ex A.Rich. (*Ficus vallis-choudae* Delile and *Gardenia aqualla* Stapf & Hutch required incantations when churning the galactogen preparation or administering it to cow. For *Adansonia digitata* (L), *Euphorbia balsamifera* Aiton and *Bombax costatum* Pellegr. & Vuillet, it was rather Quranic verses that were recited at the time of their harvest. These incantations and Koranic verses were not only recited at the time of obtaining the plant material to be used for the recipe. They were recited both at the time of preparation and at the time of administering the recipe to the animals. Practitioners' beliefs went so far as to admit that the recipe based on the whole carcass of *Erinaceus europaeus* (Hedgehog) was ineffective. On the other hand, the recipe based on the skin of this species found dead in the bush was very effective and gave a better yield of milk.

Respondents specify that a particular part of the plants must be collected at a specific time for it to have the desired effectiveness. The practice of collecting plant leaves for certain recipes before sunset was a cultural belief of its breeders and agro-pastoralists using galactogenic recipes to improve milk production. Practitioners had reported that some plants such as *Euphorbia balsamifera* Aiton, *Bobgunnia madagascariensis* (Desv.) J.H.Kirkbr. & Wiersema must be harvested very early in the morning before 8:00 a.m. When preparing certain recipes, herders and agro-pastoralists specify that fallen dead leaves of certain plants should be harvested for use rather than the green leaves still turgid on the tree. According to these practitioners, the dead leaves of *Carica papaya* L. had a greater effect on the efficacy of galactogenic preparations than the turgid leaves on the tree. In some other cases, fresh young leaves rather than older leaves were specified for use in the recipe. Young leaves of *Vitellaria paradoxa* C.F.Gaertn. were used rather than older leaves in galactogenic preparations. Therefore, illiterate agro-breeders had proven to know where to find the resources necessary for their galactogenic preparations in the highest concentrations without a Western knowledge.

4. Discussion

4.1. Relationship between cited recipes, socio-cultural groups, gender and age

In Benin, very few women own cattle herds. The management of large ruminant herds and ethno-veterinary knowledge are much more the prerogative of males. The majority of the herders interviewed (69.3%) practicing traditional veterinary medicine based on galactogenic plants are over 40 years old. Some authors (Mpondo et al., 2012; Klotoé et al., 2013) had already made the same observation. The large number of recipes identified at the level of Peulh and Gandos socio-cultural groups demonstrates quite well that these groups have a better knowledge of endogenous practices on galactogenic recipes. These results confirm the work of Bâ (1994) and Dassou et al. (2015) who have shown that the Fulani and Gandos have an excellent knowledge of ethno-veterinary practices in Africa. During the surveys, these two Peulhs and Gandos socio-cultural groups indicated that after Allah (God), the cow represents for them one of their divinities to whom they owe all recognition. Thus, it is their commitment to take care of this species which provides wealth and well-being to their families. Traditionally, there is a division of labour in the production, processing and marketing of milk. In a traditional farming environment, milk belongs to women and is their main source of income. Proceeds from the sale of milk and milk products are used to provide condiments for household food. The rest of the revenue is used for the needs of the woman and her children (Mama Sambo, 2013). The male head of the household does not have access to this income, yet it is the latter who makes and administers the supposedly galactogenic recipes for animals in order to stimulate milk production. This result is in line with those already obtained in various studies (Kabore et al., 2007; Youssao et al., 2013; Houndje et al., 2016).

Table 3
Lists of homemade galatogenic remedies retained at the end of the dendrogram results.

Codes	Recipes	Organs	Modes of use	Route of administration	Quantities administered (L)	Treatment Periods	Processing time (day)	Milk Yields (L)	UR
R1	*Bobgunnia madagascariensis* (Desv.) J.H. Kirkbr. & Wiersema + *Vigna unguiculata* (L) Walp	Root + Seed	Pounding	Oral	1	Morning	2	1.4	40
R100	*Balanites aegyptiaca* (L.) Delile + *Anoeisus leiocarpa* (DC.) Guill. & Perr. + *Pterocarpus erinaceus* Poir. + *Khaya senegalensis* (Desv.) a. Juss + *Afzelia africana* Pers. + *Arachis hypogaea* (L)	Bark + Bak + Bark + Root + Root + Seed	Decoction	Oral	1	Morning	3_4	1.4	5
R3	*Arachis hypogaea* (L) + *Euphorbia balsamifera* (Aiton) + *Vigna unguiculata* (L) walp	Seed + Whole Plants + Seed	Pounding	Oral	1	Morning	3	1.4	18
R84	*Bobgunnia madagascariensis* (Desv.) J.H. Kirkbr. & Wiersema + Saba comorensis (Bojer ex A.DC.) Pichon + *Euphorbia balsamifera* Aiton + *Arachis hypogaea* (L)+ salt	Roots + Roots + Whole Plant + Seed	Pounding	Oral	1	Morning	3_4	1.7	10
R72	*Bombax costatum* Pellegr. ℑ Vuillet + *Euphorbia balsamifera* Aiton + Cucurbita *pepo* L. + *Vigna unguiculata* (L.) walp	Fruit + Stem Leaf + Fruit + Seed	Decoction	Oral	1	Morning	5	1.3	10
R80	*Cucurbita pepo*(L) + *Calotropis procera* subsp. *hamiltonii* (Wight) Ali + *Vigna unguiculata* (L.) Walp	Fruit + Root + Seed	Decoction and maceration	Oral	1	Morning	7	1.5	10
R85	*Gardenia aqualla* Stapf & Hutch + *Vigna unguiculata* (L.) Walp	Root + Seed	Decoction	Oral	1	Morning	3	1.3	10
R75	*Euphorbia balsamifera* Aiton + *Vigna unguiculata* (L.) Walp	Leaf stem + Seed	Pounding	Udder massage	Random	Morning	1	1	10
R28	*Curcubita maxima* Duchesne + *Euphorbia balsamifera* Aiton + *Vitellaria paradoxa* C. F. Gaertn + *Sorghum bicolor* (L.) Moench	Fruit + Stem + leaves + Ball	Decoction	Oral	1	Morning	7	1.4	5
R18	*Curcubita maxima* Duchesne + *Vigna unguiculata* (L.) Walp	Fruit + Seed	Decoction Maceration	Oral	1	Morning	3	1.6	10
R89	*Gardenia aqualla* Stapf & Hutch + *Euphorbia balsamifera* (Aiton) + *Sorghum bicolor* (L.) Moench + *Saba comorensis* (Bojer ex A.DC.) Pichon + *Curcubita maxima* Duchesne + *Vigna unguiculata* (L.) Walp + *Arachis hypogaea* (L.) + *Calotropis procera* subsp. *hamiltonii* (Wight) Ali + *Vitellaria paradoxa* (C.F. Gaertn)	Bark + Stem + Ball + Roots + Fruit + seed + Seed + leaves	Decoction	Oral	2	Morning	7	1.7	10
R103	*Raphionacme brownii* Scott-Elliot + *Calotropis procera* subsp. hamiltonii (Wight) Ali + *Bobgunnia madagascariensis* (Desv.) JHKirkbr. & Wiersema + *Vigna unguiculata* (L.) Walp + *Sorghum bicolor* (L.) Moench	Tuber + Root + Root + Seed + Ball	Pounding	Oral	1	Morning	2_3	1.5	5
R29	*Saba comorensis* (Bojer ex A.DC.) Pichon + *Curcubita maxima* Duchesne + *Ficus trichopoda* Baker	Root + Fruit + Root	Decoction + Pounding	Oral	1	Morning	2	1.5	25
R49	*Sorghum bicolor* (L.) Moench + *Euphorbia basalmifera* Aiton + *Vigna unguiculata* (L.) Walp	Ball + Whole plant + Seed	Pounding + Decoction	Oral	1	Morning	7	1.5	15
R51	*Vigna unguiculata* (L.) Walp + *Euphorbia heterophylla* (L.) + Secamone *afzelii* (Roem. & Schult.) K.Schum.	Seed + Stem + Roots	Pounding + Decoction	Oral	1	Morning	3	1.6	15
R54	*Vitellaria paradoxa* C.F. Gaertn. + *Erinaceus europaeus*	Leaves + Skin	Calcination	Udder massage	Random	Morning Night	15	1.4	15

The plant organs mentioned follow the order of citation of the species involved in the constitution of the recipes.

4.2. Geographic and seasonal diversity of galactogenic utility flora

The 119 plant species with galactogenic uses recorded represent 4.24% of Benin's total flora, estimated at 2807 species (Akouègninou et al., 2006). This specific richness is considerable, compared to the 22 and 55 galactogenic plant species recorded respectively by Akouedegni et al. (2012) and Salifou et al. (2017). The difference in species richness is related to the species diversity that varies from, one department to another or from one phytogeographical zone to another within the country (Hilonga et al.,2019). The morphological type of species for galactogenic use indicates that trees and shrubs are the most represented (65.4%). They are followed by herbaceous species (34.3%). Trees and shrubs are available in all seasons. During the long dry season from November to March, herbaceous plants are almost absent from the vegetation. As a consequence, recipes based on *Cucurbita* spp., *Secamone afzelii* and *Euphorbia heterophylla* (R28; R72; R80; R103; R51) cannot be used during this period. The availability of galactogenic recipes is therefore linked to the season. The surveys revealed that the composition of the recipes also varies according to the agro-ecological zones. Ruminant farmers in northern Benin make greater use of recipes based on *Bobgunnia madagascariensis* (Desv.) J.H.Kirkbr. & Wiersema, *Saba comorensis* and *Euphorbia balsamifera* Aiton. On the other hand, those in southern Benin mainly use recipes based on *Gardenia aqualla* associated with *Vigna unguiculata* (L) walp or *Arachis hypogaea* (L). Indeed, the

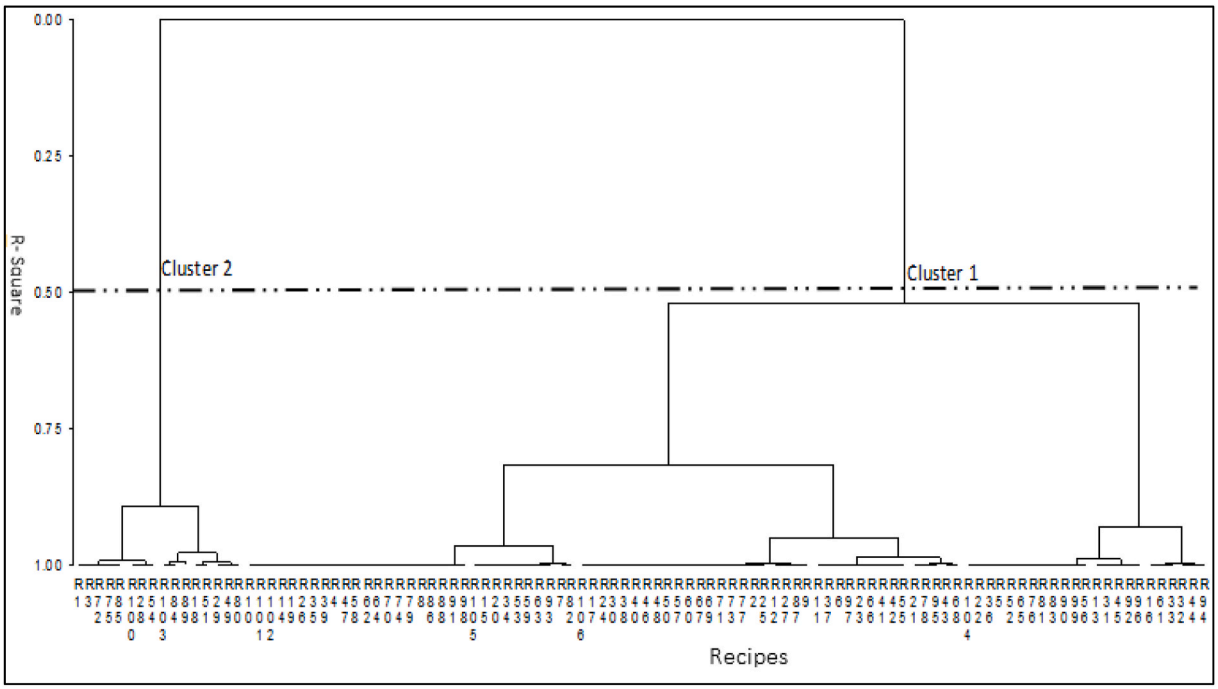


Fig. 3. Dendrogram on inventoried galactogenic recipes.

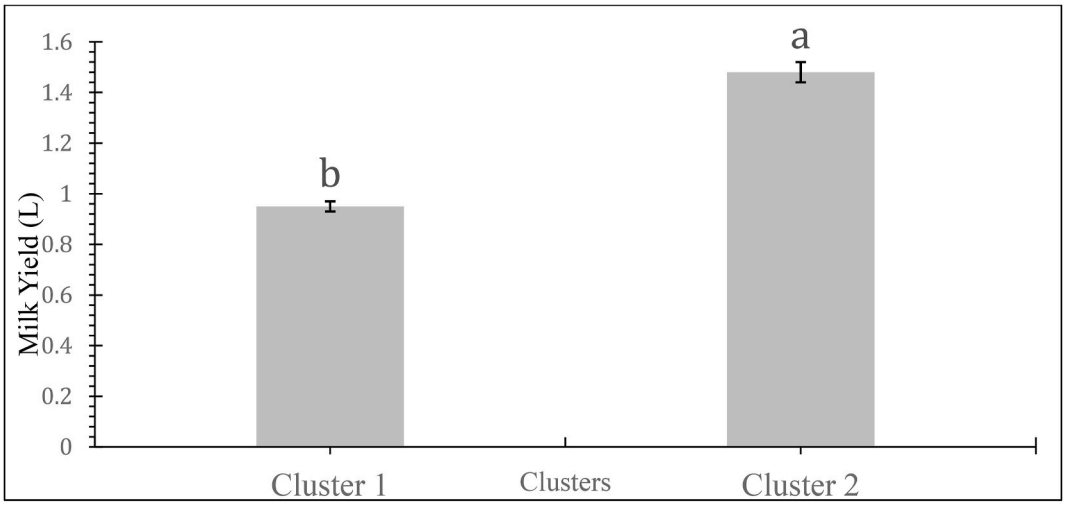


Fig. 4. Comparison of the 2 groups of recipes obtained according to numerical classification.

species *Euphorbia balsamifera* found in North Benin requires certain pedoclimatic requirements that the South-Benin areas do not meet, hence the failure of its cultivation. Surveys have shown that the use of the recipe is conditioned by the availability and ease of finding the galactogenic species used in its preparation.

4.3. Socio-cultural and magical-religious practices in the preparation and use of galactogenic recipes

Socio-cultural and magical-religious practices influence the effectiveness of galactogenic recipes, and thus the milk yield. Practitioners believe that non-compliance with these practices will prevent the plants from producing the desired effects. Mafimisebi and Oguntade (2010) found similar beliefs among users of traditional medicine products to treat illnesses suffered by the population in Nigeria. For some plants such as *Euphorbia balsamifera*, *Bobgunnia madagascariensis* (Desv.) JHKirkbr. & Wiersema that have to be harvested very early in the morning before 8:00 a.m., practitioners believe that these plants sleep at night and are awake during the day. This is their way of interpreting the physiological and biochemical processes taking place within the plants. Consequently, to the belief that plants sleep at night and awake during the day, practitioners point out that in order for certain recipes to be powerful, the collection of whole plants or parts of plants for galactogenic preparations must be done before nightfall. The reason given by them is that the forces that produce the active ingredients and make the recipe effective would be extinguished in the evening. Mafimisebi and Fakoya (2007) suggest that practitioners' opinions and beliefs about plants should be respected. Their attitude can be interpreted as a misunderstanding of the phenomenon of photosynthesis and the active ingredients it produces in plants. In reality, photosynthesis is the process by which plants use the energy of light to synthesize their biomolecules. Chemically, the starting molecules are CO_2, water, carbohydrates and fats. This photosynthesis is influenced by environmental factors such as light and temperature (which affects all biochemical reactions). Light

allows the production of nutrients essential to the proper functioning of the plant through photosynthesis. In the absence of light, the phenomenon of photosynthesis has a negative impact on the concentration of phenolic compounds (Gratzel, 2001; Bensaid et al., 2012; Blankenship, 2014; Christianson and Creel, 2015; Goulas et al., 2017; Watt et al., 2018; Liu et al., 2019).

In some cases, practitioners specify that a part of the plant must be collected at a specific time at night for it to have the desired effectiveness. This practice cannot be dismissed as totally absurd since the work of Steer (1974) and Sofowora (1993) indicates that there is diurnal variation in the concentration of certain plant constituents. Practitioners have found that collections made at night are more effective than those made during the day for some plants as testified by various experiences of preparation of the same recipe with plant parts collected at different times. It is also for an increased concentration of active components that some flowers are more productive when collected at night than during the day (Sofowora, 1993). For some recipes, fresh young leaves are indicated rather than older leaves. In reality, some transformation of constituents takes place in the leaf as it ages. Thus, it is evident that practitioners in the majority of illiterate cases know where to find the active ingredients needed for their galactogenic preparations and where to find the highest concentrations in the plant material without recourse to Western scientific knowledge. Another interesting differentiation of galactogenic plants is in terms of location. Perhaps mention that *Phragmenthera* spp. are hemi-parasites, *is* more effective on milk yield when found growing on *Vitellaria paradoxa,* rather than when growing on other plants such as *Terminalia avicennioides* and *Combretum adenogonium.*

4.4. Effectiveness of using galactogenic recipes to improve milk production

Some of the 102 frequent galactogenic recipes selected for this study have already been inventoried by authors who have worked in other agro-ecological zones in Benin (Dassou et al., 2014; Kassa et al., 2016; Noudèkè et al., 2017). These results demonstrate fairly well that the information collected on galactogenic plants in particular, their effectiveness in inducing or increasing milk production in ruminants, is consistent. Moreover, the report use of plant involvement in the constitution of recipes showed that *Vigna unguiculata* and *Arachis hypogaea* contribute more than 92% to the constitution of recipes. For cattle farmers, the absence of one or other of these plants leads to systematic rejection of the recipe. According to Hama-Ba et al. (2017) and Sombié et al. (2018), these two legumes are known as plants with important nutritional values that participate in the reconstitution and growth of certain animal cells. They have a good amount of calcium, phosphorus, magnesium and vitamins A and C (Agugo et al., 2013). The richness in Iron and vitamin B12 of these legumes means that once added to recipes after parturition strengthen the body through the mechanism of the Krebs cycle which in turn improves the dairy performance of cows (Hama-Ba et al.,2017). *Vigna unguiculata* has various pharmacological properties including the galactagenic effect (Sayeed et al.,2017). Apart from legumes (19.2%), other families with galactogenic uses such as Moraceae (15.4%); Apocynaceae (11.5%) and Euporbiaceae (7.7%) also contribute to the constitution of recipes. Previous work carried out on these plant families has shown that the majority of the plants that make up these recipes have been the subject of in-depth studies and the results have shown that these species possess phytochemical compounds including polyphenols, flavonoids, alkaloids and triterpenes (Mckay, 2009; Kumar et al., 2010; Pattaret et al., 2012; Williamson et al., 2013; Dadalto and Rosa, 2017; Sayeed et al., 2017) that have therapeutic effects. These active ingredients act synergistically to treat parasitic, bacterial, nervous and viral diseases (Koko et al., 2011; Adepo et al., 2017; Bekoe et al., 2018). Thus, the involvement of its plant essences in recipes can improve animal health and contribute to increasing milk production. In addition, preparations based on *Sorghum bicolor* (L) Moench, *Arachis hypogaea, Adansonia digitata, Bombax costatum* and *Calotropis procera* (Aiton) W.T.Aiton have the capacity to induce milk secretion in an adoptive cow in case the biologic cow of the newborn calf is diseased with a severe pathology or dead after farrowing. These results confirm the study by Koko et al. (2011) on emmenagogue plants in the Pendjari hunting zone and by Rouillé et al. (2010) on their use. These preparations involve the use of one or more plant parts. The use of several organs involved in the constitution of galactogenic recipes has already been reported by several authors (Koko et al., 2011; Akouèdégni, 2013; Salifou et al.,2017; Bekoe et al., 2018). Those studies showed that seeds are used more than the other organs composing the recipes. This use of seed is explained by the fact that for most of the selected recipes, seeds are involved in their formula. On the other hand, other studies have shown that leaves are used in proportions ranging from 61.79 to 96% (Mensah et al., 2005; Agbogidi, 2010; Dossou et al., 2012).

5. Conclusion

The aim is to identify the recipes used by breeders for improving milk production and the components used in galactogenic preparations and the recipes presumed to improve milk yield according to traditional breeders. A total of 295 recipes involving 119 species of Benin's flora are identified. The availability of recipes varies according to the season and the agroecological zone under consideration. *Vigna unguiculata* and *Arachis hypogaea* account for more than 92% of these galactogenic recipes. The most commonly used route of administration is oral. According to the beliefs of recipe practitioners, the time of collection (early morning or at sunset) of the plant material used in the preparation of the recipe influences its effectiveness. Treatments are generally done in the mornings and last no longer than 15 days. In order to obtain a better milk yield, incantations are pronounced or Koranic verses are recited at all stages of the recipe namely when collecting the plant material to be used, when preparing the galactogen and when administering the recipe to the animals. The study reveals that some of this knowledge about galactogenic recipes is preserved. The acquisition of galactogenic knowledge in this context is passed on from father to son, from one lineage to another in such a way that the secret never crosses family or tribe boundaries. This work helps to fill the information gap on the endogenous knowledge of traditional breeders using galactogenic recipes to improve the milk production of animals. However, there are many as yet unknown phenomena concerning the use of recipes by herders. These include the toxicity and efficacy of the presumed better recipes, the action of phytochemicals on galactopoietic cells and specific hormones such as prolactin in order to truly assess their impact on milk yield, the minimum dose that improves milk production, and the galenic form best suited to the socio-economic conditions of traditional stock breeders.

Authors' contributions

AAZ, conceptualized the study and AG, BC, DJ, BS and BOD reviewed the research proposal. AAZ and AG conducted the ethnobotanical survey. AAZ and PSCB identified recorded species. AAZ, BS and BOD analysed the field data. AAZ drafted the manuscript. All the authors participated in writing and giving feedback on the manuscript. PSCB corrected the grammatical and orthographic background. All the authors have read and approved the final manuscript. AAZ reviewed and edited the last version. BS have read and approved the last version.

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CRediT authorship contribution statement

Zénabou Agani Agani: Conceptualization, data retention, Formal analysis, survey, Methodology, Project administration, Writing – original draft, Writing – review & editing. **C.B. Pomalegni S:** data retention, Validation, Visualization. **Guénole Akouedegni C:** Methodology. **Cyrille Boko K:** Conceptualization, Visualization. **Daouda Bello Orou:** Formal analysis, Methodology, Software. **Joseph Dossou:** Project administration. **Séverin Babatounde:** data retention, Formal analysis, financing acquisition, Project administration, Supervision, Visualization.

Declaration of competing interest

The authors have declared that there is no conflict of interest in relation to this manuscript.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jep.2021.114869.

References

Adepo, Y.P., Bolou, G.E.K., Akoa, E.E.F., 2017. Effet sur le développement mammaire et analyse phytochimique de deux plantes lactogènes de la pharmacopée traditionnelle ivoirienne : Euphorbia hirta L. et Secamone afzelii (Roem. &Schult.). Int. J. Brain Cognit. Sci. 11 (4), 1872–1877.

Adjanohoun, E., 1989. Contribution to the Ethnobotanical and Plant Species Studies of People's Republic of Benin.

Agbogidi, O.M., 2010. Ethno-botanical survey of the non-timber forest products in sapele local government area of delta state, Nigeria. Afr. J. Plant Sci. 4 (6), 183–189.

Agugo, U.A., Okere, T.O., Anya, K.M., 2013. Investigating the nutrient composition and Anti-nutritional factors of Akidi (Vigna unguiculata unguiculata). IOSR J. Environ. Sci. Toxicol. Food Technol. 5 (4), 32–35.

Akouèdégni, C.G., 2013. Contribution à l'ethnopharmacopée vétérinaire : Cas de deux plantes galactogènes chez les ovins Djallonké au Bénin [PhD Thesis]. Thèse doctorat, Université d'Abomey-Calavi, Bénin.

Akouedegni, C.G., Tossa, I.G., Daga, F.D., Koudandé, D.O., 2012. Synthèse des connaissances sur les plantes galactogènes et leurs usages en République du Bénin. on line, p. 12.

Akouègninou, A., Van der Burg, W.J., van der Maesen, L.J.G., 2006. Flore analytique du Bénin. Cotonou & Wageningen. Edition Backhuys Publishers.

Arbonnier, M., 2002. Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest CIRAD. MNHN, Montpellier, Paris, France.

Assogbadjo, A.E., Kakaï, R.G., Chadare, F.J., Thomson, L., Kyndt, T., Sinsin, B., Van Damme, P., 2008. Folk classification, perception, and preferences of baobab products in West Africa : consequences for species conservation and improvement. Econ. Bot. 62 (1), 74–84.

Bâ, S., 1994. In: Métissages en santé animale de Madagascar à Haïti. Presses Universitaires de Namur/CTA/ACCT, pp. 41–56.

Bekoe, E.O., Kitcher, C., Gyima, N.A.M., Schwinger, G., Frempong, M., 2018. Medicinal plants used as galactagogues. In: Pharmacognosy-Medicinal Plants. IntechOpen.

Bensaid, S., Centi, G., Garrone, E., Perathoner, S., Saracco, G., 2012. Towards artificial leaves for solar hydrogen and fuels from carbon dioxide. ChemSusChem 5 (3), 500–521.

Blankenship, R.E., 2014. Molecular Mechanisms of Photosynthesis. John Wiley & Sons.

Christianson, D., Creel, S., 2015. Photosynthetic pigments estimate diet quality in forage and feces of elk (Cervus elaphus). Can. J. Zool. 93 (1), 51–59. https://doi.org/10.1139/cjz-2014-0154.

Dadalto, E.C.V., Rosa, E.M., 2017. Knowledge about the benefits of breastfeeding and disadvantages of the pacifier related to the mother's practice with preterm infants. Revista Paulista de Pediatria 35 (4), 399.

Dagnelie, P., 1973. Théorie et méthodes statistiques. Applications agronomiques. 1, La statistique descriptive et les fondements de l'inférence statistique. J. Duculot.

Dah-Nouvlessounon, D., Adoukonou-Sagbadja, H., Diarrassouba, N., Sina, H., 2015. Phytochemical analysis and biological activities of cola nitida bark. Biochemistry Research International. https://doi.org/10.1155/2015/493879, 2015.

Dassou, G.H., Ouachinou, J.M.-A.S., Adomou, A.C., Yédomonhan, H., Tossou, M., Favi, A., Djidohokpin, D., Gbèdolo, E., Akoègninou, A., 2020. Plant and natural product based homemade remedies for veterinary uses by the Peul community in Benin. J. Ethnopharmacol. 261, 113107. https://doi.org/10.1016/j.jep.2020.113107.

Dassou, G.H., Ogni, C.A., Yédomonhan, H., Adomou, A.C., Tossou, M., Dougnon, J.T., Akoègninou, A., 2014. Diversité, usages vétérinaires et vulnérabilité des plantes médicinales au Nord-Bénin. Int. J. Brain Cognit. Sci. 8 (1), 189–210.

Dassou, G.H., Yédomonhan, H., Adomou, A.C., Ogni, C.A., Tossou, M.G., Akoègninou, A., 2015. Facteurs socioculturels et environnementaux déterminant la connaissance ethnovétérinaire au Bénin. Afrique Science 11 (5), 335–360.

Déléké-Koko, K.I.E., Djego, J., Gbenou, J., Hounzangbe-Adote, M.S., Sinsin, B., 2011. Phytochemical study of the main galactogenic and emmenagogue plants used in the riparian terroirs of the Pendjari hunting zone. Int. J. Biol. Chem. Sci. 5 (2), 618–633.

Disler, M., Ivemeyer, S., Hamburger, M., Vogl, C.R., Tesic, A., Klarer, F., Meier, B., Walkenhorst, M., 2014. Ethnoveterinary herbal remedies used by farmers in four north-eastern Swiss cantons (St. Gallen, Thurgau, Appenzell Innerrhoden and Appenzell Ausserrhoden). J. Ethnobiol. Ethnomed. 10 (1), 32.

Djègo, J., Djego-Djossou, S., Cakpo, Y., Agnani, P., Sinsin, B., 2011. Evaluation du potentiel ethnobotanique des populations rurales au Sud et au centre du Bénin. Int. J. Brain Cognit. Sci. 5 (4), 1432–1447.

Dossou, M.E., Houessou, G.L., Lougbégnon, O.T., Tenté, A.H.B., Codjia, J.T.C., 2012. Etude ethnobotanique des ressources forestières ligneuses de la forêt marécageuse d'Agonvè et terroirs connexes au Bénin. Tropicultura 30 (1).

Eynden, V., Damme, P., 1993. Medicinal and aromatic plants used BY the TOPNAAR - Namibia. Acta Hortic. 330, 75–84. https://doi.org/10.17660/ActaHortic.1993.330.7.

Fagbohoun, L., Gbaguidi, A.F., Ayedoun, M.A., Mathe, C., Moudachirou, M., Vieillescazes, C., 2014. Etude ethnobotanique et phytochimique des plantes tinctoriales sources de colorants naturels et matériaux résineux traditionnels du Bénin dans le domaine artisanal (Ifangni/Benin). Ethnopharmacologia 52, 56–66.

Fasola, T.R., Oloyede, G.K., Aponjolosun, B.S., 2011. Chemical composition, toxicity and antioxidant activities of essential oils of stem bark of Nigerian species of guava (Psidium guajava Linn.). Excli Journal 10, 34.

Goulas, Y., Fournier, A., Daumard, F., Champagne, S., 2017. Gross primary production of a wheat canopy relates stronger to far red than to red solar-induced chlorophyll fluorescence. Rem. Sens. 9 (1), 1 https://doi.org/10.3390/rs9010097.

Gratzel, M., 2001. Photoelectrochemical cells. Nature 414 (6861), 338–345.

Hama-Ba, F., Siedogo, M., Ouedraogo, M., Dao, A., Dicko, H.M., Diawara, B., 2017. Modalités de consommation et valeur nutritionnelle des légumineuses alimentaires au Burkina Faso. Afr. J. Food Nutr. Sci. 17 (4), 12871–12888.

Hilonga, S., Otieno, J.N., Ghorbani, A., Pereus, D., Kocyan, A., de Boer, H., 2019. Trade of wild-harvested medicinal plant species in local markets of Tanzania and its implications for conservation. South Afr. J. Bot. 122, 214–224.

Houndje, E.M.B., Ogni, C.A., Noudeke, N., Farougou, S., Youssao, A.K.I., Kpodekon, T.M., 2016. Recettes ethno-vétérinaire à base de plantes médicinales utilisées pour le traitement de la fièvre aphteuse au Bénin. Int. J. Brain Cognit. Sci. 10 (5), 2090–2107.

Kabore, A., Tamboura, H.H., Belem, A.M., Traore, A., 2007. Traitements ethno-vétérinaires des parasitoses digestives des petits ruminants dans le plateau central du Burkina Faso. Int. J. Brain Cognit. Sci. 1 (3), 297–304.

Kassa, K.S., Ahounou, S., Dayo, G.-K., Salifou, C., Issifou, M.T., Dotche, I., Gandonou, P. S., Yapi-Gnaore, V., Koutinhouin, B., Mensah, G.A., 2016. Performances de production laitière des races bovines de l'Afrique de l'Ouest. Int. J. Brain Cognit. Sci. 10 (5), 2316–2330.

Klotoé, J.R., Dougnon, T.V., Koudouvo, K., Atègbo, J.M., Loko, F., Akoègninou, A., Aklikokou, K., Dramane, K., Gbeassor, M., 2013. Ethnopharmacological survey on antihemorrhagic medicinal plants in South of Benin. Eur. J. Med. Plants 3 (1), 40.

Koko, I.K.D., Djego, J., Gbenou, J., Hounzangbé-Adoté, S.M., Sinsin, B., 2011. Etude phytochimique des principales plantes galactogènes et emménagogues utilisées dans les terroirs riverains de la Zone cynégétique de la Pendjari. Int. J. Brain Cognit. Sci. 5 (2).

Kumar, U., Kumar, B., Bhandari, A., Kumar, Y., 2010. Phytochemical investigation and comparison of antimicrobial screening of clove and cardamom. Int. J. Pharma Sci. Res. 1 (12), 138–147.

Lesse, P., 2011. Analyse de la gestion pastorale et de l'adaptation des éleveurs transhumants face aux variabilités climatiques dans les communes riveraines de la Réserve de Biosphère Transfrontalière du W (Bénin). Mémoire de DEA, FSA/UAC.

Lesse, P., Houinato, M.R., Djenontin, J., Dossa, H., Yabi, B., Toko, I., Tente, B., Sinsin, B., 2015. Transhumance en République du Bénin : États des lieux et contraintes. Int. J. Brain Cognit. Sci. 9 (5), 2668–2681.

Liu, Q., Dong, L., Li, F., 2019. Modification of a photosynthetic light-response (PLR) model for modeling the vertical gradient in the response of crown PLR curves. Can. J. For. Res. 48 (8), 949–959. https://doi.org/10.1139/cjfr-2018-0438.
Mafimisebi, T.E., Fakoya, O.E., 2007. In: Awareness and Uptake of Traditional Livestock Health Management Practices Based on Medicines Derived from Medicinal Plants Among Farmers in Southwest, Nigeria. Medicinal Plants in Agriculture: the Nigerian Experience. Proceedings of the Akure-Humboldt Kellog/3rd SAAT Annual Conference, pp. 204–213.
Mafimisebi, T.E., Oguntade, A.E., 2010. Preparation and use of plant medicines for farmers' health in Southwest Nigeria : socio-cultural, magico-religious and economic aspects. J. Ethnobiol. Ethnomed. 6 (1), 1–9.
Mama Sambo, A., 2013. Etude relative à la formulation du programme d'actions détaillé du développement de la filière lait en zone UEMOA. Cirad, Montpellier, France.
Mckay, D., 2009. Can hibiscus tea lower blood pressure. AfroFood Industry Hi-Tech 20 (6), 40–42.
Mensah, G.A., Sobakin, L.J., Koudande, O.D., Pomalegni, C.B., Kpera, G.N., 2005. Preliminary inventory of medicinal plants used for the treatment of sick farm aulacode and for sanitary prophylaxis in aulacodiculture farms in South Benin. Technical note: bibliothèque Nationale (BN) du Bénin. -. 1 page Poster illustrated in colour, A2 format, bilingual: French and English. Résumé & Abstract published in Bul. Rec. Agr. Benin, N°54 December 2006 19–20, 99919-57-448.
Mpondo, M.E., Dibong, D.S., Priso, R.J., Ngoye, A., Yemeda, C.F.L., 2012. État actuel de la médecine traditionnelle dans le système de santé des populations rurales et urbaines de Douala (Cameroun). Journal of Applied Biosciences 55, 4036–4045.
Noudèkè, N.D., Dotché, I., Ahounou, G.S., Karim, I.Y.A., Farougou, S., 2017. Inventory of medicinal plants used in the treatment of diseases that limit milk production of cow in Benin. Journal of Advanced Veterinary and Animal Research 4 (1), 1–14.
Nunkoo, D.H., Mahomoodally, M.F., 2012. Ethnopharmacological survey of native remedies commonly used against infectious diseases in the tropical island of Mauritius. J. Ethnopharmacol. 143 (2), 548–564.
Nyamanga, P.A., Suda, C., Aagaard-Hansen, J., 2008. The socio-cultural context and practical implications of ethnoveterinary medical pluralism in western Kenya. Agric. Hum. Val. 25 (4), 513–527.
Pattaret, P.S., Mansur, C.P., Alagundagi, S.C., Karbantanal, S.S., 2012. Effect of intercropping systems on gram pod borer Helicoverpa armigera hubner and its natural enemies in chickpea. Indian J. Entomol. 74 (2), 136–141.
Rouillé, B., Lamy, J.-M., Brunschwig, P., 2010. Trois formes de consommation de la luzerne pour les vaches laitières. Renc. Rech. Rum 17, 329.
Salifou, C.F.A., Kassa, K.S., Ahounou, S.G., Moussa, H., Dotché, I.O., Agbozo, J.M., Issifou, M.T., Youssao, I.A.K., 2017. Plantes lactogènes des bovins et leurs modes de préparation dans les élevages traditionnels au Bénin. Livest. Res. Rural Dev. 29 (2), 29.
Samouh, Y., Lemrani, A., Mimouni, H., Mohamad, J., Ait Haj Said, A., 2019. Ethnopharmacological study of herbal medicines used to treat cancer in Morocco. The Journal of Phytopharmacology 8 (3), 135–141.
Sayeed, M.A., Bracci, M., Lazzarini, R., Tomasetti, M., Amati, M., Lucarini, G., Di Primio, R., Santarelli, L., 2017. Use of potential dietary phytochemicals to target miRNA : promising option for breast cancer prevention and treatment? Journal of Functional Foods 28, 177–193.
Sayeed, V.K.I., Satish, S., Kumar, A., Hegde, K., 2017. Pharmacological activities of Vigna unguiculata (L) Walp : a review. Int. J. Pharmaceut. Chem. Res. 3 (1), 44–49.
Sofowora, A., 1993. Recent trends in research into African medicinal plants. J. Ethnopharmacol. 38 (2–3), 197–208.
Sombié, P.A.E.D., Compaoré, M., Coulibaly, A.Y., Ouédraogo, J.T., Tignégré, J.-B.D.L.S., Kiendrébéogo, M., 2018. Antioxidant and phytochemical studies of 31 cowpeas (Vigna unguiculata (L. Walp.)) Genotypes from Burkina Faso. Foods 7 (9), 143.
Sossa, E.L., Amadji, G.L., Vissoh, P.V., Hounsou, B.M., Agbossou, K.E., Hounhouigan, D. J., 2014. Caractérisation des systèmes de culture d'ananas (Ananas comosus (L.) Merrill) sur le plateau d'Allada au Sud-Bénin. Int. J. Brain Cognit. Sci. 8 (3), 1030–1038.
Steer, B.T., 1974. Control of diurnal variations in photosynthetic products : I. Carbon metabolism. Plant Physiol. 54 (5), 758–761.
Toko, R.C., Adégbidi, A., Lebailly, P., 2016. Démographie et performances zootechniques des élevages bovins traditionnels au Nord Bénin. Revue d'élevage et de médecine vétérinaire des pays tropicaux 69 (1), 33–39.
Watt, A.J., Fischer, D.G., Antos, J.A., Zobel, D.B., 2018. Leaf-level physiology in four subalpine plants in tephra-impacted forests during drought. Can. J. For. Res. 48 (4), 431–441.
Williamson, E.M., Driver, S., Baxter, K., 2013. Stockley's herbal medicines interactions : A guide to the interactions of herbal medicines, dietary supplements and nutraceuticals with conventional medicines/editors, Elizabeth Williamson, Samuel Driver, Karen Baxter; editorial staff, Mildred Davis...[et al.], digital products team, Julie McGlashan, Elizabeth King. Pharmaceutical Press, London; Chicago.
World Health Organization, 2001. Legal Status of Traditional Medicine and Complementary/alternative Medicine : A World Wide Review, p. 189.
World Health Organization, 2002. Traditional available medicine, geneva. Fifty-sixth world health Assembly. http://apps.who.int/gb/archive/pdf_files/WHA56/ea5618.pdf.
World Health Organization, 2003. Traditional available medicine, geneva. Fifty-sixth world health Assembly, 4. https://apps.who.int/gb/archive/pdf_files/WHA56/ea5618.pdf.
Youssao, I.A.K., Salifou, C.F.A., Alassane, D., Senou, M., Yacoubou, A., Touré, F., Alkoiret, T., 2013. Modélisation des performances pondérales de bovins Borgou élevés sur pâturages naturels en ferme au Bénin. Livest. Res. Rural Dev. 25 (10), 186.
Zakari, S., Tente, B.A.H., Yabi, I., Imorou, I.T., Tabou, T., Afouda, F., n'Bessa, B., 2015. Vulnérabilité des troupeaux transhumants aux mutations climatiques : analyse des perceptions et adaptations locales dans le bassin de la Sota à Malanville. Afr. Sci. Rev. Int. Sci. Technol. 11 (3), 211–228.