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Review

Synthesis of Knowledge on Infant Fortification Plants and the Most Commonly Used Galactogenic Plants in Niger and Their Uses in the Republic of Niger

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Abstract: The use of plants for therapeutic purposes is an ancestral practice that dates back to the earliest times in the history of mankind. Even today the exploitation of plants for medicinal purposes plays a big role for the communities, especially in Africa, despite advances in modern medicine. According to the World Health Organization, about 80% of the population in developing countries use plants for their primary health care. In Niger, the use of medicinal plants is a foundation of traditional medicine across all ages. It remains a very common practice, especially in rural areas. This practice concerns all ages of life, including mother–child care. In infants and young children, mothers use plants as fortifiers for their prophylactic or curative powers, or to facilitate growth and weight gain, and also to fight major causes of infant morbidity and mortality. Mothers also use medicinal plants for their galactogenic power to stimulate lactation. This is even more important in rural areas where breastfeeding is the main source of infant nutrition. Over the years, these medicinal plants have been the subject of chemical and biological investigations to back up their therapeutic potential and virtues. This study aims to summarize current knowledge on the most commonly used medicinal plants in Niger in mother–child care. This helps emphasize the validation of ancestral medicinal plants through the scientific evaluation of the bioactive components and mechanisms. Elements of sustainability are discussed in future developments.

Keywords: medicinal plant; traditional medicine; prevention; fortifier; galactogen; Niger



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1. Introduction

The exploitation of plants for medicinal purposes has always played a major role for communities. This role is still preponderant today despite modern medicine. According to the World Health Organization, more than 80% of the world's population use traditional herbal medicine in primary health care [1–3]. In Africa, the art of healing with plants has been known and practiced for a long time. Traditional pharmacopoeia plays an important role, especially in rural areas [4,5]. The remoteness of rural areas, non-existent or rudimentary health infrastructure, the high cost of pharmaceutical preparations, the low incomes, and the socio-cultural habits of the populations explain the use of traditional

practices based on medicinal plants [6–8]. Medicinal plants are for rural populations not only an inexhaustible source of drugs to treat themselves but also the least expensive and most accessible source of primary health care [9–11]. Very often, rural populations go to the dispensary only as a last resort when traditional medicine has proved ineffective [8,12]. The health of these communities is therefore strongly linked to the conservation and sustainability of medicinal plants. Any threat of the disappearance of a plant variety diminishes the hopes of improved health.

In Niger, the use of medicinal plants is one of the foundations of traditional medicine [13–16]. This practice is very old, but it remains very common [17]. Indeed, despite the advent of modern medicine, rural populations continue to turn to plants for treatment [18]. The use of medicinal plants concerns all ages of life, including mother–child care [13,14,19,20].

In infants and young children, mothers use plants as fortifiers for their supposed prophylactic or curative powers, or because they are believed to facilitate growth and weight gain. Medicinal plants are used to combat the major causes of infant morbidity and mortality such as malnutrition, acute respiratory infections, diarrhea, malaria, measles, etc. The mothers use a given mixture of plants whose decoction is commonly called “Djitti” in Zarma dialect. The formulation and preparation of Djitti generally require traditional medicinal know-how within the family unit. Mothers also use medicinal plants for their galactogenic power to stimulate lactation [21–23].

Unfortunately, one observation emerges: in western Niger, multipurpose plants, in particular woody ones used in traditional pharmacopoeia, are threatened with extinction not only because of climatic variability but also because of inconsiderate sampling techniques and overgrazing [16,24–26]. The objective of this article is to establish a bibliographical synthesis on the most commonly used infant fortification and galactogenic medicinal plants in Niger, emphasizing the species, their method of preparation, the parts of the plants used, the method of preparations, the other uses of plants, and their phytochemistry. Taxonomical names reflect current status as they appear in the Kew gardens’ plants of the world depository [27].

2. Fortification and Galactogenic Plants

2.1. Ethno-Medicinal Inventory of Infant Fortification and Galactogenic Plants

The first study on the traditional pharmacopoeia of Niger listed 147 medicinal plants and their use [28]. This study was completed with a list of 97 medicinal plants. Several other authors have published on medicinal plants and their use in Niger. A total of 301 medicinal plants distributed in 68 families have been listed [13,14,16,25]. An ethnobotanical survey carried out in the W Biosphere Reserve, located in western Niger, listed 201 plant species used in traditional pharmacopoeia by local populations. This survey identified about 12 plant species that are used in the formulation of decoctions for children [25]. Another ethnobotanical survey, still carried out in western Niger but this time at markets and which concerned twenty-four healers, ten users, and three herbalists, listed 42 medicinal plants used to ensure the well-being of babies. The plants identified consist of nineteen (19) herbaceous plants, ten (10) trees, nine (9) shrubs and three (3) lianas [29].

Table 1 presents the medicinal plants most used for infant fortification. Thirteen (13) species have been identified belonging to seven families. They are intended to promote infant development (fortifying). All these plants are used systematically and in various combinations according to mothers, matrons, and healers, mainly in the form of a decoction called Djitti [22,30]. The six plants most used for their supposed or real galactogenic power are presented in Table 2. These plants are also used systematically and in various combinations according to mothers, matrons, and healers. They are intended to promote

the rise of milk (galactogen) and to prevent the loss of weight of the mother. It is mainly the aerial part of the plant that is used, namely the leaves, the flowers, the fruit, the leafy stems, the bark of the stem and trunk, and the leafy branches. These are the organs which have easy access and removal and which are easy to handle [29]. The leaves are the most used part of these plants, ahead of the bark of the trunk, the stems and leafy branches, and the fruits [15,31–33].

Table 1. Infant fortification plants encountered in Niger, the parts used, and the therapeutic methods of preparation.

Plants Species	Family	Vernacular Names in Zarma or Hausa	Part of the Plant Used	How to Use	References
<i>Blepharis linariifolia</i> Pers.	Acanthaceae	Barkari sikani ganji or Gringal (Z),	Aerial part	Decoct and drink	[14,19,34,35]
<i>Hygrophila senegalensis</i> (Nees) T Anders.	Acanthaceae	Banguizé (Z); Iyan tapki (H)	Aerial part	Decoct and drink	[35,36]
<i>Bauhinia rufescens</i> Lam.	Caesalpinaceae	Namary (Z); Dirga (H)	twigs	Decoct and drink	[33,37–39]
<i>Combretum glutinosum</i> Perr. ex DC.	Combretaceae	Kokorby (Z); Taramnya (H)	Leaves	Decoct and drink	[14,40–42]
<i>Chrozophora brocchiana</i> Vis.	Euphorbiaceae	Dorey (Z), Damaiji (H)	Aerial parts	Decoct and drink	[43,44]
<i>Phyllanthus pentandrus</i> Schumach and Thonn	Euphorbiaceae	Koln'wey wa (Z); hatsii'n kurtcya (H)	Aerial part	Decoct and drink	[19,31,39,45]
<i>Bergia suffruticosa</i> Fenzl.	Elatinaceae	Kobassay (Z); duduchiya (H).	Whole plant	Decoct and drink	[46,47]
<i>Stylosanthes erecta</i> (Retz.) Alston	Fabaceae	Kassantouri (Z)	Whole plant	Decoct and drink	[48–50]
<i>Gossypium herbaceum</i> L.	Malvaceae	Habou Lamba (Z); andiga kata (H)	Leafy stems	Decoct and drink	[51–54]
<i>Tephrosia lupinifolia</i> DC.	Papillonaceae	Ganda damsai (Z); Gudjya'l kasa (H).	Aerial part (in association)	Decoct and drink	[13,55]
<i>Tephrosia linearis</i> (Willd) Pers.	Papillonaceae	Dosari (W), Tchintchy Mahalba (H)	Aerial parts	Decoct and drink	[14,56]
<i>Indigofera leptoclada</i> Harms	Papillonaceae	Hari Kania (Z)	Aerial part	Beverage	[41,57]
<i>Gardenia sokotensis</i> Hutch.	Rubiaceae	Tondi-fara (Z); Gau dan dute (H)	Leafy twigs	Beverage	[14,18,38]

Table 2. The galactogenic plants encountered in Niger, the parts used, and the therapeutic methods of preparation.

Plants Species	Family	Vernacular Names	Part of the Plant Used	How to Use	References
<i>Launaea chevalieri</i> (O. Hoffm and Muschl)	Asteraceae	Ko kulu gna (Z)	Aerial part	Beverage	[14,58]
<i>Chrozophora brocchiana</i> Vis.	Euphorbiaceae	Damaji (H), Dorey (Z)	Aerial parts	Decoct and drink	[43,44,59]
<i>Euphorbia balsamifera</i> Aiton.	Euphorbiaceae	Barred (Z); Aguwa (M)	Whole plant	Beverage	[31,56,60]
<i>Arachis hypogaea</i> L.	Fabaceae	Damsi kolanché (W); Goujiya (M)	Aerial part	Macerate and drink	[14,61–63]
<i>Boscia salicifolia</i> Oliv.	Capparidaceae	Shiukilifa (Z); Zure (H)	Leaves, leafy twigs	Powder in drink	[60,64]
<i>Tephrosia purpurea</i> (L.) Pers.	Papillonaceae	Massah (Z); Margwa (M)	Aerial part	Decoct and drink	[56,65–67]
<i>Guiera senegalensis</i> IJ.F.Gmel.	Combretaceae	Sabara (Z); Shabara (M)	Aerial part	Decoct and drink	[14,33,68–70]

2.2. Other Uses of Infant Fortification Plants and Galactogenic Plants in Niger

Tables 3 and 4 summarize the other medicinal uses of infant fortification and galactogenic plants for the people and traditional healers of Niger. Indeed, medicinal plants recognized as having fortifying virtues for the child are also used for other therapeutic purposes to treat other diseases in traditional medicine in Niger, namely: diarrhea, dysentery, stomach aches, measles and stomach aches, urinary retention, syphilis, skin burns, urogenital infections, constipation, rubles from pregnancy or birth, genitourinary, ophthalmia, nausea, snakebites, leprosy, chest pain, smallpox, cramps, anti-abortion, kidney trouble, heart trouble, vertigo, high blood pressure, fever, jaundice, hemorrhoids, diabetes, and so on [60,71]. Those plants with galactogenic properties are also used for insanity fumigation, pregnancy stabilizers, hemorrhoids, snakebites, regulating heavy menstruation, relaxing in hemorrhage, otitis, wound dressing, stomach aches in both children and adults, and many more reasons [72].

2.3. Use of Infant Fortification Plants and Galactogenic Plants from Niger by Other Traditional Pharmacopoeias

The medicinal plants listed in Tables 1 and 2 do not only belong to the Niger Pharmacopoeia. Indeed, a review of the literature shows that they are also used by other pharmacopoeias but often against other pathologies.

Blepharis linariifolia is used against diseases such as tuberculosis, chest pains, and wounds [34,73]. Infusion from the whole plant is used in the treatment of syphilis [74,75]. Seeds and leaves are used in veterinary medicine [76], and for weight gain, but also as a galactogen [73]. In Senegal, the Socé people use drops of pounded *Hygrophila senegalensis* seed juice for all eye diseases [36]. In Burkina Faso it is used against epilepsy [77]. *H. senegalensis* is also used in Nigeria for various viral infections [78,79]. *Bauhinia rufescens* has been used in Burkina Faso against pregnancy–birth and genito-urinary disorders [18]. The twigs of the plant are used to strengthen infants. The leaves are used against diarrhea, dysentery, ophthalmia, and nausea [37,80]. *B. rufescens* is also used for viral infections [81], oral infection [82] or snakebites [83,84]. A *Chrozophora brocchiana* decoction of the whole plant is anthelmintic [85], antiseptic for purulent wounds [86], and used for anti-ophthalmia,

and the root sap is used as ear drops to treat otitis. The decoction of the leaves in drink facilitates delivery [59]. *C. brocchiana* is also used to treat dentition troubles [87]. *Bergia suffruticosa* is used to repair bones and heal wounds [47], to treat eczema [88], for stomach pains, and as an antidote to scorpion stings [89,90]. In Burkina Faso, the decoction of the whole plant in an enema or a drink is an antimalarial recipe, and it is also used to fortify children [91]. *B. suffruticosa* has also been tested as a source of antifungal bioactives [92,93]. *Stylosanthes erecta* is a potential medicinal plant, used in Burkina Faso against various ailments [71] but also in traditional Ayurveda and Siddha medicine [94]. Traditionally, it is used as an anthelmintic, for diabetes, and for various other disorders [95], but it is also used for its antibacterial properties for treatment of diarrhea [96]. *Gossypium herbaceum* is used as an abortifacient, contraceptive, and diuretic agent [53,97,98]. *G. herbaceum* has been used in traditional medicine from Africa [78,99] to India [100,101] to treat a large range of disorders [53]. *Gardenia sokotensis* has been used in Burkina Faso where the decoction of the leafy twigs is used in the treatment of malaria, the powder of the roots is used against cramps, and the bark of the trunk as an anti-abortion medicine and against nausea, kidney problems, heart problems, dizziness, arterial hypertension, and fever [71,102,103]. Among the range of action of *G. sokotensis*, we can also find malaria treatment [104] and antalgic potential which is used for stomach cramps [105] as well as sports [106]. *Combretum glutinosum* is the most widespread species of *Combretum* in Senegal and the most prescribed by traditional therapists in the treatment of common ailments throughout the territory [36,107–109]. The Fulani of Nigeria use the infused bark against influenza and rheumatism. A root decoction is used against kidney pain and gonorrhoea [57]. The crushed green seeds are used in the treatment of wounds and syphilis, as well as in veterinary practice [110]. *Combretum glutinosum* has a wide array of anti-infection properties [81,111–115]. Members of the genus *Phyllanthus* are traditionally used in the treatment of obesity [116] and liver disorders [117]. A recent study strongly suggests that the aqueous extract from the leaves of *Phyllanthus pentandrus* may be beneficial in the treatment of non-alcoholic fatty liver disease commonly associated with obesity [118]. *Phyllanthus pentandrus* seems to be widely used on the Indian continent for a variety of ailments [118–121]. Many plants of the genus *Tephrosia* are traditionally used for the treatment of diseases such as rheumatic pains, syphilis, dropsy, stomach ailments, diarrhea, asthma, abortive, respiratory, laxative, diuretic, and inflammatory disorders [122,123]. They are also used as tonic, laxative, anti-venom, anti-ulcer, anti-diarrhoea, and anti-leprosy agents [124]. The roots of *Tephrosia lupinifolia* are traditionally used in Pakistan by indigenous peoples as a medicinal plant for the treatment of diseases such as malaria, diarrhea, tuberculosis, and toothache [125]. The decoction of the leaves in drink facilitates delivery [59]. Two recent reviews connected these applications [126,127]. The bark, fruits, leaves, root bark, roots, stem bark, and twigs of *Boscia salicifolia* are mainly used as an anthelmintic and are used in herbal medicine against parasitic diseases, eye problems, infertility, fever, malaria, gastrointestinal problems, headaches, skin diseases, wounds and injuries, oedemas, toothaches, and in ethno-veterinary medicine [72,128–131]. *Guiera senegalensis* is widely used in traditional medicine by African healers in the treatment of various ailments [68,132,133]. The leaves are used in the treatment of cough, dyspneic states, bronchial and lung diseases, dysentery-like diarrhea, colic, eczema, various parasitic diseases, asthma, dental caries, gingivitis, against hypotension, and as a tenifuge [11,36,64,134,135]. The Fulani and peasants of Nigeria apply the powder of the crushed leaves to incisions made at the site of snakebites to detoxify from the venom [136]. The branches are used to treat nervous disorders (epilepsy, madness), fevers with vomiting, and sexual asthenia, and the leafy twigs are used in the form of herbal tea in breastfeeding women [36]. *G. senegalensis* is also prescribed by Senegalese healers as a diuretic in the case of oliguria and anuria [36,88]. The galls are used for their diuretic,

depurative, antispasmodic, antiseptic, antifungal, and antiviral properties [81,137]. Parts of *Euphorbia balsamifera* used for medicinal purposes include leaves, roots, and exudate [138]. The roots and the leaves are strongly laxative, and the leaves and the exudate are used for their anthelmintic and diuretic properties [139]. *E. balsamifera* is also used as a traditional analgesic in the treatment of acute dental pulpitis and as an antidiabetic [140]. *Euphorbia balsamifera* and *Arachis hypogaea* are frequently implicated in the galactogenic preparations of agro-pastoralists in Benin. The mode of preparation of these recipes was essentially that of decoction [141]. In Senegal, a study carried out on 37 teeth showed that the latex of *Euphorbia balsamifera* is an effective pulp devitalizer. Its action was comparable to that of pulpal nerve caustics [142]. In China, the nuts of *Arachis hypogaea* are considered softening, pectoral, and peptic where the aperitif and emollient oil is taken internally in milk to treat gonorrhoea and externally to treat rheumatism [143]. In Zimbabwe, groundnut is used in folk remedies for plantar warts. In DR Congo, it is used as a detoxifying agent and as an aphrodisiac [144]. Peanut consumption was also associated with a relatively low risk of coronary heart disease [145–147] and strong galactogenic potential [101,148–150].

Table 3. Other recipes related to infant fortification plants by the populations and healers of Niger.

Plants Species	Diseases or Conditions Treated	Part of the Plant Used	How to Use	References
<i>Blepharis linariifolia</i> Pers.	Child care, measles and stomach aches, urinary retention, syphilis, skin burns and urogenital infections	Aerial part	Decoct and drink; tisane; decoct and wash	[14,69,73,74,151]
<i>Hygrophila senegalensis</i> (Nees) T Anders.	Eye Diseases, jaundice and the extraction of foreign body from the eyes and ears, sickle cell crises, and epilepsy.	Seeds; aerial part	Suck in drops	[14,32,36,77]
<i>Bauhinia rufescens</i> Lam.	Pregnancy stabilizer, anti-diarrheal, against stomach aches, pregnancy–birth and genitourinary disorders, diarrhea, dysentery, ophthalmia, nausea and snakebites, leprosy, care of chest ailments, smallpox, diarrhea, and dysentery	Aerial parts; leaves; root and bark; bark	Decoct and drink	[18,37,80,85,152–154]
<i>Combretum glutinosum</i> Perr. exDC	Furuncle, abscess, anemia, cystitis, hemorrhoids, stomach aches, hepatobiliary affections, hematuria, headaches, and constipation.	Leaves	Decoct and drink	[14,31,114,153]
<i>Chrozophora brocchiana</i> Vis.	Vermifuge and antiseptic for purulent wounds, and anti-ophthalmia, treatment of otitis in the ears, treatment stomach aches in both children and adults. Hemorrhoids, dressing of wounds by the Tuaregs, and deliverance during childbirth	Whole plant; root; leaves	Decoct and drink; suck in drops; lapping powder	[14,25,31,43,59,155]
<i>Phyllanthus pentandrus</i> Schumach and Thonn	Child weaning, scorpion sting, stomach pain, and indigestion	Aerial parts; leaves	Decoct and drink	[31,45,118]

Table 3. Cont.

Plants Species	Diseases or Conditions Treated	Part of the Plant Used	How to Use	References
<i>Bergia suffruticosa</i> (Delile) Fenzl.	Care for bones, wounds, stomach pains, and an antidote against scorpion stings. Common cold, malaria, tumor, and arterial hypertension.	Aerial parts; whole plant	Decoct and drink. Decoct and wash	[31,89,90,156]
<i>Gossypium herbaceum</i> L.	Bronchial asthma, skin diseases and infections, stimulation of lactation (galactogen). First aid remedy in the treatment of cuts, bruises and wounds, amenorrhea, fever, and dysmenorrhea.	Aerial parts; flowers; leafy stems	Decoct and drink	[51,53,97,98,157]
<i>Tephrosia lupinifolia</i> DC.	Hemorrhages and abortions during pregnancy as well as immediate postpartum hemorrhages. Galactogen in the mother and as a fortifier in the child, stomach aches, and vomiting.	Aerial part; whole plant	Decoct and drink	[13,127]
<i>Tephrosia linearis</i> (Willd) Pers.	Galactogen for the mother, Treatment of abscesses, Malaria	Aerial parts	Decoct and drink	[14,127,158]
<i>Indigofera leptoclada</i> Harms	Breast abscess, treatment of skin and mucous membrane diseases, and malaria.	Whole plant	Bake and millet. Decoct and drink	[11,57,159]
<i>Gardenia sokotensis</i> Hutch.	Care of jaundice, stomach aches and stabilization of pregnancy. Malaria, cramps, anti-abortion, nausea, kidney, heart, vertigo, high blood pressure, and fever.	Whole plant; twigs; leaves; roots; bark (trunk)	Beverage; decoct and drink; powder	[14,71,102,103,160]

Table 4. Other recipes linked to galactogenic plants by the populations and healers of Niger.

Plants Species	Diseases or Conditions Treated	Part of the Plant Used	How to Use	References
<i>Sonchus chevalieri</i> (O. Hoffm and Musch L.) Dandy	Lactation stimulation	Aerial parts	Decoct and drink	[14]
<i>Euphorbia balsamifera</i> Aiton.	Insanity fumigation and pregnancy stabilizer.	Aerial part	Decoct and drink	[31,161]
<i>Arachis hypogaea</i> L.	High blood pressure and cancer	Seeds	Decoct and drink	[150,162]
<i>Tephrosia purpurea</i> (L.) Pers.	Effective against snake venom, regulator of heavy menstruation, and revitalizing in hemorrhages.	whole plant Leaves	Decoct and drink Infuse and drink	[31,64,127]
<i>Boscia salicifolia</i> Pers	Newborn skin rashes.	Leaves	Powder and drink	[64,72]
<i>Guiera senegalensis</i> J.F. Gmel.	Diarrhea, hemorrhoids, hypertension headaches, dysmenorrhea, AIDS opportunistic infections, bronchitis, diarrhea dysentery, eczema appetite, colds, coughs, asthma, sinusitis, headaches, dental caries, and asthenia.	Leaves		[14,108,133]

3. Composition of Secondary Metabolites and Biological Activities of Plants

The categorial composition in secondary metabolites of infant fortification and galactogenic plants subject to this bibliographical summary is presented in Tables 5 and 6.

3.1. *Blepharis linariifolia*

Phytochemical composition. Phytochemical screening of the aqueous extract of the whole plant reveals the presence of flavonoids, saponosides, and tannins [31]. The plant also contains sterols and triterpenes; however, quinones and cyanogenic glycosides are absent and the alkaloids and flavonoids are present only in the fruits [15]. The flowers contain saponosides, flavonoids, steroids, and anthocyanins and the seeds contain triterpenes and mucilages [11].

Biological activities. Plants of the genus *Blepharis* exhibit a wide range of pharmacological activities including antioxidant, anti-inflammatory, anti-arthritic, antimicrobial, antifungal, anti-ulcer, and cytotoxic activities [34]. The seed extract exhibits moderate antimicrobial activity, and the whole plant exhibits antioxidant and hepatoprotective activity [70,163]. The antioxidant activity and total phenol and flavonoid content of the plant [69] could explain its use in cardiovascular and anti-inflammatory diseases [164].

3.2. *Hygrophila senegalensis* (Nees) T Anders.

Phytochemical screening shows that *H. senegalensis* contains phytosterols, terpenes, phenolics, tannins, alkaloids, saponosides, and cyanogenic glycosides [32].

3.3. *Bauhinia rufescens* Lam.

Phytochemical composition. Phytochemical screening of the leaves shows the presence of triterpenes, alkaloids, tannins, saponins, and flavonoids but no coumarin glycosides [154]. We also note the presence of carbohydrates, tannins, flavonoids, saponins, terpenes, and steroids in stem bark extracts [152]. The synergistic effect of the presence of flavonoids, tannins, and saponins could be responsible for the strong antioxidant activity. The leaves could therefore contribute to the treatment of diseases caused by free radicals (RL) [153].

Biological activities. Extracts from the leaves, roots, and stem bark exhibit antibacterial [152], antioxidant [153,154], anti-inflammatory [125], hypoglycemic, and nephroprotective activities [165]. These beneficial effects could explain the use of *Bauhinia* species as medicinal plants worldwide, including Africa, Asia, South America, and Central America [165].

3.4. *Chrozophora brocchiana* Vis.

Chemical composition. The groups of secondary metabolites identified in the sample are tannins, mucilage, and anthracene derivatives [43].

Biological activities. The decoction of the whole plant is vermifuge, antiseptic for purulent wounds, and anti-ophthalmia [31,155]. The plant has anti-plasmodial activity. However, this activity is moderate (IC₅₀ = 8.2 µg/mL) compared to that of *Artemisia annua* (IC₅₀ = 0.74 µg/mL) [166].

3.5. *Bergia suffruticosa* (Delile) Fenzl.

Phytochemical composition. The presence of phenols, alkaloids, and carbohydrates has been reported but the plant does not contain saponins [167].

Biological activities. The methanolic extract has good antiradical activity [168]. *B. suffruticosa* also possesses antitumor and antihypertensive properties [156].

3.6. *Stylosanthes erecta*

Chemical composition. The leaves of *Stylosanthes erecta* contain glycoside alkaloids, saponins, phenolic compounds, flavonoids, and phytosterols. These different phytochemicals possess a wide range of interesting biological activities. As primary metabolites there are proteins, carbohydrates, and amino acids [48,94,95].

Biological activities. The methanolic extract has good antiradical activity [168]. The plant contains biologically active phytochemicals that can serve as candidates for the discovery of new drugs [94].

3.7. *Gossypium herbaceum*

Chemical composition. The phytochemical study of this plant reveals the presence of alkaloids, carbohydrates, flavonoids, glycosides, saponins, steroids, tannins, and terpenoids. The plant also contains carbohydrates, proteins, lipids, and calcium. The main pigment in cottonseed is gossypol, a phenolic compound. The unsaponifiable fraction of Indian cottonseed oil contains sitosterol, ergosterol, lipids, gossypol, oleic, palmitic, and linoleic acids [53,98,157,169].

Biological activities. The pharmacological study of this plant reveals antibacterial, anti-convulsive, antidepressant, anti-diabetic, anti-fertility, anthelmintic, antioxidant, antitoxic, anti-spermatogenesis, antitumor, anti-ulcer, antiviral, abortive, contraceptive, and diuretic activities [51,53,97,98].

3.8. *Gardenia sokotensis* Hutch.

Chemical composition. Phytochemical screening of the crude extract from the roots of *G. sokotensis* revealed the presence of alkaloids, glycosides, saponins, and steroids and very little or no tannins and flavonoids [170]. On the other hand, the phytochemical screening of the fruits revealed the presence of flavonoids. Also noted is the presence of alkaloids, saponins, steroids, tannins, cardiac glycosides, and flavonoids [160]. The pulp is eaten as food but the seeds are discarded [171].

Biological activities. The extract from the roots of *G. sokotensis* showed moderate antitumor activity when tested against melanoma cells [172]. On the other hand, the ethanolic extract of the leaves showed an interesting inhibitory effect on all human cancer cell lines [173]. The aqueous extract of *G. sokotensis* presented an interesting anti-plasmodial effect [174].

3.9. *Combretum glutinosum*

Phytochemical composition. The phytochemical study reveals the presence of tannins, unsaturated sterols, triterpenes, saponosides, flavonoids, polyphenols [175,176], alkaloids [177], and coumarins [176].

Biological activities. Recent studies have shown that the methanolic extract of the leaves would have a very significant antiradical power with an inhibition concentration CI 50 of 0.65 µg/mL [175]. In addition, an experiment carried out in mice has demonstrated antitussive activity [109].

3.10. *Euphorbia balsamifera*

Phytochemical composition. Phytochemical analysis of crude extracts from different parts of *E. balsamifera* (leaves, stem, roots) has revealed the presence of tannins, saponins, steroids, terpenoids, flavonoids, cardiac glycosides, and gum [178].

Biological activities. Extracts from the leaves, stems, and roots exhibit antibacterial properties. These extracts were especially effective against *Salmonella typhimurium*, *Pseudomonas aeruginosa*, *Klebsiella* spp., *Escherichia coli*, and *Candida albicans* [178].

3.11. *Guiera senegalensis*

Phytochemical composition. The phytochemical study of the leaves, roots, and trunk bark of *Guiera senegalensis* reveals the presence of flavonoids, alkaloids, saponins, gallic and catechin tannins, coumarins, mucilage, cardiogenic and cyanogenic glycosides sterols, and triterpenes [179]. The methanolic and aqueous extracts of the galls contain alkaloids, flavonoids, steroids, triterpenes, saponosides, and anthocyanins [137]. Experimental studies have shown the presence of harmine, tetrahydroharmine, harmaline, and Guieranone A in the leaves and roots of *G. senegalensis* [133].

Biological properties. The aqueous extract of the leaves has an antihypertensive property [180] and the macerated extract has antibacterial properties. The decoction of the leaves has antitussive activity. The chloroform extract of the roots has antimalarial activity [181,182]. The galls have an antidiabetic power [183], a strong anti-inflammatory activity [184], and an antioxidant activity in vitro [137]. The aqueous decoction of the galls has an anti-proliferative activity [185].

3.12. *Arachis hypogaea*

Phytochemical composition. *Arachis hypogaea* contains several active components including flavonoids, phenolic acids, phytosterols, alkaloids, and stilbenes [186]. Roots have the highest levels of phytochemicals [187].

Biological activities. *Arachis hypogaea* has a wide variety of pharmacological activities. It has antimicrobial, antifungal, antiviral, antioxidant, anticancer, antihypertensive, neuroprotective, antimutagenic, antiproliferative, and anti-inflammatory activities [162,188]. Peanut allergy is the most common cause of death from food allergy [188].

3.13. *Boscia salicifolia*

Phytochemical composition. Ethnopharmacological research has identified alkaloids, anthraquinones, flavonoids, saponins, tannins, and several glycosides in the leaves of *B. salicifolia* [72,189].

Biological activities. The following biological activities have been reported from the leaf, root, and stem bark extracts of *B. salicifolia*: anthelmintic, antibacterial, antiplasmodial, antioxidant, uterotonic, and cytotoxic activities [72].

3.14. *Tephrosia lupinifolia*

Phytochemical composition. Phytochemical screening carried out on the methanolic extract of the whole plant reduced to powder showed the presence of saponins, sterols and terpenes, tannins, and alkaloids. Flavonoids were present in the aqueous extract only [190].

3.15. *Indigofera leptoclada* Harms

Phytochemical composition. Phytochemical screening of the aerial part by sonication showed the presence of phenolic compounds [191].

Biological activities. The decoction of the aerial part is used in drinks as a tonic for infants. Studies have shown that *I. leptoclada* is used for its anti-protozoal properties in the central plateau of Burkina Faso [11]. It is also used to treat malaria in Burkina Faso.

3.16. *Sonchus chevalieri*

Phytochemical composition. The phytochemical screening carried out on the leaves contained flavonoids whose HPLC-MS+ analysis revealed the presence of quercetin and luteolin [191].

3.17. *Tephrosia purpurea*

Phytochemical composition. Phytochemical screening of whole-plant extracts showed the presence of alkaloids (Dragendorff test), flavonoids, tannins (Stiasny reagent), sterols, and terpenes (sulfuric acid) and an absence of saponins and quinones [31].

Biological activities. The aerial part is used in decoction as a galactogen for mothers and a fortifier for children.

Overall, most phytochemical categories are represented in these plants. In terms of the specific identification of bioactive molecules, polyphenols and phenolic acids seem to have been investigated the most [69,192–194]. While common molecules such as gallic or vanillic acid, resveratrol, apigenin, kaempferol, quercetin or myricetin, and their derivatives are present in plants like *E. balsamifera*, *A. hypogaea*, *G. senegalensis*, or *B. linariifolia*, other more specific structures have also been identified. We can cite for example verbascoside in *B. linariifolia* [69], lupinifolin, and derivatives in *T. lupinifolia*, or purpuritenin in *T. purpurea* [127], menisdaurin and oxepin derivative in *B. rufescens* [125], dammarolic acid derivative and β -amyrin in *C. glutinosum* [195], isoorientin and cycloartanol in *E. balsamifera* [193], or arachidins and pinosylvin in *A. hypogaea* [194]. The structure of these molecules can be found in Figure 1. An extensive investigation of lactogenic molecules has been carried out recently and we can find similar structures in their listing [196].

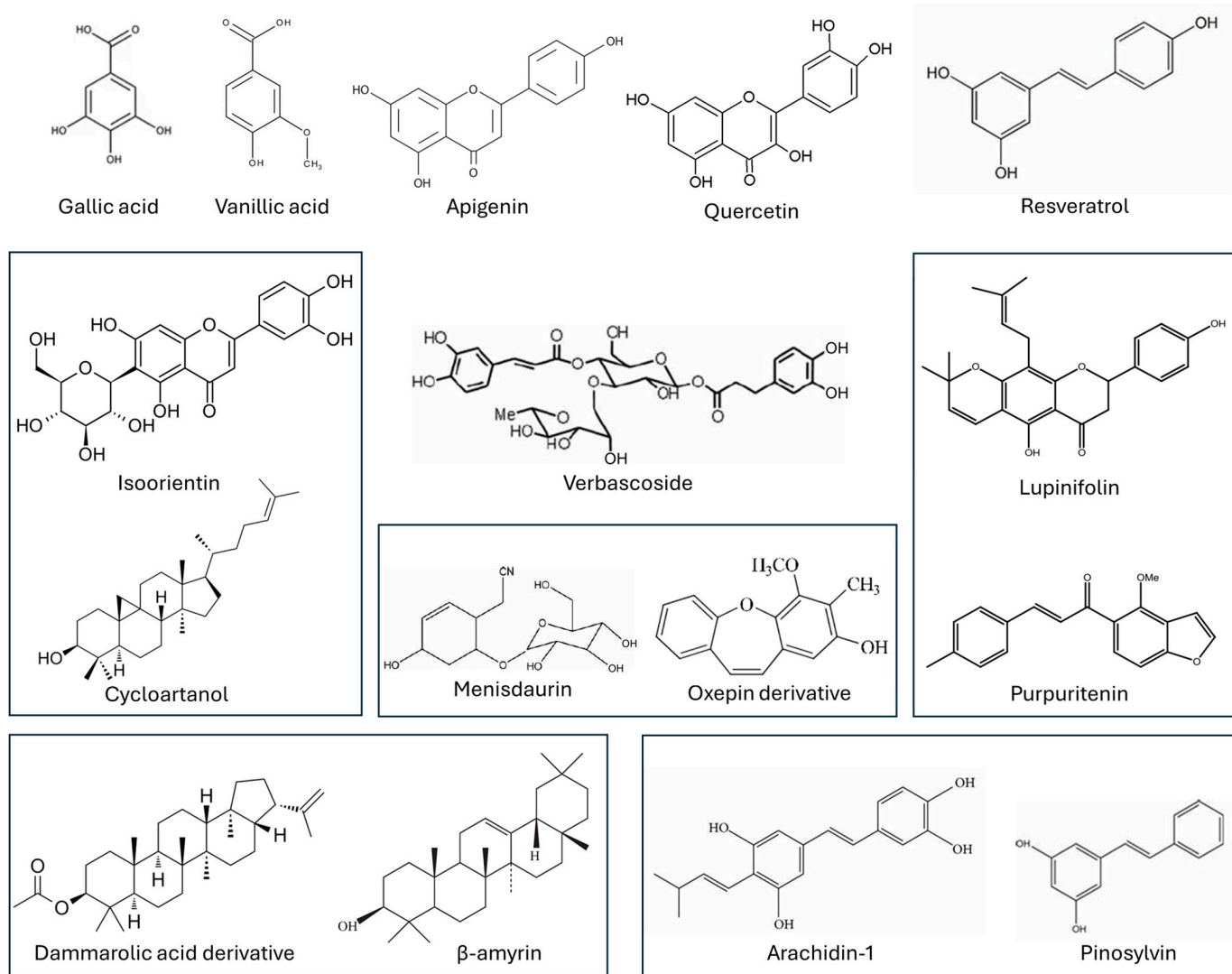


Figure 1. Chemical compounds of traditional medicinal plants used in Niger.

Structure–function relationships have been investigated for veterinary purposes in relation to galactopoiesis and the authors indicated that alkaloids were more likely to help in the letting down of milk, while polyphenols improved milk yield and protein content, and saponins and tannins helped with global health status [197].

Table 5. Chemical compounds of infant fortification plants encountered used in Niger.

Plants	Method of Extraction	Method of Detection	References	Organs	Chemical Compounds											
					Al	dQ	Ta	Fl	An	Lan	dCy	T	St	Card	Sap	Cou
<i>Blepharisternariaifolia</i>	Decoction	Screening	[31,34]	Whole plant	+	–	+	+	+	–	–	+	+	–	+	+
<i>Hygrophila senegalensis</i>	Decoction	Screening	[32]	Leaves	+	–	+	+	–	–	+	+	+	–	+	–
<i>Bauhinia rufescens</i> Lam	Decoction	Screening	[152,154]	Bark leaves	+	–	+	+	–	–	–	+	+	–	+	–
<i>Combretum glutinosum</i>	Decoction	Screening	[175–177]	Leaves	–	–	+	+	+	–	+	–	–	–	–	–
<i>Chrozophora brocchiana</i>	Maceration	Screening	[43,190]	Whole plant	+	–	+	+	–	–	–	+	+	–	+	–
<i>Phyllanthus pentandrus</i>				Aerial part	+	–	+	+	–	–	–	–	–	–	+	–
<i>Bergia suffruticosa</i>	Soxhlet	Screening	[156,167]	Whole plant	+	–	+	–	–	–	–	+	+	–	–	–
<i>Stylosanthes erecta</i>	Decoction	Screening	[48,94,95]	Leaves	–	–	+	–	–	–	–	+	+	–	+	–
<i>Gossypium herbaceum</i>	Maceration	Screening	[53,98,157,169]	Aerial part	+	–	+	+	–	–	+	+	+	–	+	–
<i>Tephrosia lupinifolia</i>	Maceration	Screening	[190]	Whole plant	+	–	+	+	–	–	–	+	+	–	+	–
<i>Indigofera leptoclada</i>	Sonication	HPLC-MS+	[191]		No data in the literature											
<i>Tephrosia linearis</i>																
<i>Gardenia sokotensis</i>	Decoction	Screening	[32,170]	Root and fruit	+	–	+	+	–	–	+	+	+	–	+	–

Al: alkaloids; dQ: quinone derivatives; Ta: tannins; Fl: flavonoids; An: anthocyanin; T: terpenes; dCy: cyanogenic derivatives; St: sterols; Card: cardiogenic glycosides; Sap: saponins; Lan: leucoanthocyanins; Cou: coumarins. + is a positive reaction; – is a negative reaction.

Table 6. Chemical compounds of galactogenic plants used in Niger.

Plants	Method of Extraction	Method of Detection	References	Organs	Chemical Compounds											
					Al	dQ	Ta	Fl	An	Lan	dCy	T	St	Card	Sap	Cou
<i>Sonchus chevalieri</i>	Sonication	HPLC-MS+	[191]		No data in the literature											
<i>Chrozophora brocchiana</i>	Maceration	Screening	[190]	Whole plant	+	–	+	+	–	–	–	+	+	–	+	–
<i>Euphorbia balsamifera</i>	Maceration	Screening	[178]	Whole plant	+	–	+	–	–	–	–	+	+	–	–	–
<i>Arachis hypogaea</i>	Maceration	HPLC	[186,187]	Fruits	–	–	–	+	–	–	–	–	–	–	–	+
<i>Tephrosia purpurea</i>	Decoction	Screening	[198]	Leaves	+	–	+	+	–	–	–	–	–	–	+	–
<i>Boscia salicifolia</i>	Decoction	Screening	[31]	Leaves	+	–	–	+	–	–	–	+	+	–	+	–
<i>Guiera senegalensis</i>	Decoction		[137,179]	Leaves	+	–	+	–	–	–	–	+	+	–	+	+

Al: alkaloids; dQ: quinone derivatives; Ta: tannins; Fl: flavonoids; An: anthocyanin; T: terpenes; dCy: cyanogenic derivatives; St: sterols; Card: cardiogenic glycosides; Sap: saponins; Lan: leucoanthocyanins; Cou: coumarins. + is a positive reaction; – is a negative reaction.

4. Conclusions

The synthesis of current knowledge on the medicinal plants cited shows that these medicinal species are used in Niger as infant fortification and galactogens for breastfeeding mothers. It should also be noted that none of these plants have been the subject of in-depth study for their potential use as actual therapeutic agents. Consequently, many investigations remain to be undertaken and the research needs to be carried out for a better valorization of medicinal plants in Niger. The future direction for scientific knowledge

is to take into account the clinical proof available through meta-analyses to ensure that traditional medicine options do not lead to unnecessary harm for the patient. An element of standardization of treatments and quality control of the preparation would be important as well. Through collection of individual processes, some common patterns could emerge that differentiate treatment protocols depending on the health issue to be targeted.

The topic of conservation of plants for sustainable use in traditional medicine is also of great importance. Some of the medicinal plants cited in this review are on the red list of species threatened by extinction [27]. Whether this risk is due to climate change [199,200], cultural malpractice, or economic reasons [201,202], it is essential for local populations to be aware of this risk [26,126,203]. On a positive note, some work has been conducted at the Federal Polytechnic Kaura Namoda Campus, Zamfara State, Nigeria leading to the proposed creation of a depository for seeds of endangered medicinal plants [56]. Another interesting point is the high level of literacy about traditional medicinal plants, not only in rural areas but also in the bigger cities [35,38,204,205]. An ethnobotanical approach helps in gathering the missing information [206,207]. There are also a number of initiatives to involve local populations in conservation through literacy programs of the traditional knowledge [208–210], including digital media to safekeep that ancestral knowledge as oral traditions tend to disappear [211–213]. Initiatives can also include multi-dimensional approaches [214] and other uses of technology for culture of endemic plants [215].

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