Chapter

Medicinal Plants Used as Galactagogues

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Abstract

The recommended diet for human infants within the first 6 months of life is breast milk. No other natural or artificial formulation has been able to match up to this gold standard. Mothers who have attempted to pursue exclusive breastfeeding can, however, attest to numerous nutritional and non-nutritional challenges mainly resulting in insufficient milk production (hypogalactia) or the absence of milk production (agalactia). There are very few and officially recommended orthodox drugs to increase lactation. The most widely used galactagogues being chlorpromazine, sulpiride, metoclopramide and domperidone are associated with very high incidences of unpleasant side effects including their extra-pyramidal effects in both mother and infant. There is therefore a need to keep searching for more acceptable galactagogues. This section reviews current literature on medicinal plants used within the local Ghanaian community to enhance lactation. Various electronic databases such as PubMed, Science Direct, SciFinder and Google Scholar as well as published books on Ghanaian medicinal plants were searched. A total of 22 plants belonging to 13 families were reviewed with regards to their medicinal values, information on lactation and toxicity.

Keywords: galactagogues, lactation, breastfeeding, medicinal plants

1. Introduction

Exclusive breast feeding involves feeding only breast milk without any added fluids or solids. It is highly recommended by the World Health Organization (WHO) for the first 6 months of life with supplemental breast feeding continuing for at least 2 years [1]. This is because optimal breastfeeding of infants has a direct impact on growth, development, and health in the neonatal period [2, 3]. Breastfeeding is known to have invaluable benefits both for the child and mother. For the mother, breast feeding causes weight reduction, provides stronger interaction with the infant as well as pleasure and pleasant emotion. It also provides a more practical approach to feeding in comparison to the use of a bottle prevents breast cancer and pregnancy and provides relief in breast pain while also being economical. For the infant, it promotes affectional bond with the mother while adequately supplying the nutritional and emotional needs [3]. In the developing world, low immunization rates, contaminated drinking water,

and reduced immunity as a result of malnutrition make breast feeding crucial to reducing life threatening infections. A review of interventions in 42 developing countries estimated that exclusive breast feeding for 6 months, with partial breastfeeding continuing to 12 months, can prevent 1.3 million (13%) deaths each year in children under 5 years [3]. However exclusive breastfeeding is not without challenges.

2. Challenges with breastfeeding

The WHO's recommendation for breastfeeding has been adopted by several countries all over the World and also in West Africa, but this has presented with several challenges, hence reducing the number of children who could potentially be breastfed. In the United States, for example, less than half of infants receive any breast milk at 6 months (49.4%), and approximately one-quarter are breast-fed up to 1 year (26.7%) [4]. Breast discomfort or pain, sore nipples, mastatitis, inverted nipples, presence of breast implants, difficulty getting baby to suck, poor weight gain and hypernatremia dehydration due to insufficient milk intake are rampant challenges encountered during breast feeding [3]. Lactation failure is also common among postpartum women, resulting in insufficient milk supply which is a major reason for early weaning. It has been claimed that at least 5% of women experience lactation failure (agalactias) whiles approximately 15% of women experience inadequate supply of their breast milk (hypogalactias) [5] at 3 weeks postpartum. The number of lactating women who have produce insufficient breast milk is on the rise [2]. There are a number of well-known causes of low breast milk supply that is primarily related to breast feeding management. These factors are difficult to control and require a good knowledge of breastfeeding practices. These factors include; schedule breastfeeding, skipping breastfeeding, supplementing the diet of the baby with infant formulas and poor latching of the baby on the breast. However, there are more complicated causes of low breast milk supply such as; insufficient mammary tissue (hypoplasia), medications (hormonal contraceptive pills), retained placenta, diseases (diabetes, jaundice), metabolic conditions (obesity), previous breast surgeries, cesarean section, thyroid and other hormonal disorders. Another cause is even environmental toxins such as pesticides. A study found that daughters of women who grew up in a pesticide contaminated environment had much higher incidence of insufficient mammary tissue than those living on the hill top of the same an area [6].

3. Solutions to breastfeeding challenges

To respond to the challenge of insufficient milk production (hypogalactia) or the absence of milk production (agalactia) milk banks are being created and the use of medication that induces, maintains or increases milk production are being used [2, 7].

Throughout history, donor breast milk banks have been the choice of some parents, and it is currently recommended as second choice if the mother's own milk is not available. However, the risk of possible transmission of diseases including HIV, cytomegalovirus, and Creutzfeldt-Jakob disease has induced the need for pasteurization. There are major concerns however as to what extent pasteurized donor breast milk retains the biological properties of mother's milk. Evidence on donor milk quality is limited [3] and operational human milk banks are not able to meet demands for especially the most vulnerable neonates [8].

3.1 Synthetic galactagogues

Orthodox drugs that are widely used as galactagogues are chlorpromazine, sulpiride, metoclopramide and domperidone [2] but there are reservations as to their efficacy and their association with very high incidences of unpleasant side effects including extra-pyramidal effects in both mother and infant. There is therefore a need to keep searching for more acceptable, safe and efficacious galactagogues [2, 9]. In the United States, Canada and Europe, metoclopramide and domperidone are widely prescribed [10].

Metoclopramide though prescribed off-label as a lactation aid has one troublesome side-effect of inducing depression. Extrapyramidal symptoms also occur in about 1 in 500 patients at even usual adult doses resulting in involuntary movements of limbs, facial grimacing, torticollis, oculogyric crisis, and rhythmic protrusion of tongue, bulbar type of speech, trismus, or dystonic reactions resembling tetanus. Metoclopramide is secreted in human milk and its safety in infants has not been established. Neonates are less able to clear the drug from their systems hence dystonias and other extrapyramidal reactions are more common in this pediatric population than in adults [10]. Severe depression, seizures and intestinal discomfort have also been reported in infants that consume milk from mothers treated with metoclopramide [2, 11]. Other adverse effects additionally reported in mothers include anxiety, several gastrointestinal disorders and insomnia [2].

Domperidone use in human clinical trials has also been associated with varying findings. In some recent human data no maternal or neonatal adverse effects were reported [2]. Other studies have however reported adverse effects in mothers such as xerostomia, gastrointestinal disorders, cardiac arrhythmia, and sudden death but none in infants [2]. Domperidone is reported to also increase the risk of sudden cardiac death or could be linked with increased risk of prolonged QT syndrome (arrhythmia) [4].

Sulpiride and chlorpromazine are also typical antipsychotics that have been documented to be effective as galactagogues but are also associated with extrapyramidal reactions and weight gain. Human growth hormone and thyrotropin-releasing hormone are other agents have also been utilized to increase breastmilk production, but these agents have very limited clinical experience behind them [2, 7]. Oxytocin, although widely used in the past, has limited scientific data as a galactagogue also [7].

3.2 Botanical galactagogues

There are numerous references in literature for herbal medicines that are used to aid breastfeeding. However these are mainly based on empirical traditions with few human studies that show evidence that milk synthesis can be increased and that these are safe [2]. Most herbal galactagogues are believed to exert their pharmacologic effects through interactions with dopamine receptors, resulting in increased prolactin levels and there by augmenting milk supply [7]. Galactagogues are useful for women who are unable to produce breast milk on their own due to infant prematurity, illness of the mother or child, adoption, or surrogate motherhood [7].

The use of medicinal plants to stimulate breastmilk production has a long history of use [10] in almost all cultures over the world but has not been extensively studied nor fully exploited for use in lactating mothers [2]. The use of herbal medicines and phytonutrients or nutraceuticals to treat various conditions is expanding rapidly worldwide [12]. Botanical galactagogues may have the advantages of various claims of efficacy, preference of consumers for natural therapies, erroneous belief that herbal products are superior to manufactured products as well as dissatisfaction with the results, cost and side effects from the orthodox galactagogues [12].

A literature search on botanical galactagogues used within Ghanaian communities revealed a number of plants that are used for such purposes but with very little information and scientific studies to back their efficacy and safety.

4. Medicinal plants used as galactagogues

4.1 Amaryllidaceae

4.1.1 Allium sativum L.

A. sativum (garlic) is a perennial herb cultivated in various parts of the world and widely used as a food ingredient [13, 14]. Garlic has been used as a spice, food, and medicine for over 5000 years, and is one of the earliest documented herbs utilized for the maintenance of health and treatment of disease [15]. Garlic has many medicinal properties including, anti-microbial, anti-fungal, anti-viral, anti-protozoal, anti-inflammatory, anticancer and antioxidants [13, 14]. Garlic has traditionally been used to strengthen the immune system and gastrointestinal health. Today, this intriguing herb is probably the most widely researched medicinal plant [15]. Garlic is given for nutritional purposes to enhance gestation and lactation [16]. In a study conducted to evaluate the effectiveness of naturally prepared galactagogue mixtures containing garlic on breast milk production and prolactin levels in postnatal mothers, it was observed that the galactagogue mix increased prolactin production, confirming the folkloric use of garlic as a galactagogue [17]. Garlic is also known to impart odor and flavor to breast milk when consumed and infants tend to breast-feed longer on such milk [18].

Chemical constituents isolated from *A. sativum* were diallyl trisulfide (50.43%), diallyl disulfide (25.30%), diallyl sulfide (6.25%), diallyl tetrasulfide (4.03%), 1,2-dithiolane (3.12%), allyl methyl disulfide (3.07%), 1,3-dithiane (2.12%), and allyl methyl trisulfide (2.08%) [19]. The essential oil of *A. sativum* possessed contact toxicity against overwintering *C. chinensis* [19].

4.2 Annonaceae

4.2.1 Xylopia aethiopica A. rich

X. aethiopica is an evergreen tree with many-branched and narrow crown; it can grow from 15 to 30 m high. It is planted for medicinal purposes, as a shade tree and as an ornamental. The fruits are used as a tonic to improve women fertility and to aid delivery. Various parts of this plant are used across Ghana and Nigeria for various medicinal purposes. Powdered samples are taken or applied directly for use. The fruits also serve as a condiment, an emmenagogue, anthelmintic, antitussive, carminative and rubefacient. Xylopia is used generally for pain and in the treatment of bronchitis, asthma, arthritis, rheumatism, headache, neuralgia and colic pain [20, 21]. The seeds are ground and used as a galactagogue, emetic, rubefacient, stimulant and vermifuge [22]. The seeds are crushed and applied on the forehead for treating headache and neuralgia and its extract for round worm infestation and as a treatment for biliousness. Decoction of leaves serves as an emetic and is used against rheumatism. The powdered leaves are rubbed on the chest for treating bronchio-pneumonia and taken as snuff for treating headaches. Roots are powdered and applied to sores and also to treat cancer. Lactating mothers take the ground seed to increase milk flow. Fruits are particularly high in zinc content, perhaps the reason behind its consumption during lactation. The fruit contains xylopic acid,

volatile oils, fixed oils, rutin and zinc. Compounds isolated from *X. aethiopica* include Lupeol, 16α-hydroxy-ent-kauran-19-oic acid, 3, 4′, 5-trihydroxy-6,6″-dimethylpyrano[2,3-g]flavone, 3-O-β-sitosterol β-D-glucopyranoside, isotetrandrine and trans-tiliroside [22–24].

4.3 Asclepiadaceae

4.3.1 Secamone afzelii (Roem. & Schult.) K. Schum

S. afzelii, is a familiar creeping woody climber found on fences, unkempt farm lands, on trees and grows to a very long length of about 2–3 cm. It is often seen as a nuisance to other plants because of its domineering spread wherever it grows. It is used in traditional medicine for stomach problems, diabetes, colic, dysentery and also for kidney problems. The whole plant boiled with rice is used as purgative for children. The decoction of the entire plant is prescribed for cough and catarrhal. For the treatment of gonorrhea, the whole plant is crushed with fresh palm nuts and oil [25]. A decoction of the whole plant is used as a galactagogue [26]. Studies have shown that *S. afzelli* has antimicrobial effects and also protect cells against damage by reactive oxygen species [27–30]. The anti-inflammatory property of the leaf extract has also been demonstrated [30] in a murine model. Kaempferol-3-O-β-D-apiofuranosyl-(1 → 2)-α-L-rhamnopyranoside, rutin, myricetin 3-O-α-L-rhamnopyranosyl-(1 → 6)-β-D-glucopyranoside, kaempferol-3-O-α-L-rhamnopyranosyl-(1 → 6)-β-D-galactapyranoside, mauritianin, and vicenin-2 have been isolated from *S. afzelii* [26]. The methanol extracts of *S. afzelii* is reported to be toxic in *Artemia salina* [31].

4.4 Costaceae

4.4.1 Costus afer Ker-Gawl

C. afer, natively called the bush sugar cane is classified as an endangered medicinal plant in Nigeria. It is a perennial, rhizomatous herb that can grow to a height up to 4 m. Leaves are arranged spirally, simple and entire [32]. It can be found in the forest belt of Senegal, South Africa, Guinea, Niger, Sierra Leone, Ghana, Cameroon and Nigeria [33]. *C. afer* is a useful medicinal plant that is highly valued for its antidiabetic, anti-inflammatory and anti-arthritic properties in South-East and South-West Nigeria, the plant extract is used as fodder to treat goats with retained placenta. The decoction of the stem or powdered fruits is used as a cough remedy. Its boiled root is applied to cuts and sores. A soothing formulation for rheumatic pains is prepared with the boiled leaves [33]. The leaves and stem are cut and crushed into smaller bits and boiled together with other plants such as *Alchornea cordifolia*, pawpaw, citrus species and the bark of *Mangifera indica* for the treatment of hunch back and malaria. Also the juice of *C. afer* is used as eye drop for inflammation and other eye defects. The young and tender leaves when chewed are believed to give strength to the weak and dehydrating patient. An infusion of the inflorescence is taken to treat stomach complaints. The stem or fruit decoction mixed together with sugarcane juice are taken to treat cough, respiratory problem and sore throat [32]. Alkaloids, saponins, flavonoids, anthraquinones, cardiac glycosides, terpenoids, phenolic compounds and tannins have been found to be present in the plant [33]. This plant contains diosgenin which is used as a precursor in the synthesis of a number of steroid drugs including corticosteroids, sex hormones, oral contraceptive and anabolic agents. The rhizome also contains saponins aferosides A–C, as well as diosein and parphyllin c and flavonoid glycoside kaempterol

3-0-rhamnopyranoside [34]. Extracts from the leaves exhibits antioxidant, hypolipidemic, hepatoprotective, anti-inflammatory, and analgesic, anticancer, antimicrobial, insecticidal and nematcidal activity and also contains verbascoside, which possesses antimicrobial activities [35]. Acute and chronic toxicity studies on *C. afer* showed no inherent toxic effects in animal models [35]. Liver function experiments of this plant in rats showed significant differences in the test groups when compared with the control while there was no significant effect on kidney function [33].

4.5 Euphorbiaceae

4.5.1 Euphorbia hirta L.

E. hirta is a slender-stemmed, annual hairy plant with many branches from the base to the top, spreading up to 40 cm in height. *E. hirta* is often used traditionally for female disorders, respiratory ailments (cough, coryza, bronchitis, and asthma), worm infestations in children, dysentery, jaundice, pimples, gonorrhea, digestive problems, diabetes and tumors. It is reported to contain alkanes, triterpenes, phytosterols, tannins, polyphenols, and flavanoids. The root exudate exhibits nematicidal activity [3]. The decoction of the dry herb is used for skin diseases while that for the fresh herbs is used as gargle for the treatment of thrush. Roots are also used for snake bites. This herb shows antibacterial, anti-inflammatory, antimalarial, galactogenic, anti-asthmatic, anti-diarrheal, anti-cancer, anti-oxidant, anti-infertility, anti-amoebic, and anti-fungal activities [36]. The root decoction is also beneficial for nursing mothers deficient in milk [36]. *E. hirta* has shown a galactogenic activity in guinea pigs before puberty by increasing the development of the mammary glands and induction of milk secretion [36].

4.5.2 Euphorbia thymifolia wall

E. thymifolia is a softly hispid prostrate herb that is slender, cylindrical, pale green but often pink in color when fresh, becoming grayish green or dark purplish on drying. Stems are with white latex, spreading on the ground, 10–20 cm in length with a diameter from 1 to 3 mm [37]. *E. thymifolia* is traditionally used as a blood purifier, sedative, hemostatic, aromatic, stimulant, astringent in diarrhea and dysentery, anthelminthic, demulcent, laxative; and also in cases of flatulence, constipation; chronic cough; as an antiviral in bronchial asthma and paronychia. The dried leaves and seeds are given along with butter-milk to children in bowel complaints. Root is given in amenorrhea and gonorrhea. The oil is used as an insect repellant and in medicinal soaps for the treatment of erysipelas. It is also used as a vermifuge for dogs and farm foxes. Plant juice is employed in southern India as a cure for ring worms. The plant powder is given with wine as a remedy for bites of venomous reptiles. It is applied on the scalp with ammonium chloride to cure of dandruff. The fresh plant is considered vulnerary and used in ophthalmia and other eye troubles, ardor, sores, atrophy, dysentery and breast pain [24]. This plant is reported to be used as a galactagogue both in West-Africa and in India [24, 38].

4.5.3 Hymenocardia acida Tul

H. acida is a small tree of about 6 m high, gnarled and twisted with characteristic rough, rusty-red bark. It is widespread in tropical Africa [39]. The leaves of *Hymenocardia acida* are commonly used in Northern Nigeria alone or in combination with other plant parts to manage sickle cell disease. The plant contains carbohydrates, tannins, flavonoids, saponins, alkaloids, cardiac glycosides,

resins, steroids and terpenes [38]. The root of this plant is reported to be used within West-Tropical Africa to stimulate lactation but [24] there are however anecdotal reports that this plant it is also given to diminish breastmilk supply. Ethnopharmacological studies of *H. acida* revealed an extensive array of medicinal uses, particularly from tropical African countries. In Senegal and Ivory Coast, an infusion or decoction of its leaves is used for the treatment of chest complaints, small pox, in baths and draughts as a febrifuge, and is taken as snuff for headaches or applied topically for rheumatic pains and toothaches. The bark and leaves are prescribed together with other plants in various ways in Nigeria for abdominal and menstrual pains and as poultices to treat abscesses and tumors. The powdered leaves of this tree are also used for the treatment of arthritis. Pharmacological activities reported on the plant include anti-ulcer, anti-plasmodial and cytotoxic activities [39].

4.5.4 Plagiostyles africana Prain exDe wild

P. africana trees grow in the lowland rainforest of south Nigeria and West Cameroons extending to Zaïre (the Democratic Republic of Congo). It reaches 16 m tall by 1.30 m in girth. The wood is light yellowish white and it is cut in Gabon to make spoons, combs and hair-pins. A wood-decoction is taken in the belief that it promotes milk-production [24]. The bark contains a white to yellowish viscid latex. The bark is used for chest-affections, and for fever [40].

4.5.5 Ricinus communis L.

R. communis (castor oil plant) is a perennial shrub whose leaves have long petiole and palm like lobed blades. Fruit is three chambered, globose capsule with soft spines. When capsules mature, they split up into three cavities and the seeds are expelled out [41]. This plant is grown worldwide for the production of castor oil. *R. communis* exhibits various biological and pharmacological activities such as abortifacient effect, acid phosphatase inhibition, acid phosphatase stimulation, agglutin activity, alkaline phosphatase inhibition, anti-conceptive activity, anti-diabetic activity, anti-infertility effects anti-inflammatory activity, antimicrobial activity, antioxidant activity, free radical scavenging activity, hepatoprotective activity, insecticidal activity and repellent properties [5, 41]. Castor oil is massaged over the breast after child-birth to increase the flow of milk as it stimulates the mammary glands. The leaves of castor can also be used to foment the breast for the same purpose [5, 24].

4.6 Leguminosae

4.6.1 Tamarindus indica L.

The tamarind (*T. indica*) is a common tree, especially in West Africa [42] and India. It is a moderate to large sized, evergreen tree that grows up to 24 m in height and 7 m in girth. *T. indica* has antimicrobial, antioxidant, anti-venom properties and it is also used as a galactagogue [43]. It is indigenous to tropical Africa and is also cultivated in subtropical China, India and Spain. Initially, the fruit shows a reddish-brown color that turns black brown, becoming more aromatic and sour on ripening. The fruit pulp is used for seasoning, as a food component and in juices. *T. indica* has antimicrobial, antioxidant, anti-venom properties and also used as a galactagogue [43]. Tamarind is most commonly used as a laxative and in the treatment of wounds and abdominal pains, followed by diarrhea, helminth

infections, fever, malaria, aphrodisiac, respiratory problems and dysentery [42]. Its fruit is regarded as a digestive, carminative, laxative, expectorant and blood tonic [44]. Other parts of the plant have anti-oxidant [45], anti-hepatotoxic [46], anti-inflammatory, anti-mutagenic, anti-cancer, anti-ulcer and anti-diabetic [47] activities. The flower and leaf are eaten as vegetables, while the germ obtained from the seed is used for manufacturing tamarind gum which is well-known as a component of jelly [5, 48]. Toxicity study in rat modules showed that tamarind pulp extract was generally safe and well tolerated at 5, 200, 1000 mg/kg body weight per day for 6 months [49].

4.6.2 Acacia nicolita var. adansonaii (Guill. & Perr.) Brenan

A. nicolita also known as gum Arabic occurs as a tree which can grow up to about 50 feet high. It has a dark brown bole with deeply fissured bark. The leaves are compound and alternately arranged with about 10 to 30 elliptical pubescent leaflets on each leaf. The flowers occur as round, yellow heads situated at the end of branches. Fruits are thick, gray and are well constricted hairy pods [50]. Various parts of *A. nicolita* have been used for the treatment of various cancers in Western Africa. These include cancers of the ear, eye and testicles. Roots of the plant are used to treat tuberculosis, its wood for the treatment of smallpox, and the leaves for the treatment of ulcers [51]. In the Katsina state of Nigeria, decoction of the pod is used for postpartum wound healing [52] and here also the young shoots and pods are used to stimulate lactation [53]. When the effect of the aqueous extract of *A. nicolita* was investigated on milk production in rats, it was observed that, the extract was able to significantly stimulate the release of prolactin. Also, it was observed that the mammary glands of estrogen-primed rats treated with the extract showed clear lobuloalveolar development with milk secretion [54]. Present in *A. nicolita* are tannins, flavonoids, alkaloids, fatty acids and terpenes have been isolated from various parts of the plant. This plant is also known to have anti-inflammatory, anti-oxidant, anti-diarrheal, anti-hypertensive and anti-spasmodic, anti-bacterial, anti-helminthic, anti-platelet aggregatory, and anti-cancer activities [50]. Toxicological studies on *A. nicolita* showed that it has a low toxicity potential [55]. However it is also reported that repeated administration of doses higher than 250 mg/kg body weight for 28 days caused hepatotoxicity in rats [56].

4.6.3 Desmodium adscendens (Sw.) DC

D. adscendens is a herbaceous non-climbing perennial shrub that commonly occurs in tropical areas of Africa, South America, Asia, Australia and Oceania [57]. The plant thrives in varying habitats ranging from forests to grasslands and in secondary/disturbed vegetation. A decoction of the leave and stem is used for asthma and other diseases associated with smooth muscle contraction and epilepsy in Ghana [57]. It is used for the treatment of fever, pain and epilepsy in the Congo. In Brazil the plant is used in the treatment of ovary inflammation. It is used in Ghana to enhance lactation [22]. *D. adsendens* contains indole alkaloids, unsaturated fatty acids, tyramine, hordenine and saponins [58, 59]. Triterpenoid saponins, tetrahydroiso-quinolones, phenylethylamines and indole-3-alkyl amines have been isolated from the leaves [60]. *D. adscendens* causes dilation, relaxation of smooth muscles, anti-histamine effects and normalizes elevated liver enzyme levels [58].

4.7 Malvaceae

4.7.1 Hibiscus sabdariffa Linn

H. sabdarriffa commonly known as Roselle (English), Sobolo (Akan Ghanaian language) is widely cultivated among the tropical and subtropical regions of the world. These include some parts of Asia and West Africa. This plant was domesticated by natives of Western Sudan before 4000 BC [61]. The plant is an erect herbaceous annual and a shrub that can grow up to about 2 m in height. It consists of smooth cylindrical and typically red stems. The leaves are simple, deeply lobed, petiolate and alternately arranged with reddish reticulate veins. The flowers occur singly in the axils of the leaves. The calyces are typically red and made up of five sepals fused at the base which become fleshy and juicy upon maturity [62, 63].

The main class of phytochemicals present in *H. sabdariffa* is anthocyanins and flavonoid, as well as organic acids and polysaccharides. Citric acid, malic acid, tartaric acid and ascorbic acid are also present [64]. Some flavonoids that have been described in *H. sabdariffa* extracts include hibiscitrin, sabdaritrin, gossytrin and gossypitrin [65, 66]. Different parts of *H. sabdariffa* are used for various medicinal purposes. The calyces of the flower are commonly incorporated in hot and cold drinks due to its pleasing taste. In many parts of Africa, it has been used for its spasmolytic, antioxidant [67–69], antibacterial [70, 71], antipyretic [72], diuretic and anthelmintic properties [73]. It is also used for the treatment of high blood pressure and liver diseases. Additionally to their medicinal uses, various parts of the plants are incorporated in meals and used for other culinary purposes. In some cultures, *H. sadariffa* is included in some herbal mixtures and consumed by nursing mothers to increase milk supply [74]. In Nigeria also, the decoctions of the seeds have been reported to be used to increase lactation in cases of poor milk supply [75]. In 66 healthy mothers who took extracts of hibiscus, fennel, fennel oil, verbena, raspberry leaves, fenugreek and vitamin C, there was an increase in breastmilk production by the third day [76]. Toxicity studies have shown that the prolonged usage of the aqueous-methanolic extract of *H. sabdariffa* calyces at the dose of 250 mg/kg could cause liver injury in rats [77]. Also, the 12-week subchronic effect of *H. sabdariffa* calyx aqueous extract at the doses of 1.15, 2.30, and 4.60 g/kg induced testicular toxicity [78].

4.7.2 Gossypium herbaceum L. (Malvaceae)

G. herbaceum is an erect, shrubby, hairy plant that grows up to 2–8 m high [79]. The decoction of this plant is used traditionally across West Africa as an aphrodiasiac, galactagogue, spermatogenic, expectorant, laxative, demulcent, emenagogue, dysmenorrhea, and for the expulsion of retained placenta [80, 81]. In human studies *G. herbaceum* was shown to be efficacious, safe and cost effective in augmenting lactation in perceived insufficient milk supply [9]. This plant is known to contain carbohydrates, tannins, saponins, steroids, glycosides, phenolics, sitosterol, ergosterol, lipids, gossypol, oleic, palmitic and linoleic acid [79]. Extracts from this plant and it active constituents gossypol have shown anti-cancer, anti-infertility, anti-malarial, anti-oxidant, anti-trypanosomal, anti-viral, anti-microbial, anti-viral, hepatoprotective and anti-depressant activities in animal models [16, 82, 83].

4.8 Moraceae

4.8.1 Milicia excelsa (Welw.) C.C. Berg

M. excelsa is commonly known as odum or iroko in Ghana. It is a large, dioecious tree that grows up to 50 m high [84]. This plant is widely used in African folk medicine as a decoction to treat several ailments. A root decoction is taken to treat female sterility. A decoction of the root and stem bark is taken as an aphrodisiac. The extracts from the bark are taken to treat cough, asthma, heart trouble, lumbago, spleen pain, stomach pain, abdominal pain, edema, ascites, dysmenorrhea, gonorrhea, general fatigue, rheumatism, sprains, and as a galactagogue, aphrodisiac, tonic and purgative. Also the stem bark preparations are topically applied to treat scabies, wounds, and loss of hair, fever, venereal diseases and sprains. They are applied as an enema to cure piles, diarrhea and dysentery. The latex is applied on burns, wounds, sores, eczema and on other skin problems as well as taken to treat type 2 diabetes [85, 86]. Additionally, it is taken against stomach problems, hypertension, tumors, and obstruction of the throat and as a galactagogue [87]. Leaves are eaten to treat insanity; a leaf maceration is drunk as a galactagogue. A decoction of the leaves is taken for the treatment of gallstones. Leaf preparations are externally applied to treat snakebites and fever and as eye drops to treat filariasis. Alkaloids, flavonoids and saponins are present as well as triterpenes and glycosides [79, 88]. The leaf extract of *M. excelsa* is reported to be safe in rodents [79, 89, 90].

4.8.2 Ficus sp. L.

Ficus species comprises one of the largest genera of angiosperms with more than 800 species of trees, shrubs, hemiepiphytes, climbers, and creepers in the tropics and subtropics worldwide [91]. The bark, root, leaves, fruit and latex of this plant are frequently used for the treatment of various illnesses including gastrointestinal, liver, venereal, respiratory, metabolic and cardiovascular disorders. It is used in traditional medicine as a galactagogue [92]. The fresh juice (50–100 ml) of leaves of *F. racemosa* L. is given with water for about 10 days to treat gastrointestinal problems. Bark of *F. arnottiana* and *F. hispida* shows hypoglycaemic activity. Roots of *F. bengalensis* show anthelmintic activity. This extract is also reported to inhibit insulinase activity from liver and kidney. Fruit extracts exhibits antitumor activity. Various pharmacological actions such as anti-ulcer, anti-diabetic, lipid lowering and antifungal activities have been described for *F. exasperata*. Ethanolic leaf extract of *F. exasperata* shows anti-bacterial activity. Leaves exhibit hypotensive activity. Ethanolic and aqueous wood extracts of *F. glomerata* shows Anti-HIV-1 integrase activity. *F. religiosa* is reported to be used for the treatment of asthma, cough, sexual disorders, diarrhea, hematuria, ear-ache and toothache, migraine, eye troubles, gastric problems and scabies; leaf decoction has been used as an analgesic for toothache; fruits for the treatment of asthma, other respiratory disorders and scabies; stem bark is used in gonorrhea, bleeding, paralysis, diabetes, diarrhea, bone fracture, antiseptic, astringent and antidote. Fruit of *F. carica* shows spasmolytic activity, mediated through the activation of K^+-ATP channels along with anti-platelet activity. Hence, it can be used in gut motility and inflammatory disorders [93]. Most species of Ficus contain phenolic compounds, organic acids, and volatile compounds [91]. Some species have been reported not to be toxic in rodents [93].

4.9 Musaceae

4.9.1 Musa paradisiaca L.

M. paradisiaca is an herbaceous plant that grows up to about 9 m with a robust treelike false-stem. The unripe fruits and juice of *M. paradisiaca* is used in folk medicine to treat and manage diarrhea, dysentery, cholera, intestinal lesions, ulcerative colitis, diabetes, sprue, uremia, nephritis, gout, hypertension, cardiac disease, otalgia and hemoptysis [94, 95]. The flowers are also employed in treating dysentery, diabetes and menorrhagia [94]. The root is also used traditionally as an anthelmintic [95], for treating blood disorders and venereal diseases [94]. It is also used as an anti-inflammatory, analgesic and anti-dote for snakebites [96].

The green fruits of *M. paradisiaca* has been reported to possess anti-hypertensive [97] as well as hypoglycemic effect due to effects on insulin production and glucose utilization [98]. *M. paradisiaca* inhibits cholesterol crystallization in vitro [99]. *M. paradisiaca* has also been shown to induce atherosclerosis [100]. There have been reports of the potential of *M. paradisiaca* flower to enhance milk production of nursing rats [101, 102]. Serotonin, nor-epinephrine, tryptophan, indole compounds, tannin, starch, iron, crystallisable and non-crystallisable sugars, vitamins, albuminoids, fats, mineral salts have been found in the fruit pulp of *M. paradisiaca* [94] with several other compounds that have been isolated and identified from various parts of the plant [103].

4.10 Ranunculaceae

4.10.1 Nigella sativa L.

N. sativa is a small herb of about 45 cm long with linear-lanceolate leaves and a pale blue flower. It is used as a food and medicine frequently to treat a variety of health conditions pertaining to the respiratory system, digestive tract, kidney and liver functions, cardiovascular system, and immune system support, as well as for general well-being [104] and as a galactagogue [105].

Phytochemical analysis has revealed the presence of nigelline, nigellicine, nigelimine, nigellimine-*N*-oxide, avenasterol-5-ene, avanasterol-7-ene, campesterol, cholesterol, citrostadienol, cycloeucalenol, sitosterol, stigmasterol, stigmastanol, 24-ethyl-lophenol, obstafoliol [105]. This plant is reported to have anti-cancer, antimicrobial, analgesic, antipyretic, contraceptive and anti-fertility, anti-oxytocic, anti-tussive, anti-inflammatory, and anti-oxidant potentials. Anti-cancer activity has been demonstrated for blood, breast, colon, pancreatic, liver, lung, fibrosarcoma, prostate, and cervix cancer cell lines and in animal models as well [106–109]. Toxicological studies showed no toxic effect in rodents [105].

4.11 Solanaceae

4.11.1 Solanum torvum Swartz

S. torvum is an evergreen, widely branched, prickly shrub that grows up to 5 m tall [110]. The fruits of *S. torvum* are edible and commonly available in the markets for incorporation into stews and soups across West-Africa. A decoction of the fruits is given for cough ailments and is considered useful in cases of liver and spleen enlargement. The plant is used as a sedative and diuretic and the leaves are used as a

hemostatic. The ripened fruits are used in the preparation of tonic and hemopoietin agents and also for the treatment for pain. It has antioxidant properties. It is intensively used worldwide in traditional medicine as a poison anti-dote and for the treatment of fever, wounds, tooth decay, reproductive problems and arterial hypertension [17, 111–113]. *S. torvum* fruits are reported to contain alkaloids, flavonoids, saponins, tannins, glycosides, fixed oil, vitamin B group, vitamin C and iron salts. It also has number of chemical constituents like neochlorogenin 6-O-β-D-quinovo-pyranoside, neochlorogenin 6-O-β-D-xylopyranosyl-(1 → 3)-β-D-quinovopyranoside, neochlorogenin 6-O-α-L-rhamnopyranosyl-(1 → 3)-β-Dquinovopyranoside, sola-genin 6-O-β-D-quinovopyranoside, solagenin 6-O-α-Lrhamnopyranosyl-(1 → 3)-β-D-quinovopyranoside, isoquercetin, rutin, kaempferol and quercetin [16, 113, 114]. *S. torvum* also possesses antimicrobial, antiviral, immuno-secretory, antioxidant, analgesic, anti-inflammatory, anti-ulcerogenic activities, cardiovascular, nephroprotective, antidiabetic, angiotensin and erotonin receptor blocking activities [110]. It is reported to be used in a concoction to nourish pregnant and lactating mothers with vitamins and proteins and to enhance lactation [115].

4.12 Verbanaceae

4.12.1 Lippia multiflora Moldenke

L. multiflora is an aromatic, perennial plant with woody stems growing up to 3 m high [53]. The plant is locally harvested in Ghana and Benin and the leaves are steeped in hot water for tea. It is used in the treatment of stomach aches, nausea and fever. The leaves and immature flowering stems have anti-biotic, laxative and vermifuge activities [116]. The leaves contain limonene, a-caryophyllene, trans-farnesene, caryophyllene oxide and farnesol [117]. Tea infusion of plant is used for the treatment of arterial hypertension in Ghana [118]. A herbal extract of the plant exhibits anti-malarial, anti-microbial, anti-inflammatory, diuretic, laxative, muscle relaxant and is also used in lactation failure [22]. Lippia oil is effective topically gram-negative bacteria [117] and body lice, head lice, scabies' mites [119]. This plant possesses a tranquilizer and analgesic activities as diazepam [118].

4.13 Zingiberaceae

4.13.1 Aframomum melegueta (Roscoe) K. Schum

A. melegueta is commonly known as grains of paradise or alligator pepper. It is a spicy edible perennial fruit which grows to about 1 m high. *A. melegueta* produces reddish-brown seeds, which have a strong aromatic flavor and a pungent taste. These seeds are widely employed as spices and it is also an ingredient in numerous West African ethno medical practices. *A. melegueta* is a remedy for a number of diseases such as constipation, rheumatic pains and fever [120, 121]. The medicinal uses of *A. melegueta* also include its use as an aphrodisiac, measles and leprosy. It is also taken to treat excessive lactation, post partem hemorrhage, purgation and used as a galactagogue, anthelmintic and hemostatic [122]. *A. melegueta* exhibits anti-inflammatory, anti-oxidant and anti-tumor effects [123, 124] as well as anti-protozoal activity against schistosomes [22]. The phytochemical constituents are essential oils—such as gingerol, shagaol, paradol. Alkaloids, flavonoids, saponins, tannins, cardiac glycosides, terpenoids, steroids [125] as well as essential oils and resins have also been identified in this plant [126]. The LD_{50} of 273.86 mg/kg body weight and lower than normal hemoglobin and red blood cells in animal studies seems to confirm the possibility of toxicity from this plant [125].

5. Conclusion

There are numerous references in literature for herbal medicines use to aid breastfeeding. However, the use of herbal galactagogues is mainly based on empirical traditions with little scientific data. With increase in the complexity of breastfeeding, it is imperative that these herbal galactagogues be studied. There is a need to standardize the herbal galactagogues, investigate their nutritional and phytochemical composition as well as conduct clinical trials to generate scientific evidence of their efficacy and safety, as a basis for commercial production and usage. Conducting pharmacodynamics and pharmacokinetic studies will also play a vital role in determining their metabolism in the mother and neonate. Their mechanism of action will also need to be investigated. These herbs will have the advantages of being easily available, cheaper and more tolerable to both mother and neonate.

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Conflict of interest

The authors declare no conflict of interest.

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