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Sudanese Medicinal Plants for Enhancing Lactation: Integrating Traditional Knowledge and Scientific Evidence

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A B S T R A C T

Objective: This review aims to integrate traditional Sudanese knowledge and scientific evidence regarding medicinal plants used to stimulate lactation in nursing mothers. It focuses on the botanical, phytochemical, and pharmacological profiles of commonly used galactagogues in Sudan, highlighting their mechanisms of action and potential for integration into primary healthcare.

Methodology: A comprehensive literature search was conducted using databases such as PubMed, Scopus, and Google Scholar to identify peer-reviewed articles, ethnobotanical surveys, and clinical reports from 2000 to 2025. Keywords included "Sudanese medicinal plants," "galactagogue," "lactation support," and "traditional herbal medicine." Studies were selected based on their relevance to Sudanese flora and evidence of lactogenic effects, including experimental and clinical data.

Results: The review identifies about ten medicinal plants traditionally used in Sudan to enhance milk production, including *Trigonella foenum-graecum* (fenugreek), *Sesamum indicum* (sesame), *Adansonia digitata* (baobab), and *Nigella sativa* (black cumin). These plants exhibit diverse phytochemical compositions such as saponins, flavonoids, phytoestrogens, and essential fatty acids that act through prolactin stimulation, estrogenic activity, and nutritional support. Despite promising ethnomedical use and preliminary scientific evidence, most of these galactagogues lack standardized formulations, clinical validation, and regulatory oversight. Integrating validated herbal galactagogues into primary healthcare systems presents a culturally acceptable and operationally viable solution to support lactation, especially in resource-limited Sudanese communities.

Conclusion: Sudanese medicinal plants hold significant potential as natural lactation enhancers. However, their incorporation into maternal health strategies requires further clinical research, phytochemical standardization, and supportive health policy frameworks.

Keywords: Sudan, Medicinal plants, lactation, Traditional medicine, Maternal health, Herbal remedies, Phytotherapy

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Introduction

Breastfeeding is universally recognized as the optimal method for infant nutrition, providing essential nutrients, immune protection, and promoting both maternal and child health. The World Health Organization (WHO) recommends exclusive breastfeeding for the first six months of life, citing its proven benefits in reducing infant morbidity and mortality from infectious diseases and supporting postpartum maternal recovery [1].

Despite these benefits, many lactating mothers—particularly in low-resource settings like Sudan—struggle with insufficient breast milk production. This issue has direct implications for child growth and development, especially in conflict-affected and displaced communities where infant formula and healthcare services are scarce or unaffordable.

In Sudan, prolonged political instability and humanitarian crises have severely undermined the national health system,

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limiting access to maternal and child health services [2]. As a result, large segments of the population increasingly rely on traditional medicine. Estimates suggest that 70–90% of Sudanese people use herbal remedies for primary healthcare needs [3]. Within this context, medicinal plants are frequently employed as galactagogues—agents believed to enhance breast milk production—based on generations of ethnobotanical knowledge.

Phytochemical studies have shown that many of these plants contain bioactive compounds such as saponins, flavonoids, and phytoestrogens, which may contribute to lactation through various hormonal and nutritional mechanisms [4]. However, existing scientific evidence supporting their efficacy remains limited. While ethnographic reports are abundant, few systematic and controlled clinical trials have been conducted, making it difficult to validate traditional practices within an evidence-based medical framework.

This lack of robust clinical validation highlights a significant gap in current research. Most available data are anecdotal or derived from animal studies, and there is limited pharmacokinetic or toxicological information to guide safe use in humans. Furthermore, standardized formulations and regulatory protocols are largely absent, increasing the risk of inconsistent outcomes and potential adverse effects. Given the widespread use of these remedies, there is an urgent need to critically evaluate the scientific validity of Sudanese galactagogue plants. This review aims to consolidate ethnobotanical knowledge and pharmacological evidence to support the safe and effective integration of traditional galactagogues into maternal healthcare.

To our knowledge, this is the first comprehensive review focusing specifically on Sudanese medicinal plants used to enhance lactation. It addresses a critical knowledge gap by combining traditional wisdom with modern scientific perspectives and aims to provide guidance for future research, clinical validation, and health policy development.

Methodology

This review was conducted through a comprehensive literature search across multiple scientific databases, including PubMed, Scopus, and Google Scholar, to identify relevant studies on Sudanese medicinal plants traditionally used as galactagogues. The search included peer-reviewed articles, ethnobotanical surveys, clinical reports, and pharmacological investigations.

To enhance reproducibility, Boolean operators and quotation marks were used in the search strategy. Key search strings included:

"Sudanese medicinal plants" AND "lactation"; "galactagogue herbs" AND "breast milk"; "traditional medicine Sudan" AND ("milk production" OR "maternal health"), and "herbal lactation aids"
These combinations allowed precise identification of studies focused on lactation-enhancing herbs within the Sudanese context.

The inclusion criteria were

Studies published between 2000 and 2025

Articles written in English

Studies reporting ethnobotanical use, phytochemical composition, pharmacological effects, or clinical relevance of Sudanese galactagogue plants

Reports with sufficient detail on plant identity and usage

The exclusion criteria included

Studies not involving Sudanese flora

Articles lacking primary data (e.g., opinion pieces, editorials)

Reports with incomplete botanical identification or unclear lactogenic relevance

Duplicates or studies with irreproducible methods

The time frame was chosen to reflect two decades of contemporary research, while the language restriction to English was based on accessibility, indexing in international databases, and standardization. However, ethnomedical sources in Arabic were reviewed where possible, particularly Sudanese herbal books and field reports, to incorporate traditional knowledge. These sources were selected based on historical credibility, frequency of citation in academic studies, and validation by local herbal practitioners.

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Data extraction parameters included

Scientific and local plant names

Plant parts used and preparation methods

Phytochemical constituents (e.g., saponins, flavonoids, phytoestrogens)

Mechanisms of action (e.g., prolactin stimulation, estrogenic activity)

Reported safety profiles

Pharmacological or clinical outcomes

Studies were analyzed using a qualitative synthesis approach, and their methodological quality was assessed using standard critical appraisal tools, such as the CASP checklist for qualitative studies and PRISMA guidelines for systematic reviews. The initial search yielded ٥١٤ articles.

After screening titles and abstracts, and applying the inclusion/exclusion criteria, ٤٥ studies were included in the final review

Biodiversity of Medicinal Plants in Sudan

Sudan is recognized as one of the most biologically diverse countries in Africa, particularly in terms of medicinal plant species. Its vast and varied geography—which ranges from arid deserts in the north to fertile savannahs and wetlands in the south—creates numerous ecological niches that support a wide variety of flora. This climatic and topographic diversity directly influences the distribution and chemical diversity of plant species used in traditional medicine [5,6].

Estimates suggest that Sudan is home to over 3,000 plant species, of which a significant proportion possess documented medicinal properties [7]. Many of these plants are deeply embedded in local ethnomedical systems and are traditionally employed to manage various health conditions, including maternal and child health concerns such as lactation insufficiency [8]. The therapeutic potential of Sudan's medicinal flora is largely attributed to its rich phytochemical profiles. Bioactive compounds such as alkaloids, flavonoids, tannins, saponins, and essential oils have been identified in many indigenous species [9].

These constituents contribute to the observed pharmacological activities of galactagogue plants and offer promising avenues for drug development. However, this valuable biodiversity is increasingly threatened by environmental degradation, including desertification, unsustainable harvesting practices, agricultural expansion, and the effects of climate change. Human pressures and weak enforcement of conservation policies have further exacerbated the loss of medicinal plant habitats [10,11]. If left unaddressed, these threats could jeopardize the survival of many plant species and limit future research and healthcare applications. Therefore, the conservation and scientific documentation of Sudanese medicinal plants are of critical importance—not only to preserve traditional knowledge and local heritage but also to support sustainable healthcare innovation. Strengthening research on biodiversity, promoting habitat protection, and integrating local communities into conservation efforts are key to safeguarding these resources for future generations.

Sudanese Medicinal Plants Used as Galactagogues

Fenugreek Seeds (Trigonella foenum-graecum, Leguminosae/Fabaceae)

Fenugreek is well adapted to the northern and central regions of Sudan. The seeds are rich in proteins, vitamins, mucilage, and bioactive compounds such as saponins (1–2%) and the phytoestrogen diosgenin. These components are believed to stimulate milk production by mimicking estrogenic activity and activating sweat glands. Animal studies have reported increased milk yield and offspring weight after fenugreek extract administration [11].

However, human clinical data on fenugreek's galactagogue effects remain limited and inconsistent. Further randomized controlled trials are needed to establish its safety, optimal dose, and efficacy.

Sesame Seeds (Sesamum indicum L., Pedaliaceae)

Sesame is widely cultivated in the eastern and central regions of Sudan. The seed oil contains about 40% linoleic acid and 40% oleic acid, along with palmitic and stearic acids. Sesame seeds are rich in essential fatty acids, lignans with phytoestrogenic activity, and B vitamins nutrients that support hormonal balance and milk production [12]. Despite traditional use, clinical validation of sesame seeds as

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galactagogues in human populations remains scarce. Future research should focus on clinical efficacy and long-term safety.

Baobab (*Adansonia digitata* L., Malvaceae)

Baobab is native to many parts of sub-Saharan Africa, including western Sudan. Its fruit pulp is rich in dietary fiber, vitamin C, and polyphenols such as flavonoids and tannins [14–19]. These nutrients may enhance antioxidant status and support overall maternal health. Traditionally, powdered baobab fruit is consumed to stimulate lactation [20].

Although nutritional benefits are well documented, its direct effect on lactation requires further clinical evaluation. Human trials assessing dosage and mechanisms of action are needed.

Cumin Seeds (*Cuminum cyminum* L., Apiaceae)

Cumin thrives in central and northern Sudan. Its seeds contain volatile oils, particularly cuminic aldehyde, which may promote prolactin and corticoid secretion. Cumin is also a rich source of iron, contributing to maternal vitality during lactation [21].

Most evidence is based on traditional use and animal models. Human studies are necessary to evaluate therapeutic potential and safety in lactating women.

Fennel (Foeniculum vulgare Mill., Apiaceae)

Fennel is cultivated in parts of northern and central Sudan. It contains essential oils (up to 6%), mainly anethole and fenchone, which possess estrogen-like activity that may promote prolactin secretion [22]. Small-scale studies have reported increased milk volume and infant weight gain. However, caution is advised, as excessive intake may cause hormonal disruption. Further research is needed to determine safe dosages and confirm efficacy in large-scale human trials.

Black Cumin (*Nigella sativa* L., Ranunculaceae)

This herbaceous plant grows well in Sudan's moderately light soils. Its seeds contain thymoquinone, saponins, tannins, and alkaloids. In lactating rat models, Nigella sativa increased milk production and improved offspring growth [23].

Despite promising preclinical findings, well-designed human clinical studies are lacking. Future research should assess pharmacokinetics and safety profiles in nursing mothers.

Caraway (*Carum carvi* L., Apiaceae)

Caraway is found in northern and central Sudan. The seeds contain essential oils (mainly carvone and limonene), proteins, and tannins. Traditionally used for digestive and reproductive health, it is also believed to support lactation [21].

However, scientific validation of its lactogenic effects in humans is minimal. More studies are required to substantiate traditional claims.

Anise (*Pimpinella anisum* L., Apiaceae)

Anise grows in light, well-drained soils across Sudan. Its essential oil, rich in anethole (up to 90%), is considered estrogenic and may support milk production [24]. Although traditional use is well established, clinical trials on lactating women are limited. Further research is recommended to evaluate efficacy and safety.

Arabic Gum (Acacia nicolita, Fabaceae)

Native to western Sudan, Arabic gum contains tannins, flavonoids, and fatty acids. Studies on rats show it enhances prolactin release and mammary development [25]. Despite strong preclinical evidence, human data are absent. Future clinical trials should investigate therapeutic dosing and safety in breastfeeding mothers.

Roselle (*Hibiscus sabdariffa*, Malvaceae)

Roselle has been used in Sudanese traditional medicine for over 4,000 years. Its calyces contain anthocyanins, flavonoids, and organic acids. A clinical study involving 66 mothers showed increased breast milk production on the third day of hibiscus extract consumption [32]. Although this finding is encouraging, additional well-controlled human trials are necessary to confirm the consistency and

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safety of this effect.

Table 1: Summary of Common Sudanese Medicinal Plants Used to Enhance Lactation

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Scientific Name	Common Name	Plant Part Used	Preparation Method	Reported Use	Safety Note	References
Trigonella foenum-graecum	Fenugreek	Seeds	Boiled as tea or porridge	Enhances milk secretion	GI discomfort at high doses	(21,33,34)
Sesamum indicum L.	Sesame	Seeds	Roasted whole seeds or ground powder	support better breast milk production	Likely safe, but clinical studies needed	(20)
Adansonia digitate	Baobab	Fruit	Bowered fruit	Stimulates lactation	Human lactation studies needed	(١2)
Cuminum cyminum	Cumin	Seeds	Infused in hot water	Stimulates lactation	Human data needed	(21)
Foeniculum vulgare	fennel	Seeds	Infusion or decoction	Enhances milk flow	Caution at high doses	(٢٢, 24)
Nigella sativa	Black cumin	Seeds	Ground or infused	Tonic and galactagogue	Further human studies required	(21,33,34)
Carum carvi	Caraway	Seeds	Warm tea	Milk production, colic relief	Likely safe, lacks dosage data	(21)
Pimpinella anisum L	Anise	Fruit	Warm tea	Helps unblocked clogged milk ducts and increasing breast milk supply	Use in moderation	(21,24)
Acacia nicolita	Arabic gum	Fruit	Infusion or decoction	Increase milk secretion in nursing mother	Lacks clinical validation	(25)
Hibiscus sabdariffa	Roselle	Calyces	Warm or cold infusion	General postpartum tonic and increase in breastmilk production	Needs replication and dose studies	(31,32)

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Mechanisms of Action of Most Galactagogue Plants in Milk Production

Many medicinal plants used as galactagogues enhance milk production through diverse biochemical and hormonal pathways. While specific mechanisms vary among species, common modes of action include:

Prolactin Stimulation

Several plants contain phytochemicals such as saponins, flavonoids, and phytoestrogens that can stimulate the anterior pituitary gland to increase secretion of prolactin, the primary hormone responsible for lactogenesis. For example, *Trigonella foenum-graecum* (fenugreek) and *Asparagus racemosus* (shatavari) have been shown to elevate prolactin levels in animal and human studies [32,33].

Estrogenic Activity

Certain herbs, like *Foeniculum vulgare* (fennel) and Pimpinella anisum (anise), possess compounds with estrogen-like effects that may support mammary gland development and enhance milk synthesis by promoting ductal growth and alveolar proliferation [34,35].

Modulation of Oxytocin Release

Some galactagogues may enhance the release or action of oxytocin, which is essential for milk ejection ("let-down") by stimulating myoepithelial cell contraction around alveoli. Although less studied, this mechanism could explain anecdotal reports of improved milk flow with certain herbs [36].

Nutritional Support and Antioxidant Effects

Many lactation-supportive plants are rich in vitamins, minerals, and antioxidants, which improve maternal health and reduce oxidative stress. Enhanced maternal nutrition indirectly supports lactation by ensuring adequate substrate availability for milk synthesis [37].

Lactogenic Enzyme Activation

Some phytochemicals may activate enzymes involved in lactose synthesis or lipid metabolism within mammary cells, thereby improving milk composition and volume [38].

Overall, the synergistic effects of these mechanisms contribute to improved quantity and quality of breast milk. However, variability in plant composition, dosage, and individual response necessitates further research to optimize clinical use.

Table 2: Mechanisms of Action of Common Sudanese Galactagogue Plants Based on Phytochemical Properties

Mechanism of Action	Representative Sudanese Plants	References
1. Prolactin stimulation	Trigonella foenum-graecum, Nigella sativa, Acacia nicolita	[21,23,25]
2. Estrogenic activity	Foeniculum vulgare, Pimpinella anisum, Carum carvi	[22,24,34,35]
3. Oxytocin modulation	Cuminum cyminum, Pimpinella anisum (suggested)	[21,36]
4. Nutritional support	Adansonia digitata, Sesamum indicum, Hibiscus sabdariffa	[12,14–18,19,27]
5. Antioxidant effects	Hibiscus sabdariffa, Nigella sativa, Adansonia digitata	[18,23,19]
6. Enzyme activation	Trigonella foenum-graecum, Hibiscus sabdariffa (suggested)	[33,38]

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Barriers to Breastfeeding Among Mothers in Sudan

Breastfeeding mothers in Sudan face multiple challenges that compromise lactation and infant nutrition, particularly in the context of conflict, displacement, and systemic health collapse. One of the most critical barriers is maternal undernutrition, which reduces both the quantity and quality of breast milk and affects maternal stamina and recovery after childbirth [39]. Additionally, physical and psychological stress associated with forced displacement, loss, and insecurity further impairs lactation by disrupting hormonal balance and diminishing maternal mental well-being [40,41].

Cultural beliefs also play a significant role. In some Sudanese communities, there are misconceptions that breast milk may be "too weak" or "insufficient," leading to early supplementation or cessation of breastfeeding, which undermines exclusive breastfeeding practices [42]. Compounding this is the lack of access to education and counseling on breastfeeding techniques and lactation support, especially in rural and crisis-affected areas where healthcare services are sparse [43].

Given these challenges, traditional medicinal plants used as galactagogues are often viewed as culturally acceptable, affordable, and practical solutions. Their use is deeply embedded in local traditions and provides a sense of agency and support for mothers who lack access to formal healthcare. These plants may help enhance milk production, restore maternal strength, and address lactation concerns in a holistic manner [44].

These multifactorial barriers underscore the urgent need for culturally grounded, accessible, and evidence-informed interventions such as validated herbal galactagogues to support lactating mothers in Sudan.

Safety and Regulatory Challenges in the Use of Galactagogue Plants

While medicinal plants used to enhance lactation offer a culturally accepted and accessible alternative for many Sudanese women, their widespread use raises critical concerns about safety, efficacy, and regulatory oversight. One of the main challenges is the lack of standardized dosing, which can result in inconsistent therapeutic effects or potential toxicity [45]. For instance, although *Trigonella foenum-graecum* (fenugreek) is commonly used to boost milk supply, high doses may cause gastrointestinal discomfort, allergic reactions, or interact with certain medications [46].

In Sudan, the absence of a formalized national framework for evaluating, registering, and monitoring herbal medicines has led to unregulated markets where products vary widely in quality, purity, and labeling accuracy. This regulatory gap not only undermines consumer safety but also limits the integration of effective galactagogues into mainstream healthcare systems [37,47].

Moreover, scientific data on the pharmacokinetics, active constituents, and long-term effects of many traditional galactagogues remain scarce. This lack of robust clinical evidence impedes efforts to establish official guidelines for their use among lactating women, especially in vulnerable populations such as malnourished or displaced mothers [48].

To address these issues, there is an urgent need for multidisciplinary collaboration among pharmacologists, ethnobotanists, public health professionals, and regulatory bodies. Developing safety profiles, toxicological studies, and clear usage protocols alongside capacity-building for quality control labs will be essential to ensure that galactagogue plants are both effective and safe for maternal health support [49].

The lack of legal recognition for traditional herbal formulations in Sudan not only compromises patient safety but also discourages investment in research and product development, limiting the translation of indigenous knowledge into formal therapeutics.

Integrating Traditional Medicine into Primary Health Care: A Pathway for Supporting Lactating Mothers

Integrating traditional medicine, particularly the use of galactagogue plants, into primary health care (PHC) systems presents a promising opportunity to improve maternal and infant health in Sudan. Given the widespread reliance on traditional healers and herbal remedies in rural and underserved communities, formal recognition and integration of these practices can enhance accessibility, cultural relevance, and patient trust in health services [50,51]. In the context of post-conflict recovery and health system collapse, leveraging the existing ethnobotanical knowledge of midwives, herbalists, and community elders offers a cost-effective way to support lactating mothers with safe and familiar remedies. For example, incorporating

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standardized herbal preparations such as Moringa oleifera leaves or Nigella sativa seeds into antenatal and postnatal care packages could help address common lactation challenges while empowering local supply chains [52,53].

However, integration requires systematic training of primary healthcare providers in ethnopharmacology, quality assurance, and patient counseling. It also demands the development of clear regulatory frameworks and clinical protocols to ensure safety and efficacy. Successful models from other countries—such as India and China demonstrate that traditional medicine can coexist and complement biomedical approaches when governed by supportive policies and robust monitoring systems [54-56]. In Sudan, such integration could contribute to rebuilding the national health system from the ground up, while preserving indigenous knowledge and promoting maternal health equity. In addition to improving health outcomes, promoting standardized herbal galactagogues could stimulate local economies through cultivation, small-scale production, and commercialization of validated plant-based remedies.

Conclusion

Sudan's rich biodiversity of medicinal plants offers significant potential to support maternal and infant health through traditional galactagogue remedies. While these plants are widely used, especially in rural and displaced populations, there is a critical need for rigorous scientific validation of their efficacy and safety. Addressing this gap will enable the development of standardized, effective, and safe herbal formulations that can be integrated into primary healthcare systems.

To maximize the benefits of Sudanese medicinal plants for lactation support, future efforts should focus on promoting multidisciplinary research to elucidate mechanisms of action and potential side effects. Standardization and quality control protocols must be established to ensure consistency and safety of herbal products. Additionally, incorporating validated herbal galactagogues into healthcare programs can improve breastfeeding outcomes, particularly in underserved communities. Raising awareness among healthcare providers and mothers about proper use is equally important. Finally, conserving Sudan's rich medicinal plant biodiversity is essential to sustain these resources for future generations.

With appropriate investment in research, regulation, and public health education, Sudan's traditional galactagogue plants could play a transformative role in maternal healthcare.

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The authors declare there is no Competing interests

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