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Review

Phytotherapy for Future: Herbal Medicinal Plants and Their Role in Developing Effective Formulations

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Abstract

Herbal medicinal products have attained worldwide importance due to their healing properties, cultural acceptance and relatively low side effects when compared to synthetic medications. This review examines the progression of herbal medicine and its incorporation into contemporary pharmaceutical practices. It emphasizes the increasing dependence on plant-based treatments, particularly in developing countries, along with the economic potential of the herbal market in India. Major advancements include innovative drug delivery methods such as liposomes, phytosomes and nanoparticles, which improve the bioavailability and effectiveness of active phytochemicals. The article addresses challenges related to standardization, safety issues and the necessity for stringent quality control to guarantee consistency and dependability. Different forms of dosage such as tablets, capsules, syrups, creams and ointments showcase the adaptability of herbal products. Nonetheless, challenges like variability in phytochemicals, toxicity risks, and inadequate regulatory frameworks inhibit full-scale commercialization. In sum, the research emphasizes the significance of merging traditional knowledge with contemporary scientific validation to create safe, effective and globally accepted herbal medications.

Keywords: Liposomes, phytosomes, nanoparticles, Quality control, Scientific validation, Economic potential

1. INTRODUCTION

A medication made from herbs is one that is meant to treat conditions, prevent them, and be safe for daily use by people. Herbal medicines have become crucial to the traditional practice of human health care in an Asian nation. Modern science and technology are employed in human healthcare to formulate natural drugs in a variety of form of dosage. A majority of people in several Asian and African nations worldwide utilize herbal medicine

for primary healthcare and treatment, according to estimates from the World Health Organization. [1] The Latin word "herb" and the old French word "herb" are the origins of the word "herb." Aloe, ginger, turmeric and tulsi are examples of therapeutic plants. In many regions of the nation, they are mostly seen as home remedies. The advancement of human civilization has had a significant impact on herbal medicine. [2] Advanced herbal medicine formulations have several advantages and fewer side effects when compared to alternative drug delivery methods. Several reasons contribute to the appeal of herbal therapy. Alkaloids, terpenoids and phenolic compounds secondary metabolites of plant metabolism have produced the majority of novel herbal medications. [3] More lately, scientists have relied more on evidence-based medicine and contemporary scientific techniques to demonstrate the effectiveness of herbal remedies and to better understand the mechanisms underlying their action. The herbal medication is frequently used to treat wounds resulting from a wide range of skin-related conditions. Throughout history, plants and plant-based products have been used to treat and prevent illnesses with differing degrees of effectiveness. [4] Herbal products are becoming more and more popular in the Indian and global markets as a result of the negative impacts of synthetic items. Numerous medical disorders are treated using herbs that have multiple therapeutic uses. Herbal medications are prepared in various herbal product types and come in a variety of dosage forms for safety. It has been established that the traditional usage of medicinal herbs to treat specific illnesses results in beneficial therapeutic effects. Neem for its antiviral, antifungal and anti-inflammatory properties [5] and St. John's Wort for depression [6] are two of the most popular examples. Potential molecular processes that support the healing process are demonstrated by this data. It is proving to be very difficult to develop medicinal products made from plants because some active phytochemicals are highly soluble in water but have low absorption because of their large molecular size, while others have poor water solubility [7, 8], which results in poor bioavailability. Furthermore, there is a problem with the lack of understanding regarding the hazardous effects of herbal remedies and potential negative combinations between them [9].

2. CURRENT METHODS

2.1. RESEARCH AND ADVANCEMENT

Due to their broad biological activity, greater safety margin than synthetic pharmaceuticals, and lower costs, herbal medicines are in considerable demand in both developed and developing nations. Because plant-based components are used to make herbal medications, they are susceptible to contamination, degradation and compositional change. The intended biological response is often caused by a combination of bioactive elements, and the percentage of active constituents might differ between plants in the same species as well as between different plant parts. For instance, using the HPTLC approach. discovered significant differences in the commercial oil formulation of Celastrus paniculates[10]. Thirty percent of the world-wide sales of drug is based on Natural products[11].

New means for the compounds that plants generate are made possible by advances in biotechnology, especially in the area of plant cell and tissue culture [12-14]. The forces of natural products chemistry, molecular and cellular biology, synthetic and analytical chemistry, biochemistry, and pharmacology come together to take advantage of the enormous diversity of chemical structures and biological activities found in natural products, creating enormous opportunities for multidisciplinary research [15]. Studying structural chemical databases that contain information on target genes and proteins and developing new chemical entities using computational molecular modeling for pharmacological evaluation are crucial aspects of drug development [16].

India's herbal medicine market, which includes ethical and traditional formulations, over-the-counter drugs, and cures from the Ayurvedic, Unani, and Siddha systems, generates around $1 billion in revenue annually, with just $80 million exported. Among the top ten herbal remedies in developed nations that are imported from overseas are *Allium salivum, Aloe barbadensis,* and *Panax species*.Additionally, *Psyllium (Plantago ovata), Senna (Cassia Senna),* and *Castor (Ricinus communis)* are the plants that India grows the greatest amount . Advanced extraction methods, including supercritical fluid extraction, ultrasound-assisted extraction, and microwave-assisted extraction, are utilized to improve the recovery of bioactive compounds. results and adherence to regulatory standards.

Table 1: List of very high market potential Herbal Medicines.[17]

S.No	Name of Plant	Common Name	Medicinal use
1.	*Allium sativum*	Garlic	Anti-hypertensive,Antihyperlipidemic, Platelet aggregation suppressant.
2.	*Azartica indica*	Neem	Anti-septic, Anthelmintic
3.	*Emblica officinallis*	Amla	Anti-oxidant, Hepatoprotective Diuretic, Laxative, Anti-inflammatory.

4.	*Asparagous racemosus*	Satavari	Galactogogue, Diuretic, Nerving disorder.
5.	*Oscium santum*	Tulsi	Aromatic, Anti-diabetic, Anti-inflammatory.
6.	*Plantago ovate*	Isabgol	Laxative, Demulcent, Anti-inflammatory
7.	*Withina somnifera*	Ashwagandha	Sedative, Anti-rheumatic, Anti-inflammatory, Diuretic, Anti-tumour, Immunomodulator.

2.2 HERBAL MEDICINE STANDARDIZATION

About 75–80% of people worldwide still rely on herbal medication for their basic medical needs, primarily in underdeveloped nations, because to its greater cultural acceptability, superior body compatibility, and lower risk of adverse consequences. Their use in affluent nations like Germany, France, the European Union, and the United States of America has significantly increased in recent years [18]. The market for herbal drugs in India is valued at over $1 billion, while the export of crude plant-based medications is valued at approximately $80 million [19].

WHO Guidelines for Standardization of Herbal Formulations' Quality:

- Control of the quality of plant preparations, final goods and raw medicinal ingredients.
- Shelf life and stability evaluations.
- Safety evaluations and records of safety derived from topological research or experience.
- An illustration of a system and procedures used to standardize herbal drugs. [20]

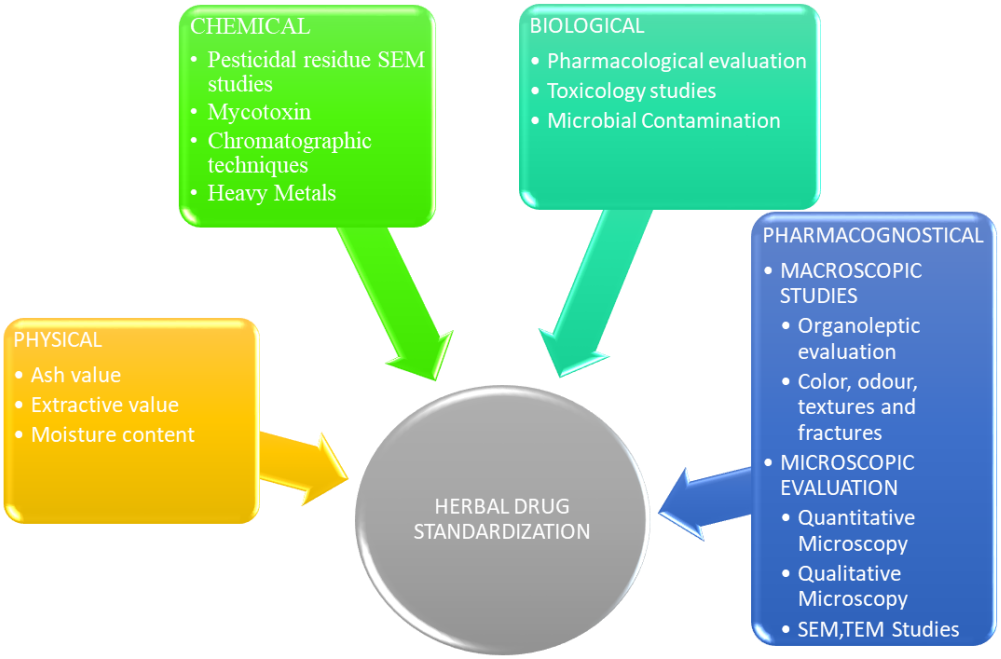

Fig 1: A diagramatic representation of herbal drugs standardization

3. THE INDIAN HERBAL MEDICINE SCENARIO:

About $1 billion is made up of herbal medicines in India, including over-the-counter items, ethical and traditional formulations, and therapies from the Ayurvedic, Unani and Siddha medical systems, with only $80 million exported. Crude pharmaceuticals, not fully developed formulations, account for 80% of exports to industrialized nations, which results in poor national income.

The following are listed as medicinal plants that are exported from India: *Podophyllum emodi* (rhizome*), Rheum emodi* (rhizome), *Saussurea lappa* (rhizome*), Swertia shirayita* (whole plant), *Valeriana jatamansi* (rhizome), *Zingiber officinale* (rhizome), *Colchicum luteum* (rhizome and seed), *Hedychium spimcatu* (rhizome and seed), Inula racemose (rhizome), *Juglans regia* (husk), *Juniperus communis* (fruit), and *Juniperus macropoda* (fruit). In modern medical practice, five of these , *Glycerriza glabra, and Azordica indica* are utilized. Other herbs, such as *Terminalia belerica, Embelica officialis* and *Terminalia chebula*, can be found in 52–141 herbal formulations, while triphala is utilized in 219 formulations[19].

The study of diverse plant extracts is limited by the use of widely utilized analytical techniques like chromatography. One or more bioactive plant components are often responsible for a desirable biological

response, and the relative amounts of each bioactive components can change from batch to batch while the bioactivity stays within acceptable bounds. Emerging trends in the standardization of herbal raw materials include the use of polyphenols, which are phytoconstituents with a total content that can be linked to biological activity like antioxidant activity, which frequently has an either indirect or direct connection to pathophysiological disorders like diabetes, cancer, inflammatory diseases and age-related disorders [21].

4. ROLE OF HERBS IN THE TREATMENT OF MAJOR AILMENTS:

India has one of the longest histories of plant-based medicine in the world. More than 25,000 powerful herbal remedies used in traditional Indian medicine. A traditional medical system employs medicinal plants for curative, preventative, and promotional purposes is practiced by more than 1.5 million people. Roughly 2000 tonnes of herbs are used annually by the approximately 7800 pharmaceutical production companies in India.

Plant-based medications have made a significant contribution to contemporary medicine. For instance, the 1953 isolation of serpentine from the root of the Indian plant Rauwolfia serpentina was a breakthrough in the management of hypertension and blood pressure reduction. Vinblastine, which was extracted from *Catharanthus rosesus*[22], is used to treat testicular and neck cancer, non-Hodgkins lymphomas, choriocarcinoma, and Hodgkins leukemia in children. Vincristine is advised for advanced stages of Hodgkins, lymphophosarcoma, cervical and breast cancer, as well as acute lymphocytic leukemia in children[23].

Using plant material as an indigenous remedy in folklore or traditional medical systems led to the introduction of plant-derived medications into contemporary medicine. Researchers have discovered that over 64 plants have strong antibacterial qualities, while over 24 plants have antidiabetic qualities. As an antidote, *Daboia russellii* and *Naja kaouthia* are utilized. Indian sarsaparilla Hemidesmus indicus root extract contains lupeol acetate, which neutralizes venom [24].

Table 2: List of export of herbs from India

S.no	Botanical Names	Parts used	Uses
1.	*Taxus brevifolia*	Bark of the Pacific yew tree	Treatment of ovarion and breast cancer.
2.	*Salix alba*	Bark of willow tree	Treatment of aches, fevers and inflammation.
3.	*Andrographis peniculata*	Leaves and Roots	Anti-inflammatory and anti-oxidant properties.
4.	*Commiphora weightii*	Resin	Used in pharmaceuticals and Ayurvedhic products.
5.	*Elettaria cardamomum*	Fruits and seeds	Digestive and anti-oxidant properties.
6.	*Mentha arvensis*	Leaves and oil	Cooling and digestive properties.
7.	*Cassia angustifolia*	Leaves and pods	Laxative properties and dietry supplements.
8.	*Emblica officinalis*	Fruits	Anti-oxidant and immunity boosting properties.
9.	*Zingiber officinale*	Rhizome	Digestive and Anti-inflammatory properties,
10.	*Curcuma longa*	Rhizome	Used in pharmaceuticals, foods and cosmetics.

Table 3: List of import of herbs from India

S.no	Botanical names	Parts used	Uses
1.	*Ginkgo biloba*	Leaves	Used in dietrysupplements, and pharmaceuticals.
2.	*Hypercium perforatum*	Leaves, Flowers and stems.	Anti-depressant properties, and dietry supplements.
3.	*Ashwagandha*	Root	Adaptogenetic and stress-relieving properties.
4.	*Echinacea*	Roots, Flowers and leaves	Immune-boosting properties and dietry supplements.
5.	*Adhatoda vasica*	Whole plant	Relieve bronchitis, cough andupper respiratory infections.
6.	*Juniperus communis*	Fruit	Anti-septic and anti-inflammatory properties
7.	*Gloriosa superba*	Tuber and seed	Analgesic and anti-arthritic properties.
8.	*Strycnos nux-vomica*	Bark and seed	Used in arrow poison and baits to kill feral mammals.
9.	*Phyllanthus amarus*	Fruit	Used in liver and kidney ailments.
10.	*Ricinus communis*	Seed	Laxative and Eye lubricant.

5. PROCESS INVOLVED IN THE HERBAL FORMULATIONS

International trade and commerce have previously acknowledged the economic value and relevance of herbal ingredients and completed herbal products. Herbs and herbal goods are hence profitable for the Indian market. The use of herbal formulations has been linked to a number of negative effects, though, which are typically linked to the poor quality of the raw materials, variations in the herbal material used as a source, the inherent toxicity of herbal medicines, and issues related to manufacturing and processing. To ensure the safety, purity, and efficacy of herbal medicines, it is essential to properly identify the species of the source plant and gather the necessary parts for their preparation [25].

Herbal processing is the process of applying post-harvest techniques to raw plant materials in order to create herbal ingredients, preparations, and final herbal products. For raw herbs or herbal materials to be as safe and effective as possible and to improve the therapeutic activity and quality of final herbal products, post-harvest processing is essential. In order to produce and manufacture herbal medications, a number of processing techniques have been developed by Good Herbal Processing Practices (GHPP), Good Agricultural and Collection Practices (GACP), and Good Manufacturing Practices (GMP).[25 primary and secondary processing are included in the "processing" of herbal materials. However, different herbs may require different processing methods.

6. MODERN HERBAL FORMULATIONS AND ITS DEVELOPMENT

Liposomes, composed of phospholipid bilayers, are highly effective drug delivery vehicles [26,27]. Depending on the characteristics of the substances, the encapsulation of plant extracts in liposomes aids in drug containment, either in the lipid phase or the aqueous phase. Liposomes function as solid particles that provide safe delivery of herbal formulations to their intended locations. To enable the sustainable release of small amounts of the herbal formulation, for example, leucine peptides will help open a narrow tunnel-like gap [28,29].

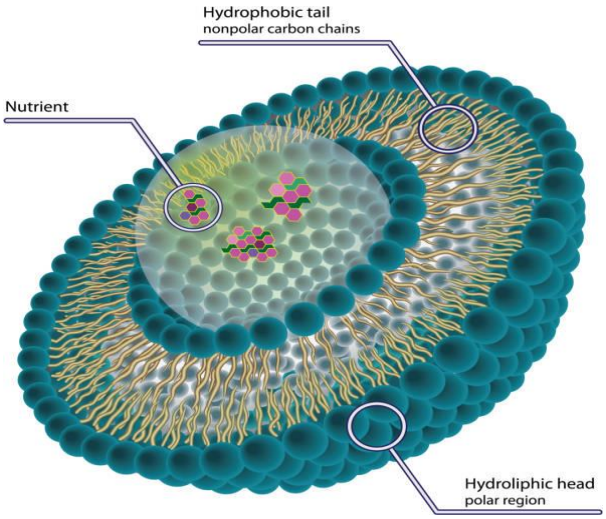

Fig 2: Structure of liposomes

The number of herbal formulations made using nanoparticles is steadily rising. Enhancing the solubility profile, increasing bioavailability, and improving therapeutic efficacy are just a few of the remarkable advantages that have been discovered when using nanoparticles in herbal formulations [30]. While active targeting, which entails adding ligands to the polymer, can be utilized for contemporary herbal formulations, passive targeting is appropriate for tumors because they have leaky vasculature [31].

It will be expected that a sufficient quantity of active phytochemicals would be effectively transported through the layers of the skin and eventually accumulate at the targeted areas when phytosomes are designed for dermal administration [32]. After being administered orally, phytosomes are anticipated to absorb more active phytochemicals via the gastrointestinal barrier, increasing their bioavailability in the plasma [33,34]. The fundamental obstacle to preserving the bioavailability of phytochemical substances, however, is avoiding the liver and kidneys' fundamental metabolic processes [35].When it comes to phytosomes, even if the intestinal layers can absorb a lot of active phytochemicals. According to prior research, phytosomes are a remarkable delivery mechanism that may be further altered to enhance its phyto-carrier capacities.

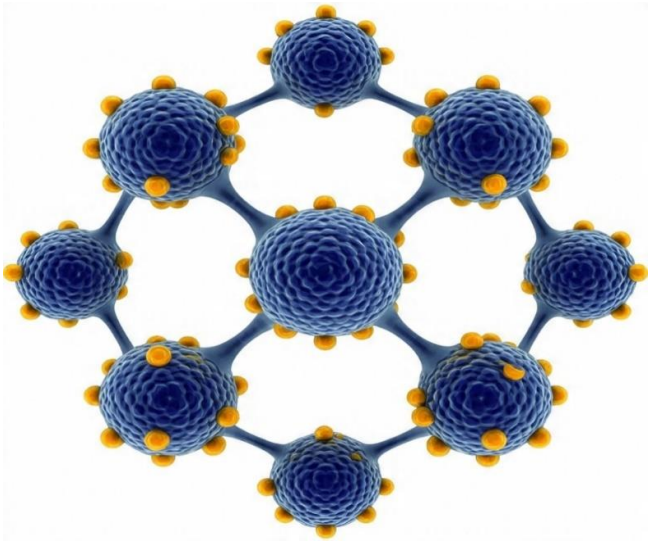

Fig 3: Structure of Phytosomes

The modern herbal sector has undergone a significant transformation due to the advancements in herbal formulations and innovations, resulting in the creation of products that are both effective and safe while maintaining high quality. Techniques such as phytochemical standardization guarantee that the formulations are consistent and of superior quality. Innovative extraction methods, including supercritical fluid extraction and nanotechnology, enhance the recovery of bioactive compounds and boost their bioavailability. The integration of Quality by Design (QbD) principles and Process Analytical Technology (PAT) tools promotes systematic formulation development, process improvement, and real-time quality monitoring. Adherence to regulations and comprehensive clinical trials validate the efficacy and safety of these formulations, thus transforming the development process and setting new benchmarks for the industry. They improve the absorption of liquid-insoluble polar botanical extracts through oral and topical routes, showing greater therapeutic benefits.

Table 4: A list of emergence of modern heral formulaions and nano- based herbal formulations.

Year	Details	Year	Details
1920s	Herman Staudinger pioneered polymer science [36]	**1989**	First controlled-release drug depots approved by FDA (Zoladex) [51]
1955	First polymer drug conjugate designed by Jatzkewitz [37]	**1990**	First PEG-protein conjugate (Adagen) marketed [52]
1960	First vinca alkaloid (Vinblastine) isolation reported [38]	**1992**	Another plant-based drug (Taxol) approved by FDA [53]
1963	FDA approved Vincristine Sulfate (Oncovin) [39]	**1995**	Lipophilic nanoparticles succeeded crossing blood brain barrier reported
1964	First polymeric drug carrier reported by Folkman & Long [40]		FDA approved first nano formulation (Doxil) [54]
1965	Liposomes reported by Bangham & his research team [41, 42]	**2001**	First TCM drug approved by FDA for clinical trial (Kanglaite) [55]
1971	Kulkarni & his team suggested PLA as drug carrier matrix [43]	**2004**	Irinotecan approved by FDA [56]
		2006	First botanical prescription drug approved by FDA (Veregen) [57]
1972	Albumin-based nanoparticle reported by Scheffel & his team [44]	**2008**	Vitamin C oral liposomal formulation reported [58]
1973	First drug-loaded liposomes reported by Gregoriadis [45]	**2011**	Nanoemulsion of plant-derived anticancer reported (Betulinic acid) [59]
1975	Ringsdorf described polymer-drug conjugates [46]	**2012**	First oral botanical drug approved by FDA (Fulyzaq)
1976	First enzyme-loaded liposomes reported [47]		FDA approved plant-based formulation to treat Gaucher disease (Elelyso) FDA approved plant-derived liposome injection (Marqibo) [60]
1980	Dendrimers reported by Duncan		

	& Kopeček [48]		
1983	First micelle formulation approved by FDA (Sandimmune) [49]	**2015**	First conjugation of nanodiamond with plant phytochemicals reported [61]
1985	PLA nanoparticles reported [50]	**2016**	Co-encapsulation of silbinin and glycirrhizic acid into nano-liposomal formulation reported [62]

6.1. DEVELOPED HERBAL FORMULTIONS

The developed Herbal Formulations include Herbal Tablets, Herbal Capsules, Herbal Syrups, Herbal Oinments, Herbal Suspensions, Herbal powders and Granules etc.

6.2. Herbal Tablets:

Herbal tablets are solid dosage forms containing herbal extracts or powders, often combined with excipients.

Advantages:

- Convenient to use
- Easy to swallow
- Can be coated for improved appearance and taste

Types:

- Immediate release: Tablets dissolve quickly, releasing the herbal extract.
- Sustained release: Tablets release the herbal extract slowly over time.
- Enteric coated: Tablets are coated to resist stomach acid and release the herbal extract in the intestines.

Manufacturing process:

- Extraction: Herbal extracts are obtained through various methods (e.g., solvent extraction, steam distillation).
- Mixing: Extracts are mixed with excipients (e.g., binders, fillers) and lubricants.
- Compression: The mixture is compressed into tablets using a tablet press.
- Coating: Tablets may be coated for improved appearance, taste, and stability.

Fig 4: Herbel Tablets

6.3. Herbal Capsules

Herbal capsules are solid dosage forms containing herbal extracts or powders, enclosed in a gelatin or vegetarian capsule shell.

Advantages:

- Easy to swallow
- Can be designed for targeted release
- Can be filled with a variety of herbal extracts or powders
- Vegetarian and vegan options available

Types:

- Hard gelatin capsules: Capsules made from gelatin, often used for dry herbal powders.
- Soft gelatin capsules: Capsules made from gelatin, often used for oily herbal extracts.
- Vegetarian capsules: Capsules made from plant-based materials (e.g., cellulose, pullulan), often used for dry herbal powders.

Manufacturing process:

- Extraction: Herbal extracts are obtained through various methods (e.g., solvent extraction, steam distillation).
- Filling: Extracts or powders are filled into empty capsule shells.
- Sealing: Capsules are sealed and packaged.

Fig 5: Herbal capsules

6.4. Herbal Syrups:

Herbal syrups are liquid dosage forms containing herbal extracts or decoctions, often sweetened and flavored.

Advantages:

- Easy to administer, especially for children and elderly
- Can be flavored to mask unpleasant tastes
- Can be used as a vehicle for other herbal extracts

Types:

- Simple syrup: A basic syrup made with sugar, water, and herbal extract.
- Compound syrup: A syrup made with multiple herbal extracts and other ingredients.
- Medicated syrup: A syrup containing a specific medicinal herb or extract.

Manufacturing process:

- Extraction: Herbal extracts are obtained through various methods (e.g., solvent extraction, steam distillation).
- Decoction: Herbal materials are decocted in water to create a liquid extract.
- Filtration: The liquid extract is filtered to remove impurities.
- Sweetening and flavoring: The filtered liquid is sweetened and flavored as desired.
- Packaging: The syrup is packaged in bottles or other containers.

Fig 6: Herbal Syrups

6.5. Herbal creams:

Herbal creams are semi-solid dosage forms containing herbal extracts or oils, used for topical application.

Advantages:

- Provide moisturizing and emollient properties
- Can be used for skin conditions, wound healing, and pain relief
- Can be more cosmetically appealing than ointments

Types:

- Simple cream: A basic cream made with herbal extracts or oils and a base (e.g., water, oil).
- Compound cream: A cream made with multiple herbal extracts or oils and other ingredients.
- Medicated cream: A cream containing a specific medicinal herb or extract.

Manufacturing process:

- Extraction: Herbal extracts are obtained through various methods (e.g., solvent extraction, steam distillation).
- Mixing: The herbal extracts or oils are mixed with a base (e.g., water, oil) and other ingredients (e.g., emulsifiers).
- Homogenization: The mixture is homogenized to create a uniform cream.
- Packaging: The cream is packaged in jars or tubes.

Fig 7: Herbal creams

6.6. Herbal Oinments:

Herbal ointments are semi-solid dosage forms containing herbal extracts or oils, used for topical application.

Advantages:

- Provide a protective barrier on the skin
- Can be used for wound healing, skin conditions, and pain relief
- Can be more stable than creams

Types:

- Simple ointment: A basic ointment made with herbal extracts or oils and a base (e.g., petroleum jelly).
- Compound ointment: An ointment made with multiple herbal extracts or oils and other ingredients.
- Medicated ointment: An ointment containing a specific medicinal herb or extract.

Manufacturing process:

- Extraction: Herbal extracts are obtained through various methods (e.g., solvent extraction, steam distillation).
- Mixing: The herbal extracts or oils are mixed with a base (e.g., petroleum jelly) and other ingredients (e.g., emulsifiers).
- Heating and cooling: The mixture is heated and cooled to create a uniform ointment.
- Packaging: The ointment is packaged in jars or tubes.

Fig 8: Herbal Oinments

6.7. Herbal Suspensions:
Herbal suspensions are liquid dosage forms containing undissolved herbal particles, often used for topical or oral administration.
Advantages:
- Can be used for topical applications, such as skin conditions
- Can be used for oral administration, especially for children and elderly
- Can be more stable than herbal solutions
Types:
- Simple suspension: A basic suspension made with herbal particles and a liquid vehicle.
- Compound suspension: A suspension made with multiple herbal particles and other ingredients.
- Medicated suspension: A suspension containing a specific medicinal herb or extract.
Manufacturing process:
- Extraction: Herbal extracts are obtained through various methods (e.g., solvent extraction, steam distillation).
- Particle size reduction: Herbal particles are reduced in size to create a uniform suspension.
- Mixing: The herbal particles are mixed with a liquid vehicle (e.g., water, oil) to create a suspension.
- Packaging: The suspension is packaged in bottles or other containers.

Fig 9: Herbal suspensions

7. CHALLENGES OF CURRENT HERBAL MEDICINE FORMULATIONS:

Presently, herbal medicine preparations encounter significant challenges such as issues with quality control, difficulties in achieving standardization, insufficient scientific evidence, and the possibility of interactions with conventional medications. These obstacles impede the broader acceptance and proper utilization of herbal

remedies.It is impossible to dispute the possibility of creating herbal medications as a viable substitute for conventional medicine. The safety and effectiveness of these plant-derived products, as well as their regulation and standardization, are, however, not adequately supported by published scientific data [63]. The standardization of active phytochemicals and improved safety and efficacy profiles are thus the outcomes of intensive attempts to includeherbal plants into contemporary pharmaceutical formulations. Natural products made from therapeutic plants may face several difficulties, from the recovery of active phytochemicals to the stage of commercialization.

The following are only a few of the difficulties in creating natural products:
• There is a lack of information on potential side effects and toxicity concerns [64, 65].
• The active phytochemicals'low bioavailability [66]
• Inadequate production of active phytochemicals [67] and a dearth of resources for therapeutic plants [68]
• Limited data on *in vitro*, *in vivo* or both drug-phytochemical interactions have been described [69].

8. CONCLUSION

In summary, herbal preparations offer a promising avenue in contemporary medicine because of their natural source, extensive therapeutic abilities, and low risk of adverse effects. Innovations in phytotechnology such as nanoformulations, liposomes, and phytosomes—are improving the absorption and effectiveness of active plant compounds. Nevertheless, considerable obstacles persist, including the need for standardization, concerns regarding toxicity, variability in phytochemical composition, and insufficient regulatory policies. To unlock the complete potential of herbal remedies, thorough research, rigorous quality assurance and compliance with Good Manufacturing Practices are crucial. Combining traditional wisdom with modern scientific approaches can result in the creation of effective, safe and internationally accepted herbal treatments.

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