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ROLE OF MEDICINAL PLANTS IN PHARMACEUTICAL SECTOR: AN OVERVIEW

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ABSTRACT
There are different forms of medicines available in the market like Ayurvedic, Unani, Homeopathic, and allopathic. Many pharmaceutical companies use different raw material for the formulation of the different type of medicines. The approach of the Pharmaceuticals sector includes the establishment of medical as well as in cosmetics, and nutraceuticals industries. The trading is based on imports and exports. India is one of the leading exporters of raw material in pharmaceutical sector which is advancing day by day. The purpose of this review is to study and understand the role, importance, and ongoing development of medicinal plants at the industrial level.

KEY-WORDS: Pharmaceuticals, Nutraceuticals, Cosmeceuticals, Herbal, Medicine, Plants, Industries.

1. INTRODUCTION

For a very long time, human beings are relying on nature for the sources of clothing, fertilizers, flavors, fragrances, health, food, medicine, shelters, transportation, and much more that are the basic requirements of life. In developing countries from the past long years, medicinal plants have a leading role in the healthcare system among a huge proportion of the human race because of their continuous use in herbal medicine as shown in Fig 1.

In both developing and industrialized countries, the expansion and acknowledgment of medicinal plants and their financial aids are on raise (World Health Organization, 1998). Pharmaceutical plays a crucial role in the mitigation, treatment, and prevention of any disease. They are essential to drug products that affect the structure and normal functioning of the body (Vermeer and Gilchrest, 1996).

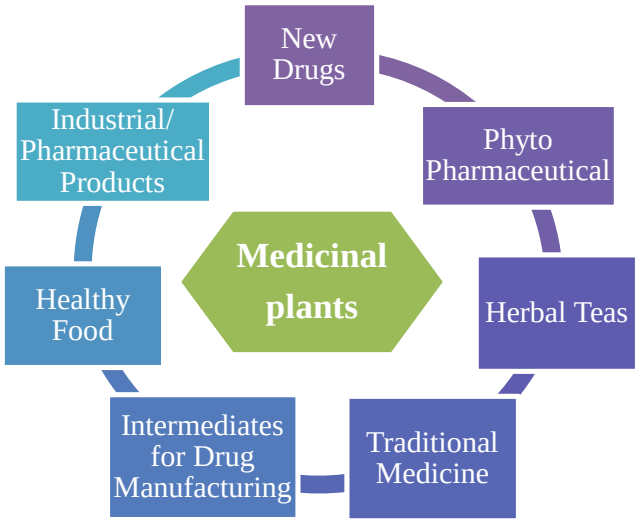

FIGURE 1: Different use of medicinal plants

In some of south eastern Asian countries such as China, Thailand, India, Sri-Lanka, Pakistan, Japan and many other countries, there is the traditional use of the medicinal plants. China alone attributed traditional tribal medicine by 40% of the total medicinal utilization. Also, in Thailand legumes of the *Mimosaceae*, the *Fabaceae*, and the *Caesalpiniaceae* came across to make herbal medicines. In the mid-90s, approx. sale of herbal medicine is US$ 2.5 billion above. In Japan itself, there is more demand for herbal medicine preparation for mainstream pharmaco-logically active products (Jones, 1998).

Plants contribution in different industries (like chemical, pharmaceutical, cosmetics, industrial raw material, and drugs.) is remarkable. In the development of new drugs,

along with medicinal plants pharmaceutical sector also play a very important role. From the last many years, medicinal plants helped in developing drugs to deal with deadly diseases like cancer and hepatitis, and others (Jain *et al*., 2020a). Different types of new drugs like vincristine, reseinnamine, vinblastine, deseridine, and reserpine were reported during 1950-1970 approximately 100 different plants in the USA drug market. In 1953, an Indian plant *Rauwolfia serpentine's* root was a pioneering incident in treatment of blood pressure and hypertension by the isolation of serpentine (Harrison, 1998). These developments were possible because of the rise in pharmaceutical sector that use medicinal plant as its primary source of formulation.

2. HERBAL MEDICINES

Worldwide, modern allopathic medicine has been replaced by herbal medicine significantly. Some herbal medicines are used in medical treatment that has been scientifically proven and apart from that, herbal medicinal products like raw material, finished products, and preparation of herbs are more accepted in place of herbal medicine. These products are made from one and another part, a mixture of various active ingredients of the therapeutical plants (Bhatt, 2016).

3. DEMANDS OF MEDICINAL PLANTS

In the modern drugs industries, old medicinal plants still have a key position due to its combined action of compounds with least side effects. From the last 50 years the vital drugs that are creating new revolution in modern medicinal practice is derived from plants mainly. The remedial characteristics of drugs by animals and plants were exhibited with the bioactive chemicals. The addition of herbal drugs to national health care programs is promoted and endorse by WHO because of its cost effectiveness for common men, time verified, approx. no side effects and is considered safe from artificial modern drugs (Singh and Singh, 1981).

Thus, the drugs obtained from the screening of biologically active agents from plant extracts with high pharmaceutical value led to a chief role in the curing human illness. Recently, pharmacological and phytochemical research work has produced many efficient solutions to several diseases, in which the synthetic drug industry was unsuccessful (Rastogi, and Meharotra, 1993).

4. INDIAN PHARMACEUTICAL INDUSTRIES

The manufacturing of traditional and allopathic medicines is depending on almost 15,000 licensed producing units. Among them, 300 are in organized sectors and from which 40% of them are of multinational accounts. The top 5-10 industrial, multinationals, and domestic companies account for market share at a growth rate of 30%, 7.2%, and 14% respectively (Viswanathan and Salmon, 2002). In India, the turnover is about US$ 1 billion, and 80 million of herbal medicine is exported annually. The worth of US$ 8 million is exported as plant products like opium extract, castor oil, psyllium seeds, and husk along with 20 other plants as a crude drug and insignificant amount around 8 plants are imported. The traditional pharmaceuticals and allopathic manufacturers in India like Alembic, Dabur, Himalaya, Hamdard, Maharshi, Lupin, Ranbaxy, and Zandu uses TLC and HPTLC fingerprinting for standardizing their herbal formulation (Kataria *et al*., 2011). There is a classification of herbal industries as shown in Fig. 2.

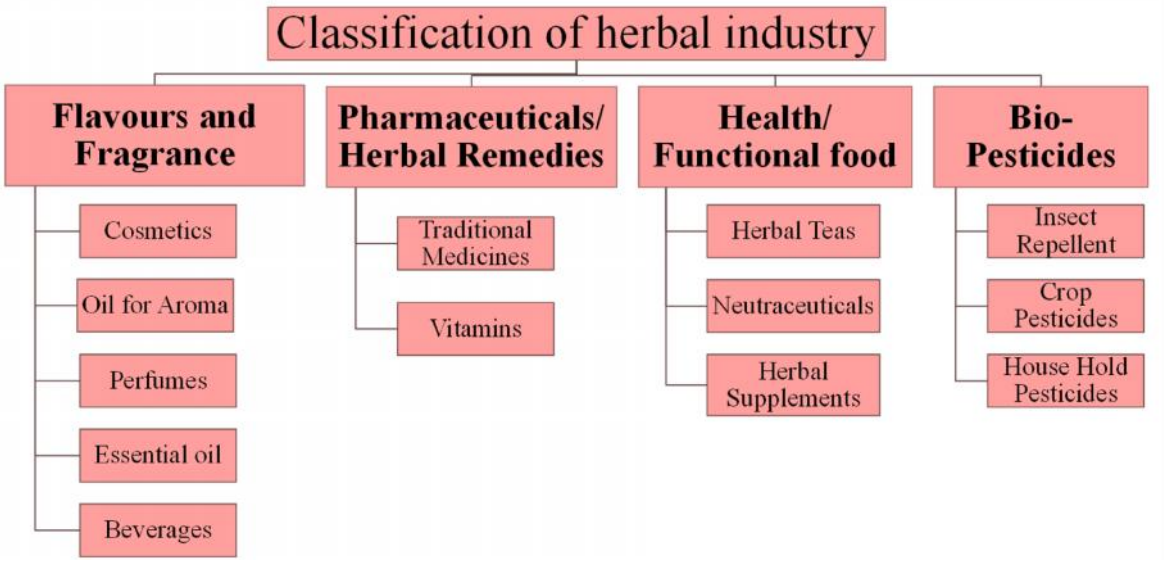

FIGURE 2: Classification of herbal industries

5. TRADITIONAL MEDICINE IN HEALTHCARE

Traditional medicines are known from an old different principle with the combination of knowledge, practice, and skill that originates from experience, theory, and belief of practicing physicians who generate remedies from original system of medicine. It is used to maintain the mental-physical illness from prevention, diagnosis, improvement, and treatment (Anonymous, 2001). Traditional medicines are formulated by utilization of minerals, medicinal, and aromatic plant and different other organic matter whereas herbal drugs are developed only from the major medicinal plants that are used for therapy from traditional medicine. Nowadays, non-conventional and conventional medical modalities are also used together with cancer therapy as

medical treatment in developed nations (Eisenberg *et al*., 1998; Olsen and Helles, 2009).

6. NATURAL HEALTH PRODUCTS

Natural health products (*e.g.* Cosmeceutical, nutraceuticals, phytomedicines, vitamins, homeopathic, minerals, herbals, and traditional medicines.) are ubiquitous (Gutierrez *et al*., 2014). Plants and herbs are complex and contain many vital components while the science behind the modern pharmaceutical agents is based on the development of single molecules. It has been observed that single compounds. Which are isolated from an herb usually have little potency, whereas a mixture of isolated bioactive compound has greater effect (Pang *et al*., 2002). Multiple individual chemicals in relatively low quantities comprise an herbal extract or mixture. The combined constituents may act together in a synergistic manner to produce a more potent and effective pharmacological action than each single chemical on its own as shown in Fig 3. The chemical mixture may also exhibit desirable pharmacological properties that are not seen with the individual components (Shan *et al*., 2007).

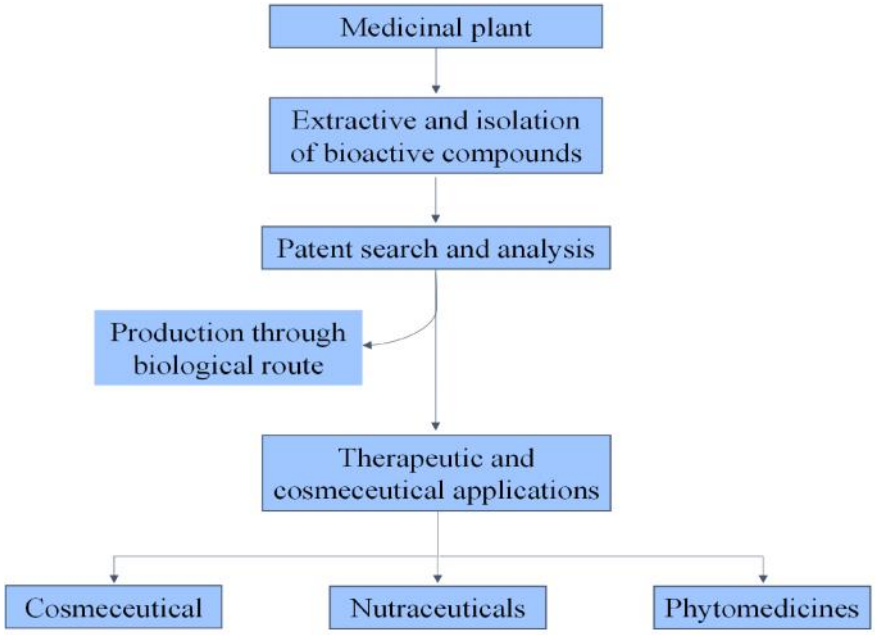

FIGURE 3: Distribution of different type of pharmaceutical sector

6.1 Cosmeceuticals:

Cosmetics was first recorded in 4000 BC used by Egyptians, products are used for cleansing and beautifying the skin (Millikan, 2001). It implies the efficacy of study for pharmaceuticals therefore it has been criticized. Veterinary and botanical cosmeceuticals are for sold of animal and oral herbal remedies respectively to avoid proof of requirement of efficacy (Rona *et al*., 2004). There is an increase of Aloe Vera in global market to treat the burns as well as skin cream. There are different medicinal plants that are been used nowadays, especially in Ayurvedic and herbal cosmetic (Oricha, 2010).

6.2 Nutraceuticals:

In 1989, Stephen De Felice coined the term "Nutraceuticals", which is the fusion of pharmaceutical with nutrition. According to the health Canada, it is a food product that is sold in different forms like pills, powder, potions, and other medicinal forms which are not generally group together with the food itself (Jain, 2020b; Jain, 2020c). There are three main segments like natural products, functional foods and, dietary supplements, under which the nutraceutical industry is placed (Das *et al*., 2012; Jain *et al*., 2020d). In India, nutraceutical industry is still in its early stage, but from the last 3 years, it is growing 18% faster than compound annual growth rate made by beverages categories and functional food. The dietary supplements and herbal natural products are the most rapidly growing segment of nutraceutical industries at annual growth percentage of 19.5% and 11.6% respectively.

6.3 Phytomedicines:

Plant composition and dose, route of administration, therapeutic class are evidence for phyto-pharmaceutical usage as well as supporting details from existing health or effectiveness literature and knowledge on human or clinical pharmacology trials. Medicinal plant antioxidants activity is compared and found to be related with secondary metabolites which provide benefits in pharmaceutical research (Prashar *et al*., 2020). USA, China, and other scientifically evaluating and data generating countries align the new regulation for pharmaceuticals with them. For the development of drugs, the new phyto-pharmaceuticals rule allows using advance techniques of modern formulation development, fractionation, potentiating steps, solvent extraction. It is expected to encourage advancement of novel drugs from herbal plants in a scientific way by these new regulations that helps in acknowledging the herbal product to be used by paramedics and will promotes research in phytopharmaceutical drug development for industry,

researchers, and academics (Narayana and Katiyar, 2013; Nooreen *et al*., 2018).

7. GLOBAL TRADE AND SUPPLY OF MEDICINAL PLANTS

Medicinal plants are a source of both health care and income. Globally, approx. 70-90 % of wild or natural resources meet the market demand and ensure the means of support to lots of rural people (Prasad and Bhattacharya, 2003). According to the societal preference and human need there were lots of changes seen by international medicinal plant's trade from more than the last 500 years. From the different sources including wild and cultivated harvesting, many countries use plant raw material for processing plant extracts such as cosmetics, solvent for food extracts, essential oils, vegetable oil, and pharmaceuticals (Prakash *et al*., 2019). It holds on the commercialization of active herbal ingredients on a global scale.

There are approximately six-seven stages in the supply chain of the products from the primary producer, collector, contractor to local, regional, and large wholesale markets, and then to specialized suppliers. These long chains do not provide sufficient prices to primary producers, cultivators or collectors for their products (Kala *et al*., 2006). On the basis of plant's area where they're grown, how they were harvested and stored and the parts of the plant used make a major difference between the quality of raw material and the amount of its active constituents. As well as the collection of wild harvesting is also adulterated, it does not guarantee the quality and uniformity of raw material (Booker *et al*., 2012). The product traceability becomes almost impossible as industries buy the brand range of raw material, which is in large quantity from suppliers and wholesalers despite small holders (Lange, 2004). Nowadays, buy-back arrangements and contract farming are the practical alternatives for exporters on the customer traceability demands.

7.1 Wild- harvest material:

Wild harvesting is the main source for plant material collection. It can be collected in many forms, such as leaves, stem, bark, flowers, roots, and fruits. Also, it can be collected from various locations, in different seasonal variations or climatic changes. Both domestically and internationally materials which are traded in bulk is still wild harvested and only a few plant species are cultivated before transporting (Lange, 1996). It is common to use unauthorized and unscientific collections. While most of the wild collected materials arrive from emerging countries, there is also a relatively massive chunk in developed countries. India had already banned the importation in the form of raw materials of many threatened plant species, but they are authorized to export fully completed plant material products. Many diverse varieties of Himalayan plants are widely cultivated but are almost extinct by untrained and over harvesting (Mebrahtu *et al*., 2016).

7.2 Cultivated material:

Cultivated material is far more appropriate for broad applications such as drug production in pharmaceutical industries and companies, involving assured, proven reliability, and value of standardized products. In most circumstances, only those plants that they use in significant amounts or for the production of their natural isolates and plant derivatives are produced by big companies and organizations. The quality and standardization are a very critical point in such cases. It is clearly visible that the cultivation of medicinal plants in both developed and developing countries is essential for traditional medicines, natural cosmetics, and important as sources of food (Lange, 1996; Klaus and Teresa, 2015).

8. MAJOR IMPORTING AND EXPORTING REGIONS AND COUNTRIES

There is the diversity in the market of herbal products as every nation is having its own conditions to market their products. On the basis of countries norms there are different intermediaries who helps in distribution of products from different sources as shown in Fig 4.

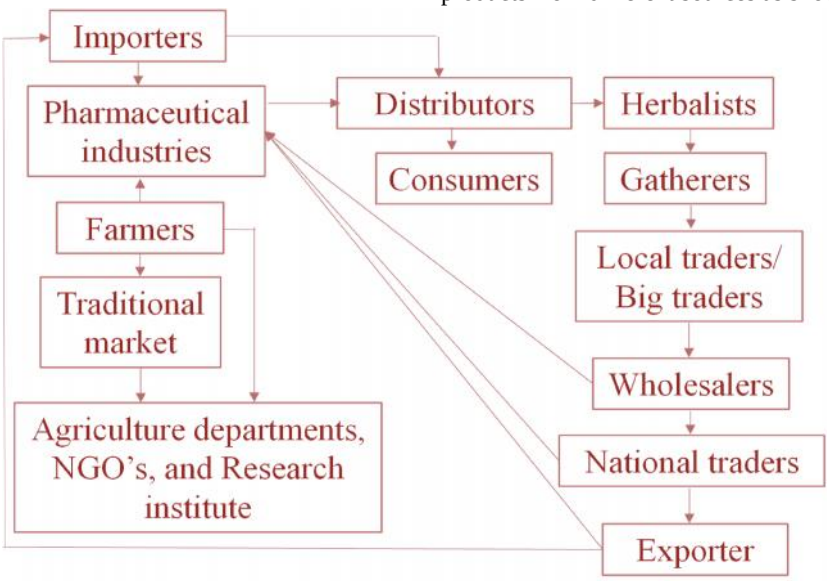

FIGURE 4: Interrelation of different export and import system

8.1 Exporters:

The plant material needs to undergo a stringent test before its mass production in pharmaceutical manufacturing. Developing countries like Brazil, Chile, China, India, the Republic of Korea, and Thailand are major exporting countries with prolong traditional use of medicinal plants. Also, developed countries like Europe and the US are well structured tend to export raw or unprocessed material and the developing or less developed countries have difficulty to participate in the market of herbal medicine. In India, 80% of raw material (like isolated ingredients, extracts, and dried plants) are exported, and the remaining 20% accounts for export in the complete medicinal products, in homeopathic, and ayurvedic medicines (Srivastava *et al*., 1996).

Indian manufacturers face major obstacles due to the difference between GMP standards of a specific country and the requirement of their drug registration (Sahoo and Manchikanti, 2013). China and India, though not the largest trader but are having the world's major marketplace for medicinal plants because of their large population and ancient inheritance of herbal based traditional medicines (Mantry *et al*., 2014).

8.2 Importers:

The medicinal plants and natural ingredients trade have surmounted the technological barriers from the past. All the extraction techniques like a distillation and soxhlation techniques of essential and cold press of vegetable oils along with their active ingredients and solvents (such as color, flavor, thickness and more) from medicinal plants are available (Wijesekera *et al*., 1997; Sharma and Pracheta, 2013b). Japan, China, US, Hong Kong (SAR), and Germany are the major importing countries. In Europe, latter is an importer having a very high value due to its pharmaceutical value in the world market. There is a different classification of herbal products based on the countries, from medicine to food. Also, there are different quality approaches on food to the medicinal products, so there are different quality safety systems like for medicine- GMP and for food- HACCP and GMO (Tchounwou *et al*., 2012).

Therefore, it is important to accommodate and guarantee these types of variation from the origin country. There is an increase in the competition among national and regional markets because of the shortage of raw materials. There are the establishment of suppliers' countries of Africa, Latin America, and Asia for processing their own facilities to offer high active ingredient to the manufacturers of nutraceuticals, cosmeceuticals, and pharmaceuticals (Klaus and Teresa, 2015).

9. DEVELOPMENTS IN HERBAL INDUSTRY

The new drugs discover from herbal medicine has led to spent around US$ 110 billion by multinational pharmaceutical companies as the annual amount. In the year 2002, Novartis announced to patent the application process of 500 traditional herbal medicine derived compounds. Top 10 pharmaceutical companies spent more than US $ 0.54 billion on developmental research of traditional herbal medicines, and studies of anti-AIDS activity from 300 and more different types of plants and was screened and conducted by American AIDS Prevention Center in the year 2003 (Wang, 2005).

Presently, in China the modern herbal drug development is on 3rd stage and the pharmaceutical multinational companies are precisely utilizing the novel drug entities from plant or herbal extracts (Pan *et al*., 2013). The significant economic growth of medicinal sector of plants globally contributes by the interest of multinational and domestic manufacturing and pharmaceutical companies for herbal based medicine. The Himalayan countries like Bangladesh, Nepal, and Bhutan provides large amount of medicinal plant that is collected as source of millions of dollars every year (Lakey and Dorji, 2016).

In India, there is a rich diversity of species of medicinal plant for the development of herbal industries which is useful for the research study for exploring its medical efficiency (Kala *et al*., 2006). In the global market, India has established its status as an economic producer with high quality standard drugs which act as an important tool for herbal products marketing.

In the future, India has expected to become a prime pillar to build a relation between modern sciences, and traditional medicine. Which leads to the development of pharmaceutical sectors and be among top five countries in terms of absolute growth revenue. India is responsible for 70% export for forest revenues and 40% of state forest-based economy on national level that come from medicinal plant also with non-timber forest products in the form of raw or unprocessed form (Johnson *et al*., 2013; Pandey *et al*., 2016). Over 200 percent the Indian pharmaceutical market has grown in 2015 from USD 6 billion to 20 billion.

The emerging market growth rate of countries like Mexico, Indonesia, Russia, Turkey, Brazil, South Africa, and China is much higher than the other developed markets. Globally operating pharmaceutical companies made it an attractive market by raise in 50% shares of global industries. Thus, emerging markets are the succeeding great factor for the drug companies (Pharma series, 2020).

10. PROBLEMS AND CONSTRAINTS IN MEDICINAL PLANTS TRADE AND MARKET DEVELOPMENT

In developing country like India, the major reason of concern for fulfilling the daily needs of medicine and food is the continual growth of population, as forest products are responsible for the livelihood and economy of societies (Satterthwaite *et al*., 2010). By which the destruction of forests and forest product's takes place continuously that leads to difficulty in fulfilling the requirement and conservation of natural resource. In spite of several species added gradually in materia medica, their purity standard and authentic identification doesn't imply growth process (Kala and Kala, 2009). In the exact market status, market price provides only limited insight for medicinal plant, it doesn't give information about demand, supply and profit. Due to quality, price and quantity factors, merchants confront many problems in finding a promising market place. In trading of medicinal plant products, it is really important for traders and collectors to have the complete knowledge on product, price and markets, along with consistency and standardization in quality for marketing internationally (Bhat *et al.*, 2018).

11. FUTURE PROSPECTS OF MEDICINAL PLANTS

Medicinal plants have a promising future, as approximately half a million plants worldwide. Many of the researchers have not yet been prosecuted for their medical activities and may be important for treating current and future science for their unknown value of medical activities (Singh, 2015). The research of medicinal plants helps to understand plant toxicity and prevents natural toxins in living creatures. The secondary metabolites production is the therapeutic effects of plants and can be increased due to several factors, including the remarkable diversity of both the chemical structure and biological activities of naturally occurring secondary metabolites, development of the novel and sensitive techniques to detect the biologically active natural products and compounds as biochemical probes, their therapeutic needs, advances in solving the urge for the supply of the complex natural products and improved techniques to isolate, purify, and structurally characterization of active constituents (Clark, 1996; Jain *et al*., 2020e; Razzak *et al*., 2020).

CONCLUSION

This increased use of medicinal plants and herbs has a major impact on raw material collection and therefore they require a sustainable conservation method as well as studies of phytochemistry, ethnobotany, and pharmacology. Almost all of the small-scale herbal industries require changes in raw material manufacturing, packaging, quality assurance, (because they have no facility for research and development).

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REFERENCES

Anonymous. (2001) Demand Study for Selected Medicinal Plants. Centre for Research, Planning and Action, New Delhi, India.

Bhat, M.H., Jain, A.K. and Fayaz, M. (2018) Indian Herbal Drug Industry: Challenges and Future Prospects, Springer International Publishing AG, part of Springer Nature, M. Ozturk, K.R. Hakeem (eds.), Plant and Human Health 1.

Bhatt, A. (2016) Phytopharmaceuticals: A new drug class regulated in India. Perspect Clin Res. 7, 59-61.

Booker, A., Johnston, D. and Heinrich, M. (2012) Value chains of herbal medicines-Research needs and key challenges in the context of ethnopharmacology. J Ethnopharmacol. 140, 624–633.

Clark, A.M. (1996) Natural Products as a Source for New Drugs. Pharm Res. 13, 1133-1141.

Das, L., Bhaumik, E., Raychaudhuri, U. and Chakraborty R. (2012) Role of nutraceuticals in human health. J Food Sci Technol. 49(2), 173–183.

Eisenberg, D.M., Davis, R.B., Ettner, S.L., Appel, S., Wilkey, S., Rompay, M.V., Kessler, R.C. (1998) Trends in Alternative Medicine Use in the United States, 1990-1997. Results of a Follow-up National Survey. JAMA. 280(18), 1569-1575.

Gutierrez, E., Silbert, F.J. and Vohra, S. (2014) Natural health product use and management in pediatrics: An integrative review. Eur J Integr Med, 6, 226–233.

Harrison, P. (1998) Herbal medicine takes roots in Germany. Can Med Assoc J. 10, 637-639.

Jain, D. (2020b) Nutraceuticals: Lifestyle Therapy, Vigyan Varta, 1 (1), 33-36.

Jain, D. (2020c) Ubtan- Gift from Ayurveda and Nature, Vigyan Varta, 1 (2), 28-29.

Jain, D., Chaudhary, P., Kotnala, A., Hossain, R., Bisht, K. and Hossain, M.N. (2020a) Hepatoprotective activity of Medicinal Plants: A mini review. J Med Plants Stud. 8(5), 183-188.

Jain, D., Uniyal, N., Mitra, D. and Janmeda, P. (2020e) Traditional resources and use of aromatic and ethno-medicinal plants in Uttarakhand: Compliment of nature. International Journal of Herbal Medicine. 8(5), 88-95.

Jain, D., Varshney, N. and Pracheta. (2020d) Human Mineral Malnutrition: Impact on Growth and Development. Vigyan Varta, 1 (2), 39-42.

Johnson, T.S., Agarwal, R.K. and Agarwal, A. (2013) Non-timber forest products as a source of livelihood option for forest dwellers: Role of society, herbal industries and government agencies. Curr Sci. 104, 440- 443.

Jones, W.B. (1998) Alternative medicine-learning from the past examining the present advancing to the future. JAMA. 280, 1616-1618.

Kala, and Kala C.P. (2009) Medicinal plants conservation and enterprise development. Medicinal Plants. 1, 79- 95.

Kala, C.P., Dhyani, P.P. and Sajwan, B.S. (2006) Developing the medicinal plants sector in northern India: challenges and opportunities. J. Ethnobiol. Ethnomed. 2, 32.

Kataria, S., Bhardwaj, S. and Middha, A. (2011) Standardization of Medicinal Plant Materials. Int J Res Ayurveda Pharm. 2, 1100-1109.

Klaus, D. and Teresa, H. (2015) International Trade of Medicinal and Aromatic Plants. In Business Media Dordrecht A. Mathe (ed.), Medicinal and Aromatic Plants of the World, Springer Science, 1.

Lakey, and Dorji, K. (2016) Ecological status of high-altitude medicinal plants and their sustainability: Lingshi, Bhutan. BMC Ecol. 16(1), 45.

Lange, D. (1996) Untersuchungen zum Heilpflanzenhandel in Deutschland. Bundesamt fur Naturschutz. Bonn.

Lange, D. (2004) Medicinal and Aromatic Plants: Trade, Production, and Management of Botanical Resources. Acta Hortic. 629(25), 177-197.

Mantry, S., Gopal, N.M., Tejaswini, J. and Kumar, S.A. (2014) International Standards of Medicinal Plants. Int j innov pharm sci res. 2(10), 2498-2532.

Mebrahtu, H., Zemede, A. and Mirutse, G. (2016) Review on value chain analysis of medicinal plants and the associated challenges, J Med Plants Stud, 4(3), 45-55.

Millikan, L. (2001) Cosmetology, cosmetics, cosmeceuticals: Definitions and regulations. Clin Dermatol. 19(4), 371- 374.

Narayana, D.B.A. and Katiyar, C.K. (2013) Draft amendment to drugs and cosmetics rules to license science-based botanicals, phytopharmaceuticals as drugs in India. J Ayurveda Integr Med. 4, 245-246.

Nooreen, Z., Rai, V.K. and Yadav, N.P. (2018) Phytopharmaceuticals: A new class of drug in India. Ann Phytomed. 7(1), 27-37.

Olsen, C.S. and Helles, F. (2009) Market efficiency and benefit distribution in medicinal plant markets: Empirical evidence from South Asia. Int J Biodivers Sci Ecosyst Serv Manag. 5, 53–62.

Oricha, B. B. (2010) Cosmeceuticals: A review. Afr J Pharm Pharmaco. 4(4), 127-129.

Pan, S.Y., Zhou, S.F., Gao, S.H., Yu, Z.L., Zhang, S.F., Tang, M.K., Sun, J. N., Ma, D. L., Han, Y. F., Fong, W. F. and Ko, K. M. (2013) New Perspectives on How to Discover Drugs from Herbal Medicines: CAM's Outstanding Contribution to Modern Therapeutics, Hindawi Publishing Corporation, Evidence-Based Complementary and Alternative Medicine, 25 pages.

Pandey, A.K., Tripathi, Y.C. and Kumar, A. (2016) Non-Timber Forest Products (NTFPs) for Sustained Livelihood: Challenges and Strategies. Res J For. 10, 1-7.

Pang, P.K., Benishin, C., Lewanczuk, R. and Shan, J. (2002) Problems in the use of herbal and natural substances, with a specific example concerning the cardiovascular system. Clin Exp Pharmacol Physiol. 29(8), 731-734.

Pharma series (2020). A Book: Global pharma looks to India: Prospects for growth, PricewaterhouseCoopers.

Prakash, A., Jain, D., Tripathi, R. and Janmeda, P. (2019) Pharmacognostical analysis of different parts of Cyperus rotundus L. Plant Sci Today. 6(1), 607-612.

Prasad, R. and Bhattacharya, P. (2003) Sustainable harvesting of medicinal plant resources. In S.B. Roy (eds.), Contemporary studies in natural resource management in India, New Delhi, India, Inter-India Publications, 168–198.

Prashar, S., Kaur, P., Sharma, P., Khatun, A. and Shaikh, N. I. (2020) A Study on Comparative Antioxidant Properties of *Mimosa pudica*, *Vachellia nilotica*, *Leucas aspera*, *Phyllanthus niruri*, *Emidesmus indicus* and *Adhatoda vasica*. Int J Curr Microbiol App Sci. 9(12), 833-840.

Rastogi, P. R. and Meharotra, B. N. (1993) In Compendium of Indian Medicinal Plants. PID, CSIR, New Delhi, India, I, 339, III, 194.

Razzak, K.S.B., Jain, D., Hossain, M.N. and Bushra, A. (2020) Plant edible vaccines: a natural way of vaccination (Let the Food be the Medicine). *Vigyan Varta*, 1 (5), 21-24.

Rona, C., Vailati, F. and Berardesca, E. (2004) The cosmetic treatment of wrinkles. J Cosmet Dermatol. 3(1), 26-34.

Sahoo, N. and Manchikanti, P. (2013) Herbal Drug Regulation and Commercialization: An Indian Industry Perspective. J Altern Complement Med. 19 (12), 957–963.

Satterthwaite, D., McGranahan, G. and Tacoli, C. (2010) Urbanization and its implications for food and farming. Philosophical transactions of the Royal Society of London. Series B, Biological sciences, 365 (1554), 2809–2820.

Shan, J.J., Rodgers, K., Lai, C.T. and Sutherland, S.K. (2007) Challenges in Natural Health Product Research: The Importance of Standardization. Proc West Pharmacol Soc. 50, 24-30.

Sharma, V. and Pracheta. (2013b) Microscopic studies and preliminary pharmacognostical evaluation of Euphorbia neriifolia (Linn.) leaves. Indian J Nat Prod Resour. 4(4), 348-357.

Singh, P. and Singh, C.L. (1981) Chemical investigations of Clerodendraon fragrans. J Indian Chem Soc. 58, 626-627.

Singh, R. (2015) Medicinal Plants: A Review. Special Issue: Medicinal Plants. J Plant Sci. 3(1), 1, 50-55.

Srivastava, J., Lambert, J. and Vietmeyer, N. (1996) Medicinal Plants: An Expanding Role in Development. World Bank. Washington, DC, 320.

Tchounwou, P. B., Yedjou, C.G., Patlolla, A.K. and Sutton, D.J. (2012) Heavy Metal Toxicity and the Environment. In: Luch A. (eds) Molecular, Clinical and Environmental Toxicology. Experientia Supplementum, Springer, Basel, 101, 133-164.

Vermeer, B.J. and Gilchrest, B.A. (1996) Cosmeceuticals. A proposal for rational definition, evaluation, and regulation. Arch Dermatol. 132 (3), 337-340.

Viswanathan, H. and Salmon, J.W. (2002) India's Pharmaceutical Industry: A Growing Influential Force in the World Pharmaceutical Market. J Manage Care Pharm. 8(3).

Wang, J. (2005) New Trends in Strategic Adjustment of Multinational Pharmaceutical Companies and The Impact on China -4: The Battle of Chinese Medicine Resources, Chinese Medicine Research and Development Center.

Wijesekera, R.O.B., Ratnatunga, C.M. and Durbeck, K. (1997) The distillation of essential oils. Manufacturing and plan construction handbook. Protrade, Department of Food stuffs and Agricultural Products GTZ.

World Health Organization (1998) Regulatory situation of herbal medicines. A worldwide review. Geneva, Switzerland, 1-5.