Research Article
Emerging Herbal Cosmetic Production in Sri Lanka: Identifying Possible Interventions for the Development of the Herbal Cosmetic Industry

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Although the herbal cosmetic industry has exponentially increased globally, manufacturing of herbal cosmetic products in Sri Lanka is still very limited. Therefore, objectives of the study were to recognize plants used in commercialized herbal cosmetic products and major constraints faced by herbal cosmetic manufacturers and to identify possible interventions for the development of herbal cosmetic industry of Sri Lanka. Information was gathered via a semistructured questionnaire by personal interviews with 11 large-scale multiple herbal cosmetic products manufacturers. Collected data were analyzed via frequency index for usage and descriptive statistics. A total of 115 plant species belonging to 56 families were identified. Extensive usage of *Aloe vera* (L.) Burm.f., *Coscinium fenestratum* (Goeth.) Colebr., and *Santalum album* L. (90.91%) was reported among herbal cosmetic manufacturers. The highest number of plants or plant materials was used for manufacturing skin care products (54.78%) followed by hair care (19.13%) and oral care (6.96%). The majority of plants were reported from the plant family Fabaceae (16 species). Leaves (20.87%) were the widely used plant part, whereas 10 plant species were used as whole plants. Inadequacy of 7 plants/plant materials and importation of 8 plant materials for the production were also recognized. As major constraints faced by herbal cosmetic manufacturers, inadequate availability and poor quality of raw materials were emphasized. In conclusion, establishing proper cultivation system, implementing strategies for quality control of raw materials, and conducting ethnobotany, ethnomedical, and pharmacological surveys to identify cosmetic potential of medicinal plants and partnerships with universities to transfer technology for product development to industries are possible interventions for the development of herbal cosmetic industry of Sri Lanka.

1. Introduction

Sri Lanka, formerly known as Ceylon, is an island with an area of approximately 65,610 km². Despite its relatively small size, Sri Lanka possesses a high level of biodiversity due to its varied climate and topographical conditions [1]. Plants have been used for treating illnesses over a thousand years by four systems of traditional medicine in Sri Lanka called *Ayurveda, Siddha, Unani*, and *Deshiya chikitsa* [2]. As a biologically diverse country in Asia, Sri Lanka currently possesses 29.7% of forest cover [3], 4143 plant species distributed within 214 families, and 1522 genera. Of these, 1025 plant species are endemic to the country [4]. Among the native flora of Sri Lanka, more than 1,400 plants are used in indigenous medicine [5]. Many formulae for medicinal preparations of Sri Lankan traditional system of medicine
are handed down from generation to generation or are found only in the scripts of old "ola leaf" books treasured by traditional and Ayurvedic practitioners [6]. The study conducted by Kankanamalage et al. [7] reveals the sources of medicinal plant materials that are obtained for numerous medicinal plant-based trades. About 71.13% of these medicinal plants/herbal materials are obtained from local sources, 26% are imported, while 2.87% are obtained through either route. Moreover, it reveals that 80% of both fresh and dry plant materials contribute to the herbal industry. Thus, it clearly implies the importance of medicinal plants in different systems of medicine in Sri Lanka. Moreover, the study conducted by Dissanayake [8] on "Medicinal plant research in Sri Lanka: a scientometric study based on Scopus database" highlights about research studies of 190 plants including 22 endemic plants. It reveals that most of the conducted studies were activity-based studies such as toxicity, antibacterial, antifungal, hypoglycemic, antioxidant, anti-inflammatory, and diuretic. This was followed by general studies such as physicochemical, chemical, postharvest, horticultural, and propagation studies of plants. This study evidently indicates the largely unexplored knowledge gap of medicinal plants in Sri Lanka.

The global consumption of herbal cosmetics has shown spectacular growth in recent years due to the growing recognition of long-term health benefits [9, 10]. According to the available market research, the current global natural and organic personal care products market is valued approximately US$ 11 billion and is expected to reach US$ 22 billion by 2022 [11]. Thus, the global enormous demand for herbal cosmetics results in a huge trade from local to the international level. Consequently, there are ample opportunities for Sri Lanka to expand its herbal cosmetic productions through its unique biodiversity of medicinal flora and a rich base of traditional knowledge. However, there has been a dearth of published information on herbal cosmetic production and plants used in the herbal cosmetic industry of Sri Lanka. Although the herbal cosmetic industry has significantly increased throughout the world, the supply of herbal cosmetic products from Sri Lanka is still very limited. Therefore, it is crucial to identify major constraints faced by herbal cosmetic manufacturers to identify possible interventions for the development of the herbal cosmetic industry of Sri Lanka. At present, this becomes a necessary area to be addressed within the country as this is one of industries which can easily capitalize the global trends. Thus, the objective of this present survey was to identify plants and plant parts used in commercialized herbal cosmetic products in Sri Lanka especially under the categories of skin care, hair care, and oral care. The constraints faced by herbal cosmetics manufacturers and their suggestions were also studied to identify possible interventions for the future improvements of the herbal cosmetic industry in Sri Lanka.

2. Materials and Methods

2.1. Study Area and Selection of Respondents. Any herbal product to be sold to the public must be registered under the Department of Ayurveda, Sri Lanka. Therefore, herbal cosmetic manufacturers were selected based on the registry maintained for herbal products at the Department of Ayurveda, Sri Lanka. This survey was conducted from January to August 2018. In total, 18 herbal cosmetic manufacturers in Sri Lanka were identified. Among these, 13 herbal cosmetic manufacturers were pioneers in the herbal cosmetic industry of Sri Lanka, while the rest were small-scale herbal cosmetic manufacturers. Prior to data collection, each respondent was informed of the aims and objectives of the study to obtain their consent and cooperation for the survey. However, permission was received only from 11 large-scale herbal cosmetic manufacturers to carry out the survey and to gather the information. Among them, 9 manufacturing factories were in the Western Province, Sri Lanka, while other two factories were in the Central Province and Southern Province, Sri Lanka, respectively.

2.2. Preparation of Questionnaire. Information was collected via a semistructured questionnaire (Supplementary 1) under two main sections. The first section was designed to gather general information about the organization including the organization name/name of the organization representative, experience of the profession, address, province/district, and registration number assigned by Ayurveda Department. The second section of the questionnaire was prepared to gather the following major information: (1) manufacturing herbal cosmetic products under skin care, hair care, and oral care categories; (2) medicinal plants and plant parts used for productions; (3) sources (local/import) of herbal materials; and (4) availability (sufficient/insufficient) of herbal materials. Furthermore, main challenges and difficulties in herbal cosmetics production and suggestions were recorded for identifying future improvements of the herbal cosmetic industry in Sri Lanka.

2.3. Data Collection and Quantitative Analysis. Personal interviews were conducted. During the survey, the information mentioned in Section 2.2 was specifically obtained. Plants/plant materials were collected at the manufacturing sites. Furthermore, collected plants/plant materials were dried, preserved, and mounted on herbarium sheets. Herbarium voucher numbers were coded from NGHC 01 to NGHC 115 as the same order of the plant list indicated in Table 1. Plant identification was carried out by comparing the deposited herbarium of the royal botanical garden, Peradeniya, Sri Lanka. The scientific names of plants were validated based on the collections listed in the homepage (http://www.theplantlist.org). Vernacular names and English names of plants were verified using the Ayurveda authentic books, "Compendium of medicinal plants, Sri Lankan study," volumes I to IV issued by Ayurveda Department of Sri Lanka and "A collection of medicinal plants in Sri Lanka," issued by Nature's Beauty creations limited, Sri Lanka. Collected data were tabulated and analyzed using descriptive statistics. The frequency index for usage of each plant was calculated using the following formula described by Dharmadasa et al. [12]:

\[ \text{Frequency Index} = \frac{\text{Number of uses}}{\text{Number of respondents}} \]
| No. | Family         | Scientific name | English name | Vernacular name | Plant part(s) | Availability | Source       | Product category(s) | Frequency index |
|-----|----------------|-----------------|--------------|-----------------|---------------|--------------|--------------|---------------------|-----------------|
| 1   | Acanthaceae    | Justicia
      adhatoda L. Malabar nut | Adathoda     | Leaves         | Sufficient     | Local         | Oral care    | 18.18              |
| 2   | Amaranthaceae  | Alternanthera
      sessilis (L.) R.Br.ex DC. Sessile joyweed | Mugunuwenna  | Whole plant    | Sufficient     | Local         | Hair care    | 45.45              |
| 3   | Anacardiaceae  | Mangifera
      indica L. Mango | Amba         | Fruit          | Sufficient     | Local         | Skin care    | 18.18              |
| 4   | Apiaceae       | Daucus carota
      L. Carrot | Carrot       | Root           | Sufficient     | Local         | Skin care    | 27.27              |
| 5   |                | Centella
      asiatica (L.) Urb. Pennywort | Gotukola     | Whole plant    | Sufficient     | Local         | Skin care, hair care | 54.55          |
| 6   | Apocynaceae    | Plumeria
      obtusa L. Singapore graveyard flower | Araliya      | Flower         | Sufficient     | Local         | Skin care    | 9.09               |
| 7   |                | Hemidesmus
      indicus (L.) R.Br.ex Schult. Indian sarsaparilla | Iramusu      | Whole plant    | Sufficient     | Local         | Skin care    | 27.27              |
| 8   | Arecaceae      | Cocos nucifera
      L. Coconut | Pol          | Fruit          | Sufficient     | Local         | Skin care, hair care | 27.27          |
| 9   |                | Cocos nucifera
      L. King coconut | Thambili     | Fruit          | Sufficient     | Local         | Hair care    | 9.09               |
| 10  | Aristolochiaceae | Aristolochia
      bracteolata Lam. Warm killer | Sapsanda     | Root           | Sufficient     | Local         | Oral care    | 9.09               |
| 11  | Asparagaceae   | Asparagus
      falcatus L. Sickle thorn | Hathawariya  | Whole plant    | Sufficient     | Local         | Skin care    | 9.09               |
| 12  | Asphodelaceae  | Aloe vera
      (L.) Burm.f. Aloe | Komarika     | Leaf gel       | Sufficient     | Local         | Skin care, hair care | 90.91          |
| 13  | Asteraceae     | Bellis
      perennis L. Daisy | Daisy        | Flower         | Sufficient     | Local         | Skin care    | 9.09               |
| 14  |                | Genus Tagetes
      Vermonia cinerea (L.) Less. Marigold | Daspethiya  | Flower         | Sufficient     | Local         | Skin care    | 9.09               |
| 15  |                | Genus Helianthus
      Saussurea costus (Falc.) Lipsch Ironweed | Monarakudumbiya | Whole plant    | Sufficient     | Local         | Skin care    | 9.09               |
| 16  |                | Sunflower | Suryakantha | Seed          | Sufficient     | Local         | Skin care    | 18.18              |
| 17  |                | Costus | Suwanda Kottam | Stem          | Sufficient     | Local         | Skin care, hair care | 36.36          |
| 18  |                | False daisy | Keekirindiya | Whole plant    | Sufficient     | Local         | Hair care    | 54.55              |
| 19  | Calophyllaceae | Mesua ferrea L. Iron wood | Na | Flower stamen | Insufficient   | Local         | Skin care    | 18.18              |
| 20  | Caricaceae     | Carica papaya
      L. Papaya | Gaslabu      | Fruit, leaves  | Sufficient     | Local         | Skin care    | 27.27              |
| 21  | Celastraceae   | Kokoaona
      zeylanica Thwaites Kokum | Bark        | Insufficient   | Local         | Skin care    | 72.73        |
| 22  | Clusiaceae     | Garcinia
      quaeita Pierre Red mango | Rath goraka  | Bark, fruit rind | Sufficient | Local         | Skin care, oral care | 18.18          |
| 23  | Combretaceae   | Terminalia
      chebula Retz. Chebulic myrobalan | Aralu       | Fruit          | Sufficient     | Local         | Oral care, hair care | 45.45          |
| 24  |                | Terminalia
      bellirica (Gaertn.) Roxb. Beleric myrobalan | Bulu       | Seed           | Sufficient     | Local         | Hair care    | 9.09               |
| 25  | Cucurbitaceae  | Cucumis sativus
      L. Cucumber | Pipinga      | Fruit          | Sufficient     | Local         | Skin care    | 36.36              |
| No. | Family       | Scientific name | English name | Vernacular name | Plant part(s) | Availability | Source | Product category(s) | Frequency index |
|-----|--------------|-----------------|--------------|-----------------|---------------|--------------|--------|----------------------|-----------------|
| 26  | Cyperaceae   | *Cyperus rotundus* L. | Nut grass     | Kalanduru       | Tuber         | Sufficient   | Local   | Skin care            | 18.18           |
| 27  | Dilleniaceae | *Dillenia retusa* Thunb. | Godapara     | Fruit           | Insufficient  | Local        | Hair care | 18.18               |
| 28  | Dipterocarpaceae | *Vateria copallifera* (Retz.) Alston | Haldummala   | Fruit           | Sufficient    | Local        | Skin care | 9.09                |
| 29  | Elaeocarpaceae | *Elaeocarpus serratus* L. | Ceylon olive | Veralu          | Leaves        | Sufficient   | Local   | Hair care            | 18.18           |
| 30  | Euphorbiaceae | *Ricinus communis* L. | Castor        | Erandu          | Leaves        | Sufficient   | Local   | Skin care            | 9.09            |
| 31  | Euphorbiaceae | *Croton aromaticus* L. | Golden shower tree | Ehela          | Leaves        | Sufficient   | Local   | Skin care            | 9.09            |
| 32  | Fabaceae     | *Cassia fistula* L. | Coral tree    | Erabadu         | Leaves        | Sufficient   | Local   | Skin care            | 9.09            |
| 33  | Fabaceae     | *Erythrina variegata* L. | Emperor’s candlesticks | Eththora      | Leaves        | Sufficient   | Local   | Skin care, hair care | 36.36           |
| 34  | Fabaceae     | *Senna alata* (L.) Roxb. | Chick pea     | Kadal           | Seed          | Sufficient   | Local   | Skin care            | 9.09            |
| 35  | Fabaceae     | *Pongamia pinnata* (L.) Pierre | Indian beech  | Karanda         | Bark          | Sufficient   | Local   | Oral care            | 9.09            |
| 36  | Fabaceae     | *Cassia auriculata* L. | Vegetable hummingbird | Kathurumurunga | Leaves        | Sufficient   | Local   | Hair care            | 9.09            |
| 37  | Fabaceae     | *Tephrosia purpurea* (L.) Pers. | Purple tephrosia | Kathurupila/Pila | Root         | Sufficient   | Local   | Oral care            | 18.18           |
| 38  | Fabaceae     | *Adenanthera pavonina* L. | Red lucky seed | Madatiya       | Leaves        | Sufficient   | Local   | Hair care            | 45.45           |
| 39  | Fabaceae     | *Indigofera tinctoria* L. | Indigo blue   | Nil–awari       | Leaves        | Sufficient   | Local   | Hair care            | 54.55           |
| 40  | Fabaceae     | *Cassia auriculata* L. | Mature tea tree | Ranwara        | Flower        | Sufficient   | Local   | Skin care            | 9.09            |
| 41  | Fabaceae     | *Pterocarpus santalinus* L.f. | Red sandalwood | Rath Handun    | Heartwood     | Sufficient   | Import  | Skin care, hair care | 18.18           |
| 42  | Fabaceae     | *Trigonella corniculata* Sibth. & Sm. | Sickle-fruit fenugreek | Siyakka       | Seed          | Sufficient   | Local   | Hair care            | 18.18           |
| 43  | Fabaceae     | *Tamarindus indica* L. | Tamarind      | Siyambala       | Seed          | Sufficient   | Local   | Skin care            | 18.18           |
| 44  | Fabaceae     | *Trigonella foenum-graecum* L. | Fenugreek     | Uluhal          | Seed          | Sufficient   | Local   | Hair care            | 36.36           |
| 45  | Fabaceae     | *Phaseolus mungo* L. | Black gram    | Undu            | Seed          | Sufficient   | Local   | Skin care            | 9.09            |
| 46  | Fabaceae     | *Glycyrrhiza glabra* L. | Liqourice     | Walmee          | Root          | Sufficient   | Import  | Skin care, hair care, oral care | 54.55 |
| 47  | Lamiaceae    | *Ocimum tenuiflorum* L. | Tulsi         | Heen Maduruthala | Leaves        | Sufficient   | Local   | Skin care            | 18.18           |
| 48  | Lamiaceae    | *Plectranthus amboinicus* (Lour.) Spreng. | Country borage | Kapparawalliya | Leaves        | Sufficient   | Local   | Skin care            | 9.09            |
| No. | Family | Scientific name | English name | Vernacular name | Plant part(s) | Availability | Source | Product category(s) | Frequency index |
|-----|--------|-----------------|--------------|----------------|---------------|--------------|--------|---------------------|-----------------|
| 50  | Lauraceae | Persea americana Mill. | Avocado pear | Aligata pera | Fruit | Sufficient | Local | Skin care | 18.18 |
| 51  | Lauraceae | Cinnamomum verum J. Presl | Cinnamom | Kurundu | Bark | Sufficient | Local | Skin care, hair care, oral care | 36.36 |
| 52  | Loganiaceae | Strychnos potatorum L.f. | Clearing-nut tree | Ingini | Seed | Sufficient | Local | Skin care | 9.09 |
| 53  | Lythraceae | Punica granatum L. | Pomegranate | Delum | Leaves, fruit rind | Sufficient | Local | Skin care | 18.18 |
| 54  | Lythraceae | Lawsonia inermis L. | Henna | Marathondi | Leaves | Sufficient | Local | Hair care | 18.18 |
| 55  | Malvaceae | Theodora cacao L. | Portia tree | Gansooriya | Leaves, bark | Sufficient | Local | Skin care | 18.18 |
| 56  | Malvaceae | Hibiscus rosa-sinensis L. | China rose | Pokuru wada | Flower | Sufficient | Local | Hair care | 27.27 |
| 57  | Malvaceae | Abelmoschus moschatus Medik. | Musk mallow | Kapu kinissa | Seed | Sufficient | Local | Skin care | 9.09 |
| 58  | Malvaceae | Sida cordata (Burm.f.) | Heart leaf | Wel babila | Leaves, stem | Sufficient | Local | Skin care, hair care | 9.09 |
| 59  | Malvaceae | Osbeckia octandra DC. | Heenbowitiya | Flower | Sufficient | Local | Skin care | 9.09 |
| 60  | Lythraceae | Azadirachta indica A.Juss. | Neem | Kohomba | Bark, leaves | Sufficient | Local | Skin care, hair care | 72.73 |
| 61  | Menispermacae | Tinospora cordifolia (Willd.) Miers | Heart leaved moosseed | Rasakinda | Stem | Sufficient | Local | Skin care | 9.09 |
| 62  | Menispermacae | Coscinium fenestratum (Goetgh.) Colebr | Calumba wood | Weni wel | Stem | Insufficient | Local | Skin care | 90.91 |
| 63  | Molluginaceae | Mollugo cerviana (L.) Ser. | Threadstem carpetweed | Pathpadagam | Whole plant | Sufficient | Local | Skin care | 9.09 |
| 64  | Molluginaceae | Ficus religiosa L. | Sacred fig | Bo | Bark | Sufficient | Local | Skin care | 9.09 |
| 65  | Moraceae | Morus alba L. | Silkworm mulberry | Mulberry | Fruit | Sufficient | Local | Skin care | 9.09 |
| 66  | Moraceae | Ficus benghalensis L. | Banyan tree | Nuga | Bark | Sufficient | Local | Skin care | 9.09 |
| 67  | Moraceae | Ficus racemosa L. | Cluster fig tree | Attikka | Bark | Sufficient | Local | Skin care | 9.09 |
| 68  | Moringaceae | Moringa oleifera Lam. | Drumstick tree | Murunga | Seed, leaves | Sufficient | Local | Skin care | 18.18 |
| 69  | Myristicaceae | Myristica fragrans Houtt. | Nutmeg | Sadhikka | Seed | Sufficient | Local | Hair care | 9.09 |
| 70  | Myristicaceae | Caryophyllus aromaticus L. | Clove | Karabu | Flower buds | Sufficient | Local | Skin care, oral care | 54.55 |
| 71  | Myrtaceae | Eucalyptus globulus Labill. | Tasmanian bluegum | Karupantine | Leaves | Sufficient | Local | Oral care | 9.09 |
| 72  | Myrtaceae | Melaleuca leucadendra (L.) L. | Cajuput tree | Lothsambulu | Bark | Insufficient | Local | Skin care | 18.18 |
| 73  | Myrtaceae | Psidium guajava L. | Guava | Pera | Leaves | Sufficient | Local | Hair care | 18.18 |
| No. | Family               | Scientific name | English name | Vernacular name | Plant part(s) | Availability | Source          | Product category(s) | Frequency index |
|-----|----------------------|-----------------|--------------|----------------|---------------|--------------|-----------------|---------------------|-----------------|
| 75  | Nelumbonaceae        | Nelumbo nucifera Gaertn. | Lotus | Nelum | Flower stamen | Sufficient | Local | Skin care | 27.27 |
| 76  | Nymphaeaceae         | Nymphaea nouchali Burm.f | Blue water lily | Nil-manel | Flower stamen | Sufficient | Local | Skin care | 9.09 |
| 77  | Oleaceae             | Olea europaea L. | Olive | Olive | Fruit | Sufficient | Import | Skin care, hair care | 27.27 |
| 78  | Jasminum grandiflorum L. | Jasmine | Saman Pichcha | Flower | Sufficient | Local | Skin care, hair care | 36.36 |
| 79  | Pandanaceae          | Pandanus tectorius Parkinson ex Du Roi | Tahitian screwpine | Watakeyya | Prop roots | Sufficient | Local | Hair care | 9.09 |
| 80  | Passifloraceae       | Passiflora edulis Sims | Passion | Wel dodam | Fruit | Sufficient | Local | Skin care | 18.18 |
| 81  | Pedaliaceae          | Sesamum indicum L. | Sesame | Thel - thala | Seed | Sufficient | Local | Skin care, hair care | 45.45 |
| 82  | Phyllanthaceae       | Phyllanthus emblica L. | Emblic myocardal | Nelli | Fruit | Sufficient | Local | Skin care, hair care | 63.64 |
| 83  | Pinaceae             | Cedrus deodara (Roxb. ex D.Don) G.Don | Himalayan cedar | Dewadara | Heartwood | Sufficient | Import | Skin care | 9.09 |
| 84  | Piperaceae           | Piper nigrum L. | Black pepper | Gammiris | Seed | Sufficient | Local | Oral care | 18.18 |
| 85  | Plantaginaceae       | Bacopa monnieri (L.) Wettst. | Water hyssop | Lunuwila | Whole plant | Insufficient | Local | Skin care, hair care | 27.27 |
| 86  | Poaceae              | Cymbopogon nardus (L.) Rendle | Citronella grass | Heen pengiri | Whole plant | Sufficient | Local | Skin care | 9.09 |
| 87  | Oryza sativa L.      | Cymbopogon citratus (DC.) Stapf | Lemon grass | Sera | Whole plant | Sufficient | Local | Skin care | 18.18 |
| 88  | Poaceae              | Saccharum officinarum L. | Sugarcane | Uk | Stem | Sufficient | Local | Skin care | 18.18 |
| 89  | Poaceae              | Vetteria zizanioides (L.) Nash | Khas-khas | Savandara | Root | Sufficient | Local | Hair care | 36.36 |
| 90  | Pontederiaceae       | Monochoria vaginalis (Burm.f.) C.Presl | Dihyabarala | Root | Sufficient | Local | Hair care | 9.09 |
| 91  | Rosaceae             | Prunus armeniaca L. | Apricot | Apricot | Seed | Sufficient | Import | Skin care | 18.18 |
| 92  | Rosaceae             | Rosa alba L. | Rose | Rosa | Flower | Sufficient | Local | Skin care | 27.27 |
| 93  | Rosaceae             | Fragaria × ananassa Duchesne | Strawberry | Strawberry | Fruit | Sufficient | Import | Skin care | 18.18 |
| 94  | Rubiaceae            | Coffea arabica L. | Coffee | Kopi | Seed | Sufficient | Local | Skin care | 9.09 |
| 95  | Rubiaceae            | Ixora coccinea L. | Flame of the woods | Rath mal | Flower | Sufficient | Local | Skin care | 9.09 |
| 96  | Rubiaceae            | Rubia cordifolia L. | Indian madder | Valmadata | Root | Sufficient | Local | Skin care | 27.27 |
| No. | Family | Scientific name | English name                  | Vernacular name | Plant part(s) | Availability | Source                  | Product category(s) | Frequency index |
|-----|--------|----------------|------------------------------|-----------------|---------------|--------------|-------------------------|---------------------|-----------------|
| 98  | Rutaceae | Acronychia pedunculata (L.) Miq. | Claw flowered laure | Ankenda | Leaves | Sufficient | Local | Hair care | 18.18 |
| 99  | Rutaceae | Ruta chalepensis L. | Garden rue | Aruda | Leaves | Sufficient | Local | Skin care, hair care | 18.18 |
| 100 | Rutaceae | Aegle marmelos (L.) Corrêa | Bael fruit tree | Beli | Fruit | Sufficient | Local | Skin care | 9.09 |
| 101 | Rutaceae | Citrus aurantiifolia (Christm.) Swingle | True lime | Dehi | Fruit, fruit rind | Sufficient | Local | Skin care, hair care | 54.55 |
| 102 | Sapindaceae | Citrus × sinensis (L.) Osbeck | Orange | Dodam | Fruit, fruit rind | Sufficient | Local | Skin care | 27.27 |
| 103 | Sapindaceae | Citrus limon (L.) Osbeck | Lemon | Lemon | Fruit, fruit rind | Sufficient | Local | Skin care, hair care | 27.27 |
| 104 | Sapindaceae | Citrus sinensis (L.) Osbeck | Sweet orange | Pani dodam | Fruit, fruit rind | Sufficient | Local | Skin care | 9.09 |
| 105 | Santalaceae | Santalum album L. | Sandalwood | Suduhandun | Heartwood | Insufficient | Import | Skin care | 90.91 |
| 106 | Sapindaceae | Sapindus mukorossi Gaertn. Schleicher | Soap nut | Gas penela | Fruit | Sufficient | Local | Hair care | 9.09 |
| 107 | Sapindaceae | Schleichera oleosa (Lour.) Merr. | Ceylon oak | Kon | Seed | Sufficient | Local | Hair care | 18.18 |
| 108 | Sapotaceae | Mimusops elengi L. | Bullet wood tree | Munamal | Bark | Sufficient | Local | Oral care | 36.36 |
| 109 | Solanaceae | Withania somnifera (L.) Dunal | Indian ginseng | Amukkara | Root | Sufficient | Import | Skin care | 27.27 |
| 110 | Theaceae | Camellia sinensis L. Kuntze | Tea | Thae | Tender leaves | Sufficient | Local | Skin care | 18.18 |
| 111 | Zingiberaceae | Curcuma zedoria (Christm.) Roscoe | Zedoary | Harankaha | Rhizome | Sufficient | Local | Skin care | 9.09 |
| 112 | Zingiberaceae | Zingiber officinale Roscoe | Ginger | Inguru | Rhizome | Sufficient | Local | Skin care, oral care | 18.18 |
| 113 | Zingiberaceae | Curcuma longa L. | Turmeric | Kaha | Rhizome | Sufficient | Local | Skin care | 54.55 |
| 114 | Zingiberaceae | Curcuma aromatica Salisb. Alpinia malaccensis (Burm.f.) Roscoe | Wild turmeric | Kasthuri kaha | Rhizome | Sufficient | Local | Skin care | 54.55 |
| 115 | Zingiberaceae | Rankihiriya | Flower bud | | | Sufficient | Local | Oral care | 9.09 |
where \( n \) is the total number of cosmetic manufacturers who listed a particular plant species for their cosmetic productions and \( N \) is the total number of large-scale multiple range of cosmetic products manufacturers.

3. Results and Discussion

3.1. General Overview about Herbal Cosmetic Manufacturers in Sri Lanka. The total respondent percentage was 61 from requested herbal cosmetic manufacturers. All, 13 large-scale manufacturers produce multiple products under the categories of skin care, hair care, and oral care, whereas small-scale manufacturers produce only single products. 7 herbal cosmetic manufacturers refused to provide necessary information to support the survey because their formulae were based on family recipes. However, 10 leading large-scale private sector herbal cosmetic manufacturers and a state herbal cosmetic manufacturer cum under the Ministry of Indigenous medicine, Sri Lanka, were interviewed to gather the information. Totally, 9 cosmetic manufacturers were located in Colombo, Kalutara, and Gampaha districts belonging to Western Province, while other 2 are located in Galle District of Southern Province and Kandy District of Central Province, respectively (Figure 1). Of these, 5 companies only cater for the local market, whereas 6 companies cater for both local and international markets. This is further proven by the list of Ayurvedic herbal product exporters in Sri Lanka published on the website of Export Development board, Sri Lanka [13]. Furthermore, multiple herbal cosmetic products under skin care, hair care, and oral care categories are manufactured by all interviewed herbal cosmetic manufacturers. Creams (moisturizer, fairness creams, night creams, and foot creams), lotions (body lotions), soap, cleansers (body wash, face wash, and hair shampoo), gel (hair, body, and face), scrubs (face, body, and foot), and mask (powder pack, creamy face masks, and foot pack) are some of main products manufactured under the skin care and hair care category, while herbal toothpastes and mouth washes are major products manufactured under the oral care category.

3.2. Plant Families. A total of 115 different plant species belonging to 56 families were documented. The most dominant family was reported as family Fabaceae (13.91%, 16 species). This was followed by Rutaceae (6.09%, 7 species), Asteraceae (5.22%, 6 species), Poaceae, Zingiberaceae, Malvaceae (4.35%, 5 species per each), Moraceae, Myrtaceae (3.48%, 4 species per each), Rosaceae, Rubiaceae (2.61%, 3 species per each), Apiaceae, Apocynaceae, Areccaceae, Combretaceae, Euphorbiaceae, Lamiaceae, Lauraceae, Lythraceae, Menispermaceae, Oleaceae, Sapindaceae (1.74%, 2 species per each), and one species each for the rest of families. The greatest utilization of medicinal plants in family Fabaceae under different disciplines such as Ayurveda, traditional systems of medicine, and medicinal plant-related industries in Sri Lanka has also been reported in [2, 7, 12, 14]. Furthermore, these studies highlight the prominent usage of medicinal plants in Rutaceae, Asteraceae, Poaceae, Zingiberaceae, Malvaceae, Apocynaceae, Euphorbiaceae, and Lamiaceae plant families.

3.3. Plants Used in Different Cosmetic Products. As indicated in Figure 2, plant species used for cosmetic purposes can be classified into three main categories called skin care, hair care, and oral care. Out of 115 plants, the highest number of plants/plant materials was used in skin care products. It was reported as 63 plant species (54.78%). 22 plant species (19.13%) were used for hair care products, while 8 plant species (6.96%) were used in oral care products. However, 16 plant materials (13.91%) were used in both skin and hair care products, whereas 3 plant materials (2.61%) were used in both skin and oral care products. Furthermore, usage of Terminalia chebula Retz in both oral and hair care products as well as usage of both Glycyrrhiza glabra L. and Cinnamomum verum J.Presl in all three cosmetic products categories were also reported. Moreover, research study conducted by Nirmalan [14] on cosmetic perspectives of ethnobotany in Northern part of Sri Lanka confirms the higher usage of local plants for skin care followed by hair care.

3.4. Widely Used Plants for Herbal Cosmetic Preparations. High-frequency usage of Aloe vera (L.) Burm.f., Santalum album L., and Coscinium fenestratum (Goetgh.) Celebr. among 10 cosmetics manufacturers out of eleven was reported. Frequency indexes of these plants were reported as 90.91%. Azadirachta indica A.Juss. and Kokonaa zeylanica Thwaites showed the second highest usage followed by Phyllanthus emblica L. Frequency indexes of Azadirachta indica A.Juss. and Kokonaa zeylanica Thwaites were reported as 72.73% and 63.64% for Phyllanthus emblica L. Moreover, Citrus aurantiifolia (Christm.) Swingle, Centella asiatica (L.) Urb., Curcuma longa L., Caryophyllus aromaticus L., Curcuma aromatica Salisb., Eclipta prostrata (L.) Indigofera tinctoria L., and Glycyrrhiza glabra L. showed 54.55% usage among cosmetic manufacturers. Furthermore, ethnobotanical surveys conducted to find out medicinal plants and plant parts used in skin diseases [6], snake bite treatments [12], and anti-inflammatory remedies [2] in Sri Lanka revealed about greater usage of Azadirachta indica A.Juss. and Curcuma longa L. in skin disease treatments, Citrus aurantiifolia (Christm.) Swingle in snake bite treatments, and Coscinium fenestratum (Goetgh.) Celebr. in anti-inflammatory remedies, respectively. According to the survey on medicinal materials used in traditional systems of medicine in Sri Lanka, Centella asiatica (L.) Urb., Phyllanthus emblica L., Azadirachta indica A.Juss., and Indigofera tinctoria L. have been listed under the most demanded medicinal plants in Sri Lanka by Kankamalage et al. [7].

3.5. Different Plant Parts Used in Cosmetic Productions. As shown in Figure 3, a wide range of plant parts are used for herbal cosmetics manufacturing in Sri Lanka. Identified plant parts were reported as leaves, fruit, seeds, bark, flower, root, stem, fruit rind, rhizome, flower stamen, heartwood,
flower buds, bran, leaf gel, prop roots, and tuber. The most utilized plant part was reported as leaves (20.87%). This was followed by fruit (17.39%), seed (14.78%), bark (9.57%), flower (7.83%), root (6.96%), fruit rind (5.22%), stem (4.35%), rhizome (3.48%), flower stamen, heartwood (2.61% per each), flower bud (1.74%), bran, leaf gel, prop roots, and tuber (0.87% per each), respectively. Usage of whole plant was recorded as 8.70%. In line with the studies of Napagoda et al. [2], Kumarasinghe [6], Kankanamalage et al. [7], Dharmadasa et al. [12], and Nirmalan [14], leaves were the commonest part of plants used in different treatments of Ayurveda, traditional system of medicine, and medicinal plant-based industries in Sri Lanka. Moreover, Kumarasinghe [6] stated that availability of most effective ingredients in leaves results in the highest usage. However, more scientific studies related to this area are required. As other reasons, Dharmadasa et al. [12] highlights availability in large quantities, easy accessibility, and cheaper costs for the
3.6. Availability of Plant Materials for Cosmetic Productions. Most of the cosmetic manufacturers mentioned about inadequate availability of 7 plant materials out of 115 plants for cosmetic productions in line with the existing demand. As they stated, *Mesua ferrea* L., *Kokoona zeylanica* Thwaites, *Dillenia retusa* Thunb., *Coscinium fenestratum* (Goetgh.) Colebr., *Melaleuca leucadendra* (L.) L., *Santalum album* L., and *Bacopa monnieri* (L.) Wettst. plant materials belonging to following plant families Calophyllaceae, Celastraceae, Dilleniaceae, Menispermaceae, Myrtaceae, Santalaceae, and Plantaginaceae were insufficient. Of these, *Kokoona zeylanica* Thwaites and *Dillenia retusa* Thunb are endemic to Sri Lanka. According to the viewpoint of cosmetics manufacturers, the main motive for the scarcity of these plant materials is lack of proper cultivation system within the country. Furthermore, Kankanamalage et al. [7] has revealed that *Coscinium fenestratum* (Goetgh.) Colebr. and *Bacopa monnieri* (L.) Wettst. are heavily used plants in Sri Lanka. Likewise, both Kankanamalage et al. [7] and Dharmadasa et al. [12] have mentioned about the limited availability of *Santalum album* L. in the Sri Lankan market.
3.7. Sources of Plant Materials for Cosmetic Productions. As cosmetics manufacturers stated, most of plants or plant materials used for cosmetics productions are bought from either local growers or local suppliers. However, Pterocarpus santalinus L., Glycyrrhiza glabra L., Olea europaea L., Cedrus deodara (Roxb. ex D.Don) G.Don, Prunus armeniaca L., Fragaria × ananassa Duchesne, Santalum album L., and Withania somnifera (L.) Dunal belonging to plant families Fabaceae, Oleaceae, Pinaceae, Rosaceae, Santalaceae, and Solanaceae were reported as importing plant materials for cosmetic productions. These results are further confirmed according to the survey conducted by Kankanamalage et al. [7].

3.8. Difficulties Encountered during the Collection of Plant Materials for Cosmetic Productions. Majority of cosmetics manufacturers emphasized about several constraints that they faced during the collection of plant materials for cosmetic productions. As they highlighted, quality of plant materials was one of the major constraints. Most of cosmetic manufacturers believed that imported plant materials are adulterated, or the active ingredients are partially extracted which cannot be identified through physical observations during buying. Furthermore, harvesting restrictions imposed by the government for some wild species such as Coscinium fenestratum (Goetgh.) Colebr which owns the highest frequency of seed or seedling, preparation of land, and preparation of seedbed, fertilizing, harvesting, and postharvest practices. Utilization of biotechnology such as tissue culture will benefit to preserve biodiversity through utilizing plants which are endangered or unavailable through conventional production or wild crafting. Moreover, conducting efficacy/safety tests on medicinal plant ingredients are important to ensure the physical and analytical characteristics of raw materials used for the production up to the standard. Additionally, product development and innovation are other key factors to succeed the herbal cosmetic industry. Thus, external collaborations with universities or research institutes will provide possible opportunities to transfer technology to produce herbal cosmetic industry of Sri Lanka.

3.9. Knowledge Gaps and Directions for Future Researches. As Napagoda et al. [18] stated, only handful of scientific evidence are available on bioactivity studies of medicinal plants in Sri Lanka that could lead to the development of herbal cosmetics. Apart from the study on “Cosmetic perspective of ethnobotany in Northern part of Sri Lanka” [14], there has been hardly any ethnobotany report on cosmetic potential of medicinal plants in Sri Lanka. Therefore, ethnobotanical and ethnopharmacological surveys to identify the cosmetic potential of medicinal plants are crucial because most of traditional knowledge on medicinal plants and treatment are passed from generation to generation within families in Sri Lanka. Furthermore, establishing proper systematic cultivation systems for identified medicinal plants is paramount to overcome the insufficient and absence of continuous supply of raw materials for the production. This field must cover the preparation of growing media, preparation of seed or seedling, preparation of land, and preparation of seedbed, fertilizing, harvesting, and postharvest

4. Conclusion

The present study reports the first survey conducted to exploit the plants used in herbal cosmetic industry and to identify major constraints faced by herbal cosmetic manufacturers in Sri Lanka. To overcome the issues faced by herbal cosmetic manufacturers, establishing proper cultivation system and implementing strategies for quality control of raw materials have become necessary requirements of the country to be addressed in the future. Conducting ethnobotany and ethnopharmacological surveys to identify cosmetic potential of medicinal plants and partnerships with universities to transfer innovative aspects of technology for product development to industries are possible interventions for the development of herbal cosmetic industry of Sri Lanka. Furthermore, findings of the study may provide necessary information for potential growers, suppliers, manufacturers, and researchers to identify interesting cosmetic potential plants for cultivation, trading, and innovation or to use for new purposes.

Data Availability

The data used to support the findings of this study are included within the article.

Consent

Written informed consent was obtained prior to the study.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this article.

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**Supplementary Materials**

Supplementary Material 1: the questionnaire which was used to collect the information on plants/plant materials used in herbal cosmetic industry of Sri Lanka and some demographic information of the herbal cosmetic manufacturers. (Supplementary Materials)

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