Anti-obesity therapeutics potential of plant genetic resources of Bangladesh and their conservation at Bangladesh Agricultural University Botanical Garden

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Abstract

Obesity, a global health issue affecting 650 million people, leads to chronic diseases and health impairments. Anti-obesity drugs are expensive and may cause side effects, raising significant concerns. One hundred eighty-eight medicinal plant species from 157 genera and 62 families in Bangladesh exhibit anti-obesity activity. Fabaceae (syn. Leguminosae) is the largest family, consisting of 25 species, while *Citrus* is the largest genus with seven species. The leaf is the most commonly used plant part, followed by the fruit. Plant secondary metabolites, including acids, alkaloids, terpenoids, saponins, glycosides, tannins, carboxylic acids, (poly)phenols, and flavonoids, serve as effective interventions in a complex system approach to obesity. Among these medicinal plants, 110 species are conserved at the Bangladesh Agricultural University (BAU) Botanical Garden, and more than 50 species are cultivated on BAU farms and in homestead gardens. Twenty species are conserved both in the Botanical Garden and cultivated as field/horticultural crops and ornamentals. According to the IUCN Red List of Threatened Taxa, the current (global) status of these species is data deficient for 11, least concern for 73, near threatened for 1, vulnerable for 3, endangered for 2, and no assessment has yet been performed for 98 species. Future studies should focus on enhancing efficacy and reducing the side effects of conventional anti-obesity medications.

Keywords: Thermodynamic imbalance, secondary metabolites, anti-obesity, IUCN Red List, Bangladesh

Introduction

Obesity is characterised by abnormal or excessive fat accumulation that poses a health concern and is defined as a body mass index of 30 or higher. Globally, the proportion of children and adolescents aged 5 to 19 quadrupled from 2% to 8% between 1990 and 2022, while the proportion of adults aged 18 and over more than doubled from 7% to 16% (https://www.who.int/health-topics/obesity#tab=tab_1). In 2016, the World Health Organisation (WHO) developed a global action plan to halt the rise in obesity prevalence by 2025 [1]. Although these conditions were previously considered exclusive to high-income nations, they are now found in every region, with the highest prevalence in some middle-income nations (https://www.who.int/health-topics/obesity#tab=tab_1). The prevalence of obesity in Bangladesh increased from 1.7% to 25.6% among adolescents and from 1% to 23% among children since 1998 [2]. Genetic factors account for just around 33% of the variation in body weight [3], while environmental factors, including lifestyle and socioeconomic influences, play a significant role. Obesity is becoming increasingly common in cities across Bangladesh due to a lack of playgrounds, declining physical activity, sedentary lifestyles, and changes in dietary habits, particularly increased consumption of energy-dense fast food [4]. It is a significant public health concern, contributing to the development of numerous non-communicable diseases such as hypertension, diabetes, asthma, arthritis, and degenerative diseases, which affect various health impairments, including cardiovascular disease, Type 2 diabetes, musculoskeletal conditions, and an increased risk of dying from cancers of the colon, rectum, oesophagus, liver, gallbladder, pancreas, and kidney [5]. Obesity and overweight significantly impact healthcare systems, and obese individuals incur 30% more medical expenses than those of normal weight [6].

Bariatric surgery, medication, behavioural modifications, and dietary changes are some ways to address obesity issues. Glucagon-like peptide-1 (GLP-1) receptor agonists, selective serotonin reuptake inhibitors (SSRIs), serotonin receptor agonists, and cannabinoid receptor type 1 (CB1) antagonists are among the medications identified to facilitate weight loss [7]. However, these drugs may cause negative side effects such as headache, nausea, drowsiness, asthenia, diarrhoea, insomnia, anxiety, depression, sweating, tremors, and sexual dysfunction, including erectile dysfunction, anorgasmia, and decreased libido, along with an increased risk of cardiovascular diseases [7, 8]. Furthermore, anti-obesity drugs often have limited accessibility and high costs [6]. Therefore, having alternative options or co-adjuvants is crucial, as the anti-obesogenic effects of natural compounds have not yet been associated with side effects. Plants are the most commonly utilised natural sources of local biodiversity, closely linked to people's daily needs. Dietary phytochemicals have recently attracted considerable attention as potential therapeutic agents to promote health and mitigate obesity and related conditions. Obese patients frequently perceive herbal medicine as natural and safe, as these treatments are easily accessible and innocuous to use without a doctor's supervision [9]. Natural resources serve as viable bases for developing novel anti-obesity products, such as functional foods and dietary supplements, including fruit extracts, vegetables, and herbal substances, to prevent obesity and metabolic syndrome [5]. Plants are abundant in diverse compounds belonging to four biochemical classes: alkaloids, glycosides, polyphenols, and terpenes. The anti-obesity mechanisms of medicinal plants include decreased lipid absorption, reduced energy intake, increased energy expenditure, decreased pre-adipocyte differentiation and proliferation, enhanced lipolysis, and reduced lipogenesis [10].

Numerous reviews on the use of medicinal plants in anti-obesity medications have been published to date [for example, 5, 7, 11–15]. Bangladesh is rich in (medicinal) plant genetic resources and possesses a long history of using plants for different disease therapies as a part of the Indian subcontinent's traditional medicine [16]. However, little is known about the anti-obesogenic effects of Bangladeshi medicinal plants [17–20]. Hitherto, the sole review paper by Rahman and Rahman [18] identified only 23 plant species from Bangladesh with anti-obesity properties. This study aims to provide a comprehensive review of the availability of natural medicinal agents, their potential to assist with weight loss in Bangladesh, and their conservation status at the Bangladesh Agricultural University Botanical Garden, hereafter "garden."

Methodology

The prospect of treating obesity in Bangladesh with medicinal plants was examined through an exhaustive literature review published during 2010-2025. Various electronic databases, including PubMed, Springer, MDPI, ResearchGate, Google and Google Scholar, ScienceDirect, and others, were searched for this publication. Bangladeshi publications were found in the BanglaJol, an exclusively Bangladeshi journal database, using a combination of keywords, such as "obesity", "medicinal plants", "traditional medicine", "plant extracts", "Bangladesh", etc. Editorials and comments without peer review and articles published in languages other than English were excluded. Information on anti-obesity activity, plant parts used, and active constituents was obtained from the selected publications. Nomenclature is updated by consulting with Plants of the World Online (https://powo.science.kew.org/), the International Plant Names Index (https://www.ipni.org/), World Flora Online (https://www.worldfloraonline.org/), and the present global status with IUCN Red List (https://www.iucnredlist.org/search) and national status with "Encyclopedia of Flora and Fauna of Bangladesh" [21, 22].

Results and Discussion

Anti-obesity activities are observed in 188 medicinal plant species from 157 genera and 62 families (Table 1). Among these, only 18 species, representing 10% of the total, are monocotyledons, while the remainder are dicotyledons (Figure 1). A significant increase in the number of Bangladeshi medicinal plant species used to treat obesity is reported here compared with the previous figure of only 23 [18]. Some of these species have extensive global use for anti-obesity management; for example, *Carica papaya*, *Zingiber officinale*, *Hibiscus sabdariffa*, *Foeniculum vulgare*, *Zea mays*, *Bauhinia variegata*, *Citrus medica*, etc. [14]. Fabaceae (syn. Leguminosae) is the largest family with 25 species, followed by Cucurbitaceae (11 species) and Lamiaceae and Rutaceae (10 species each) (Figure 2). *Citrus* is the largest genus, with 7 species, followed by *Piper* and *Solanum*, each with 3. The numerous reports from the Fabaceae family may be attributed to its vast number of species (https://powo.science.kew.org/), making it more likely to be used in Bangladesh and globally than other families with fewer species. Aumeeruddy and Mahomoodally [14] recorded 451 plant species across 110 families and 329 genera that are traditionally utilised for the treatment of obesity.

Among the plant parts used, leaves are the most common (n = 43; 23.0% of the total), followed by fruits (n = 40; 21.0%) and multiple parts (n = 35; 19.0%) (Figure 3). The biological potency and bioactive substances of various plant sections vary, a point that must be emphasised. For example, different parts of one of the most common medicinal plants, *Boerhavia diffusa*, are used for managing different diseases—roots serve as a laxative and for the management of inflammation and urinary illnesses; seeds and petals function as contraceptives; leaves lower blood glucose levels by increasing insulin release from pancreatic cells, etc. [23]. The abundance of active ingredients in leaves may explain their widespread use. Leaf harvesting is a sustainable practice because it yields rich, readily collected active constituents. Underground harvesting, such as root harvesting, can lead to plant death and threaten the survival of rare and slow-replicating plants, making leaves a more sustainable alternative to traditional harvesting methods [24].

Plant secondary metabolites, including acids, alkaloids, terpenoids, saponins, glycosides, tannins, carboxylic acids, (poly)phenols, and flavonoids, can serve as effective interventions in a complex systems approach to obesity [25]. Phytochemicals found in plants are known to exhibit anti-obesity effects, including phenolic acids, curcuminoids, flavonols, flavones, flavan-3-ol, isoflavonoids, lignans, phytosterols, anthocyanins, and alkaloids [5]. Natural remedies derived from medicinal plants act as anti-obesogenic agents through various mechanisms, including metabolic and thermogenic stimulation, appetite regulation, and inhibition of pancreatic lipase and amylase, thereby improving insulin sensitivity, inducing hypoglycaemia, inhibiting adipogenesis, and promoting adipocyte apoptosis [7], as well as exerting weight-loss effects. Hasani-Ranjbar et al. [10] reported that the anti-obesity mechanisms of herbal plants can be broadly categorised into four types: decreased lipid absorption, reduced energy intake, increased energy expenditure, and decreased pre-adipocyte differentiation and proliferation. For instance, *Camellia sinensis*, *Morinda citrifolia*, *Momordica charantia*, *Centella asiatica*, and other species exhibit anti-obesity potential through inhibitory effects on pancreatic lipase (PL) and/or lipoprotein lipase (LPL) activities [3]. Moreover, in obese rat models, the combination of these plants effectively reduced body weight and food intake compared with individual species, enhanced thermogenesis and antioxidant effects, and inhibited adipocyte proliferation [3]. The anti-obesity effects were attributed to the inhibition of carbohydrate and lipid absorption in the small intestine by certain medicinal plants, including *Hibiscus sabdariffa*, *Perilla frutescens*, *Momordica charantia*, and *Centella asiatica*.

Bangladeshi medicinal plants are natural sources of anti-obesogenic substances, including alkaloids, polyphenols, terpenes, and saponins (Table 1). Hossain et al. [26] discussed advances in our understanding of the anti-obesity potential of natural flavonoids and their molecular mechanisms in preventing and/or treating obesity. Some effects have been assessed at a molecular level, particularly those related to adipogenesis and the functions and homeostasis of adipose tissue cells. Anti-obesity compounds target lipase inhibition, regulation of adipogenesis, thermogenesis, and appetite suppression, with molecular effects focusing on adipogenesis and adipose tissue cell functions and homeostasis [6]. Polyphenols increased levels of adipohormones regulating hunger and satiety, as well as anorexigenic hormones, and decreased ghrelin levels, suggesting that AMP-activated protein kinase may regulate energy homeostasis, daily energy expenditure, and lipid metabolism. Alkaloids, like polyphenols, have been found to possess anti-obesogenic properties due to their structure, which facilitates interaction with molecules and receptors, particularly those of the nervous system [6]. Saponins, known for their anti-obesogenic effects, inhibit lipid digestion and absorption in the intestine. Two saponins, saikosaponin A and saikosaponin D, were isolated and evaluated on adipocytes. Results showed that these saponins suppress adipogenic genes, viz. CCAAT/enhancer-binding protein alpha (*C/EBPα*), peroxisome proliferator-activated receptor gamma (*PPARγ*), sterol regulatory element-binding protein-1c (*SREBP- 1c*), and adiponectin, and downregulate lipogenic genes, such as fatty acid-binding protein (FABP 4), fatty acid synthase (FAS), and lipoprotein lipase (LPL), preventing obesity development in key organs like adipose and hepatic tissues [6]. Terpenes from plants modulate lipid metabolism by acting on receptors such as PPARs and LXRs (liver X receptors), which are crucial in adipogenesis and cholesterol metabolism. PPARs express AP 2, adiponectin, FABP 4, glucose transporter type 4 (GLUT 4), LPL, and phosphoenolpyruvate carboxykinase (PEPCK), while LXRs regulate ATP-binding cassette transporters and cholesterol transport and elimination.

Anti-obesity therapeutic plant genetic resources conservation at Bangladesh Agricultural University Botanical Garden (24°43’27.9”N, 90°26’28.2”E)

The Bangladesh Agricultural University (BAU) campus has become a conservatory of agricultural and forest plant genetic resources, collected from home and abroad, along with the BAU Botanical Garden, hereafter referred to as the garden, and the BAU Germplasm Centre [27]. The garden was established in 1963 to collect and conserve the country's and surrounding areas' plant genetic resources, as well as their multiplication and relocation in natural habitats. It has become a unique hub for plant conservation, education, scientific research, and knowledge of plant biodiversity at national and regional scales [28]. Approximately 1800 plant species (including Pteridophytes, Gymnosperms, and Angiosperms), both native and foreign, can be found here [29], conserving more than 20% of the total flora (Spermatophyte) of Bangladesh [15, 30]. Plant collections in botanical gardens aid in *ex-situ* conservation of threatened species and habitat restoration and are the focus of research on population genetics, climate change responses, pest and disease susceptibility, and plant adaptive capacity [31]. Thus, the garden plays a vital role in the *ex-situ* preservation and investigation of the world's plant biodiversity. In terms of species collection, the garden is the country's second-largest botanical garden, after the National Botanical Garden (Mirpur, Dhaka; established in 1961). Botanical gardens focus on plant study, conservation, and public awareness of plant species diversity while serving human needs and promoting well-being [32]. Among Bangladeshi plants with anti-obesity potential, 110 species are conserved in the garden, and more than 50 species are cultivated on different farms and in homestead gardens at the BAU campus. Twenty species, *viz*. *Mangifera indica*, *Annona squamosa*, *Areca catechu*, *Aloe vera*, *Cosmos bipinnatus*, *Helianthus annuus*, *Stevia rebaudiana*, *Ananas comosus*, *Ipomoea batatas*, *Merremia hirta*, *Mentha arvensis*, *Punica granatum*, *Moringa oleifera*, *Psidium guajava*, *Cymbopogon citratus*, *Ziziphus jujuba*, *Aegle marmelos*, *Citrus limon*, *C. aurantiifolia*, and *C. sinensis*, were dual conservation, i.e., conserved in the garden and cultivated as field/horticultural crops and ornamentals (Table 1). We should take the initiative to collect other species with anti-obesity potentials for conservation purposes and ensure proper maintenance of plant species at the BAU campus. Replicating collections across institutions is crucial as a backup measure in case of loss due to attrition, closure, pests, disease outbreaks, natural disasters, or theft [31].

According to the IUCN Red List of Threatened Species, the current status of these species is globally categorised as data deficient (DD) for 11 species, least concern (LC) for 73 species, near threatened (NT) for 1 species, vulnerable (VU) for 3 species, endangered (EN) for 2 species, and for 98 species, an assessment has not yet been conducted, or information is unavailable (Table 1). Even rare plants often face exclusion from assessment or classification as "Data Deficient" due to insufficient information on species distributions, population decline rates, and threats. Moreover, the status of some species may differ from their global status when assessed locally. For example, *Acorus calamus* and *Terminalia chebula* are assessed as globally LC but as VU at the national level in Bangladesh. In contrast, *Cinnamomum verum* was assessed as VU globally but as LC at the national level (Table 1; [21, 22]). A brief comparative assessment of anti-obesity plant species is presented in Figure 4, along with photographs of some threatened species preserved at the garden in Figure 5. Conservation dependent (CD), an additional status, was used in the national assessment. This category was part of the IUCN 1994 Categories & Criteria (version 2.3), which is no longer used in the evaluation of taxa.

Botanical gardens frequently engage in a wide range of scientific endeavours, including public education, restoration ecology, taxonomy, systematics, genetics, horticulture, seed science, propagation, conservation, and more [32]. Currently, the garden conserves 527 medicinal and aromatic plant species from 101 families used in traditional medicine to treat various illnesses, and this number is continually growing [16]. Other notable collections include minor fruits (108 species), hydrophytes (70 species), orchids (35 species), cacti and succulents (175 species), gymnosperms (13 species), palms (42 species), Ficus (24 species), pteridophytes (24 species), mangroves (18 species), bamboos (17 species), and others [27, 29, 33–35]. Approximately 100,000 visitors, including students, researchers, forest officials, international visitors, and others, visit the garden each year for recreation, plant identification/studies, expert consultation, and more. Gardens provide urban green spaces that may be the only access to plants and nature for many people [31]. Based on this garden collection, several academic studies (leading to MS or PhD degrees), such as [36-39], have been conducted, and popular newspaper articles and YouTube videos have been published. Recently, a herbarium was established on the garden premises (the Prof. Arshad Ali Herbarium, named after the first garden curator) to enhance taxonomic research; approximately 5,000 dried plant samples are housed there. The plants conserved in the garden provide food and shelter for birds, lizards, insects, herbivores, and other wildlife, playing an important role in achieving the Sustainable Development Goals (SDGs). Plant conservation actions by botanical gardens have close links to SDG 15, with clear connections to "Life on Land" and goals to end poverty, hunger, and ensure good health (SDGs 1, 2, and 3), as well as those focusing on clean water, renewable energy, sustainable cities, responsible consumption, and climate action (SDGs 6, 7, 11, 12, and 13) (https://www.bgci.org/).

Conclusion and Future Perspectives

Bangladeshi medicinal plants demonstrate great potential for treating obesity. The garden plays a vital role in conserving plant genetic resources, conducting research, and promoting citizen science education. The rising global prevalence of obesity, along with its financial burden and fatalities, highlights the urgent need for improved herbal treatments and preventive strategies. Future research should focus on understanding the preparation methods, treatment dosages, frequencies, durations, and side effects of traditional (herbal) anti-obesity medicines. The pharmaceutical industry needs anti-obesity drugs that are more effective and have fewer side effects. Additional clinical, *in vivo*, and *in vitro* studies should aim to identify safe and potent extracts and bioactive compounds from traditional medicinal plants.

Acknowledgements

The present and previous Curators, who have enriched the collection and curated the plant genetic resources of this botanical garden, are thankfully acknowledged.

Conflict of interest

The authors declare no conflict of interest regarding the publication of this manuscript.

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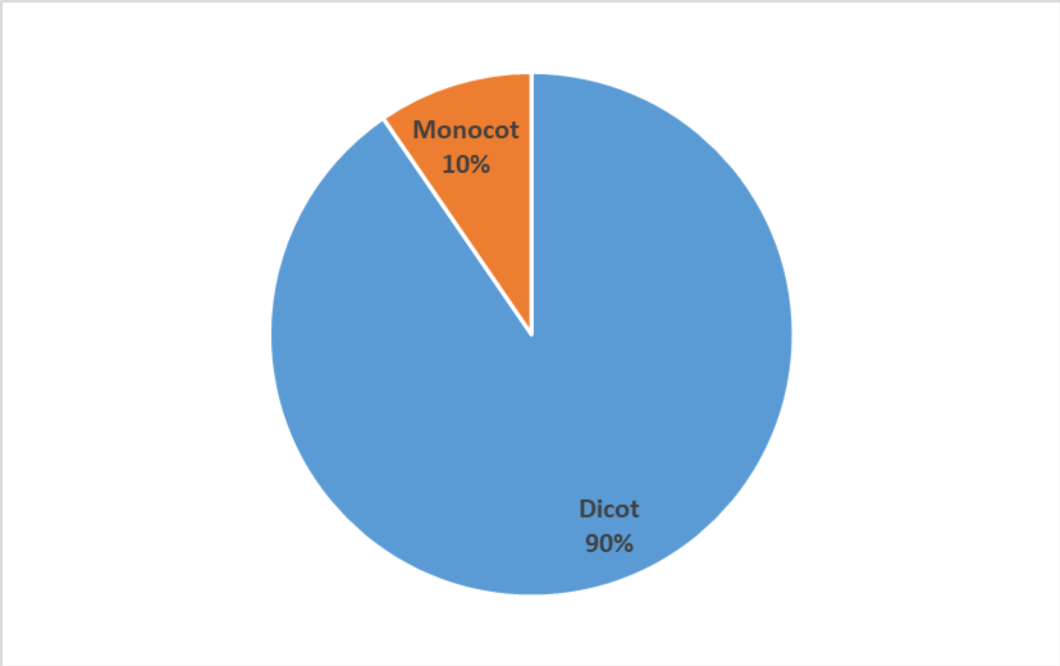


Figure 1. Taxonomic classification of anti-obesity plant species as monocots and dicots.

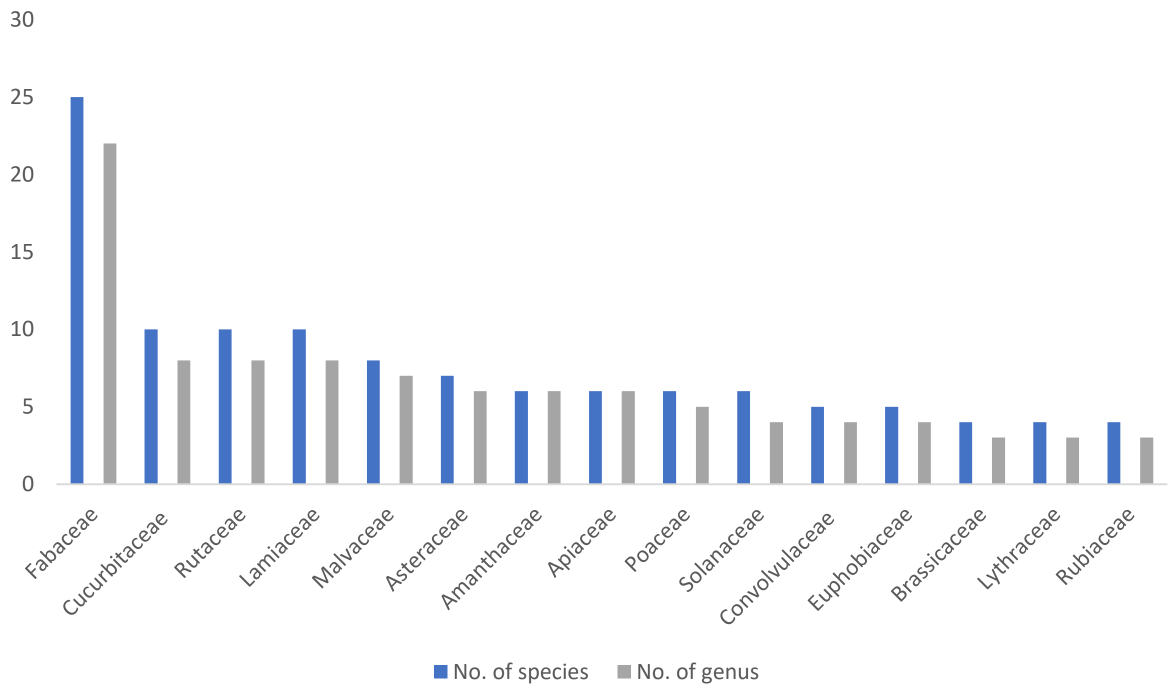


Figure 2. Top fifteen plant families with the highest number of genera and species reported for anti-obesity properties.

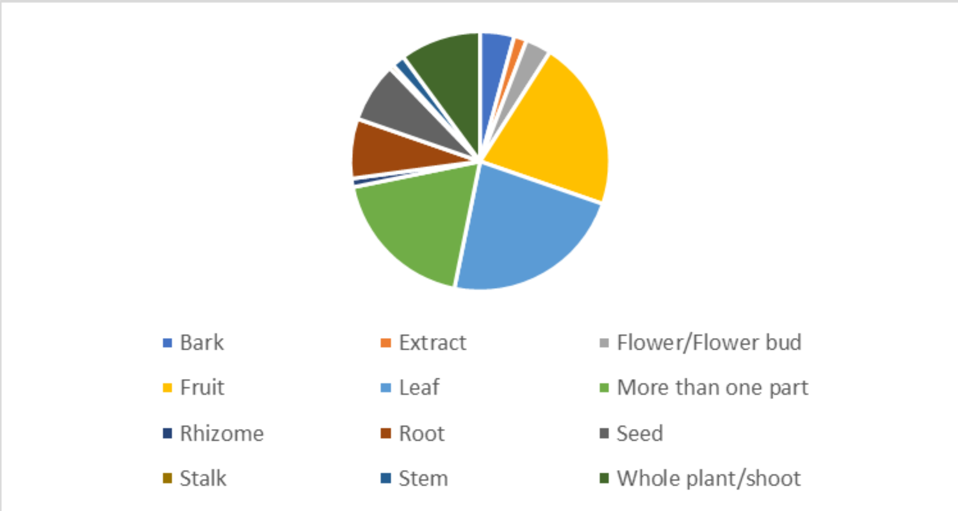
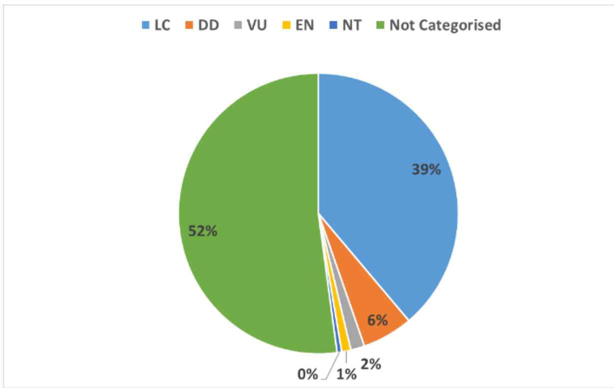
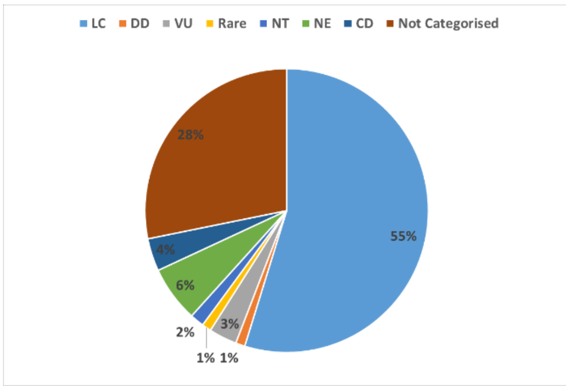


Figure 3. Pie graph of different plant parts used in anti-obesity treatments.



Global



National

Figure 4. Conservation status of the studied plant species according to IUCN.

Figure 5. Photographs of some threatened species conserved at the garden. A. *Acorus calamus*, B. *Erythrina suberosa*, C. *Cichorium intybus*, D. *Coffea arabica*, E. *Ipomoea mauritiana*, F. *Morinda citrifolia*, G. *Mucuna pruriens*, H. *Passiflora quadrangularis*, I. *Piper longum*, J. *Plumbago zeylanica*, K. *Annona muricata*, L. *Dimocarpus longan*, M. *Salacia fruticosa*, N. *Senna alata*, O. *Vanilla planifolia*, P. *Withania somnifera*.

Table 1. Medicinal plant genetic resources of Bangladesh with anti-obesity properties. LC Least Concern, DD Data Deficient, CR Critically Endangered, VU Vulnerable, EN Endangered, NT Near Threatened, NE Not Evaluated, CD Conservation Dependent. () National Status

Sl. No.	Bangla/Common name	Scientific name	Family	Parts used	Conservation status	Active constituents	Reference
1.	Kalmegh	*Andrographis paniculata* (Burm.f.) Wall. *ex* Nees*	Acanthaceae	Leaf	(LC)	Diterpenoids	40
2.	Calamas/Botch	*Acorus calamus* L.*	Acoraceae (M)	Rhizome, Leaf, root	LC (VU)	Asarone	41
3.	Prickly chaff flower	*Achyranthes aspera* L.*	Amaranthaceae	Stem, Seed	(LC)	Triterpenoid saponin	7
4.	Red Spinach**	*Amaranthus tricolor* L.	Amaranthaceae	Stem	(LC)	Flavonoid, Saponins, Tannins	42
5.		*Dysphania ambrosioides* (L.) Mosyakin & Clemants	Amaranthaceae	Leaf		-	14
6.	Botam phul	*Gomphrena globosa* L.*	Amaranthaceae	Flower	(LC)	-	14
7.		*Ouret lanata* (L.) Kuntze	Amaranthaceae	Whole plant		-	14
8.	Spinach**	*Spinacia oleracea* L.	Amaranthaceae	Whole plant		Cinnamic acid	7
9.	Onion**	*Allium cepa* L.	Amaryllidaceae (M)	Bulb, Peel	(LC)	Allicin	7
10.	Garlic**	*Allium sativum* L.	Amaryllidaceae (M)	Bulb, Root	(LC)	Allicin	7
11.	Mango**	*Mangifera indica* L.*	Anacardiaceae	Fruit, Leaf	DD (LC)	Mangiferin	7
12.	Soursop	*Annona muricata* L.*	Annonaceae	Fruit, Leaf	LC (NE)	Phenols, Flavonoids, Tannins	43
13.	Custard apple**	*Annona squamosa* L.*	Annonaceae	Fruit, Leaf	LC (LC)	Phenols, Flavonoids, Tannins	43
14.	Celery	*Apium graveolens* L.	Apiaceae	Whole shoot	LC	Cinnamic acid	7
15.	Spade leaf	*Centella asiatica* (L.) Urb.*	Apiaceae	Leaf	LC (LC)	Asiatic acid, Madecassic acid	15
16.	Coriander**	*Coriandrum sativum* L.	Apiaceae	Whole shoot	(LC)	-	14
17.	Cumin**	*Cuminum cyminum* L.	Apiaceae	Whole shoot		-	5
18.	Wild coriander	*Eryngium foetidum* L.*	Apiaceae	Root	(NE)	-	14
19.	Fennel**	*Foeniculum vulgare* Mill.	Apiaceae	Whole shoot	LC (LC)	-	13
20.	Anantamul/Karāla	*Hemidesmus indicus* (L.) R.Br.*	Apocynaceae	Extract		2-hydroxy 4-methoxy benzoic acid	44
21.	Indrajau	*Wrightia tinctoria* (Roxb.) R.Br.*	Apocynaceae	Bark	LC	-	14
22.	Supāri**	*Areca catechu* L.*	Arecaceae (M)	Fruit	LC (LC)	-	41
23.	Gurmar	*Gymnema sylvestre* (Retz.) R.Br. *ex* Sm.	Asclepiadaceae	Leaf		Gymnemic acid	41
24.	Aloe vera**	*Aloe vera* (L.) Burm.f.*	Asphodelaceae (M)	Leaf	(LC)	Gallic acid, Quercetin	15
25.	Safflower**	*Carthamus tinctorius* L.	Asteraceae	Flower, Seed	(LC)	Saffron, Crocin	45
26.	Kasni/Chikory	*Cichorium intybus* L.	Asteraceae	Leaf	LC (NE)	Tanins	46
27.	Cosmos**	*Cosmos bipinnatus* Cav.*	Asteraceae	Leaf	(LC)	-	46
28.	Sunflower**	*Helianthus annuus* L.*	Asteraceae	Seed	LC (LC)	-	13
29.	Lettuce**	*Lactuca sativa* L.	Asteraceae	Root, Leaf	(LC)	Esculin, Chlorogenic acid	
30.	Mundorokha	*Pluchea indica* (L.) Less.	Asteraceae	Leaf	(DD)	-	28
31.	Stevia**	*Stevia rebaudiana* (Bertoni) Bertoni*	Asteraceae	Shoot		Glucosides	6
32.	Malabar spinach	*Basella alba* L.	Basellaceae	Flower	(LC)	-	14
33.	Lipstick tree	*Bixa orellana* L.*	Bixaceae	Seed	LC (LC)	-	14
34.	Wild cabbage	*Brassica oleracea* L.	Brassicaceae	Leaf	(LC)	Cinnamic acid	7
35.	Mustard**	*Brassica rapa* L.	Brassicaceae	Root	(LC)	-	13
36.	Shepperd's purse	*Capsella bursa-pastoris* (L.) Medik.	Brassicaceae	Leaf	LC (NE)	-	14

37.	Radish**	*Raphanus sativus* L.	Brassicaceae	Whole plant	(LC)	-	12
38.	Pineapple**	*Ananas comosus* (L.) Merr.*	Bromeliaceae (M)	Fruit	(LC)	Bromelain	47
39.	Fonimanasa	*Opuntia ficus-indica* (L.) Mill.*	Cactaceae	Fruit	DD	-	10
40.	Fonimanasa	*Opuntia monacantha* Haw.*	Cactaceae	Fruit	LC	-	14
41.	Red pitaya	*Selenicereus monacanthus* (Lem.) D.R.Hunt	Cactaceae	Fruit		Betacyanin's	15
42.	Asian lobelia	*Lobelia chinensis* Lour.	Campanulaceae	Whole plant	(NE)	Polysaccharides	5
43.	Hemp	*Cannabis sativa* L.*	Cannabaceae	Leaf	(LC)	-	14
44.	Papaya**	*Carica papaya* L.	Caricaceae	Leaf	DD (LC)	Flavonoids	28
45.		*Salacia fruticosa* Wall. *ex* M.A.Lawson	Celastraceae	Whole plant		Mangiferin, Epicatechin	48
46.	Brindleberry	*Garcinia cowa* var. *cowa**	Clusiaceae	Fruit	LC (LC)	Hydroxycitric acid	15
47.	Arjun	*Terminalia arjuna* (Roxb. *ex* DC.) Wight & Arn.*	Combretaceae	Bark	(VU)	-	14
48.	Bahera	*Terminalia bellirica* (Gaertn.) Roxb.*	Combretaceae	Fruit	LC (LC)	-	46
49.	Horitoki	*Terminalia chebula* Retz.*	Combretaceae	Fruit	LC (VU)	-	14
50.	Sweet potato**	*Ipomoea batatas* (L.) Lam.*	Convolvulaceae	Leaf, Root	DD (LC)	-	17
51.	Vuikumra kalmi	*Ipomoea mauritiana* Jacq.*	Convolvulaceae	Leaf	(VU)	-	14
52.	Goat’s foot creeper	*Ipomoea pes-caprae* (L.) R.Br.*	Convolvulaceae	Leaf	LC (LC)	-	14
53.	Kalmi**	*Merremia hirta* (L.) Merr.*	Convolvulaceae	Leaf	(LC)	Total Phenolics, Flavonoids	49
54.	Indian Jalap	*Operculina turpethum* (L.) Silva Manso*	Convolvulaceae	Root	(LC)	-	41
55.	White gourd**	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitaceae	Fruit	(LC)	-	25
56.	Bitter Cucumber	*Citrullus colocynthis* (L.) Schrad.	Cucurbitaceae	Seed	(LC)	-	13
57.	Watermelon**	*Citrullus lanatus* (Thunb.) Matsum. & Nakai	Cucurbitaceae	Fruit	(LC)	-	14
58.	Ivy Gourd/Telakucha	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	Fruit	(LC)	β-sitosterol	17
59.	Musk melon/Bangi**	*Cucumis melo* L.	Cucurbitaceae	Fruit peel	(LC)	-	17
60.	Cucumber**	*Cucumis sativus* L.	Cucurbitaceae	Fruit	(LC)	Saponin	50
61.	Crookneck squash	*Cucurbita moschata* Duchesne	Cucurbitaceae	Stalk	(LC)	Terpenes	46
62.	Bottle gourd**	*Cucurbita pepo* L.	Cucurbitaceae	Fruit	LC (LC)	-	14
63.	Sweet tea vine	*Gynostemma pentaphyllum* (Thunb.) Makino	Cucurbitaceae	extract		Actiponin, Saponins	20
64.	Bottle gourd**	*Lagenaria siceraria* (Molina) Standl.	Cucurbitaceae	Fruit	(LC)	-	14
65.	Bitter melon**	*Momordica charantia* L.	Cucurbitaceae	Fruit	(LC)	-	41
66.	Nut Grass	*Cyperus rotundus* L.*	Cyperaceae (M)	Whole plant	LC (LC)	Cyperine	41
67.	Yam	*Dioscorea alata* L.*	Dioscoreaceae (M)	Root	(LC)	Dioscin, Diosgenin	24
68.	Bitter yam	*Dioscorea bulbifera* L.*	Dioscoreaceae (M)	Root	(LC)	Dioscin, Diosgenin	25
69.	Sal, Gajari	*Shorea robusta* Gaertn.*	Dipterocarpaceae	Leaf	LC (LC)	-	17
70.	Snake weed	*Euphorbia hirta* L.*	Euphobiaceae	Whole plant	(LC)	-	14
71.	Rangchita	*Euphorbia tithymaloides* L.	Euphobiaceae	Leaf	LC (LC)	-	14
72.	Verenda/Poison nut	*Jatropha curcas* L.*	Euphobiaceae	Leaf	LC (LC)	-	17
73.	Dati Bura, Jhakura	*Macaranga denticulata* (Blume) Müll.Arg.*	Euphobiaceae	Bark	LC (LC)	-	17
74.	Verenda	*Ricinus communis* L.*	Euphobiaceae	Leaf	(LC)	-	14
75.	Shirish	*Albizia lebbeck* (L.) Benth.*	Fabaceae	Root	LC	-	14
76.	Groundnut**	*Arachis hypogaea* L.	Fabaceae	Fruit	(LC)	Resveratrol	7
77.	Raktokanchan	*Bauhinia variegata* L.*	Fabaceae	Bark, Flower	LC	-	13
78.	Pigeon pea**	*Cajanus cajan* (L.) Millsp.	Fabaceae	Leaf, Seed	(LC)	-	19

79.	Sonalu/ Bandarlathi	*Cassia fistula* L.*	Fabaceae	Leaf	LC	-	14
80.	Pig's senna	*Chamaecrista absus* (L.) H.S.Irwin & Barneby	Fabaceae	Seed	LC	-	14
81.	Sensitive pea	*Chamaecrista nomame* (Makino) H.Ohashi	Fabaceae	Seed		-	46
82.	Sun hemp**	*Crotalaria juncea* L.	Fabaceae	Leaf	(LC)	-	13
83.	Cluster bean	*Cyamopsis tetragonoloba* (L.) Taub.	Fabaceae	Stem	(CD)	Guar gum	11
84.	Sitshal	*Dalbergia latifolia* Roxb.	Fabaceae	Bark	VU (NE)	β-sitosterol	51
85.	North Indian rosewood	*Dalbergia sissoo* Roxb. *ex* DC.*	Fabaceae	Leaf	LC (VU)	-	52
86.	Mandar	*Erythrina suberosa* Roxb.*	Fabaceae	Bark	LC (NT)	-	14
87.	Soybean**	*Glycine max* (L.) Merr.	Fabaceae	Fruit	(LC)	Daidzein	8
88.	Licorice	*Glycyrrhiza glabra* L.*	Fabaceae	Root	LC	Flavonoid oil	41
89.	Horse gram	*Macrotyloma uniflorum* (Lam.) Verdc.	Fabaceae	Leaf, Seed	LC (LC)	-	5
90.	Alfalfa	*Medicago sativa* L.*	Fabaceae	Whole plant	LC (LC)	-	14
91.		*Mimosa rubicaulis* Lam.	Fabaceae	Leaf, Flower, Bark		-	14
92.	Alkushi	*Mucuna pruriens* (L.) DC.	Fabaceae	Seed	LC (LC)	-	14
93.	Kidney bean**	*Phaseolus vulgaris* L.	Fabaceae	Fruit	LC (LC)	Phytohemagglutinin	25
94.	Dad mordon	*Senna alata* (L.) Roxb.*	Fabaceae	Leaf	LC	-	14
95.	Tanner's Cassia	*Senna auriculata* (L.) Roxb.*	Fabaceae	Leaf	LC	-	14
96.	Cassia tree	*Senna siamea* (Lam.) H.S.Irwin & Barneby	Fabaceae	Root	LC	-	17
97.	Sickle senna	*Senna tora* (L.) Roxb.*	Fabaceae	Leaf, Seed		-	14
98.	Tamarind	*Tamarindus indica* L.*	Fabaceae	Fruit, Bark, Root	LC	Tartaric acid	17
99.	Fenugreek**	*Trigonella foenum-graecum* L.	Fabaceae	Stem, Leaf	(LC)	Steroidal sapogenins	7
100.	Loha Kat/Burma Ironwood	*Xylia xylocarpa* (Roxb.) Taub.*	Fabaceae	Bark, Seed	LC	-	14
101.	Glorybower	*Clerodendron glandulosum* L.	Lamiaceae	Leaf		-	41
102.		*Clerodendrum phlomidis* L.f.*	Lamiaceae	Root	LC	-	14
103.	Indian Coleus	*Coleus barbatus* (Andrews) Benth. *ex* G.Don var. *barbatus**	Lamiaceae	Root		Forskolin	7
104.	Pudina**	*Mentha arvensis* L.*	Lamiaceae	Leaf	LC (LC)	-	14
105.	Deshi pudina	*Mentha spicata* L.*	Lamiaceae	Leaf	LC (LC)	-	14
106.	Sada tulsi	*Ocimum basilicum* L.*	Lamiaceae	Leaf	(NE)	Ursolic acid	7
107.	Perilla**	*Perilla frutescens* (L.) Britton	Lamiaceae	Seed	LC (LC)	α-Linolenic acid	3
108.	Ganiari	*Premna serratifolia* L.	Lamiaceae	Root	LC		53
109.	Chia**	*Salvia hispanica* L.	Lamiaceae	Seed		-	14
110.	Nishinda	*Vitex negundo* L.*	Lamiaceae	Leaf	LC	-	17
111.	Cinnamomum	*Cinnamomum burmanni* (Nees & T.Nees) Blume*	Lauraceae	Bark, Leaf, Root	LC	Camphor, Eugenol, Cinnamaldehyde	7
112.	Darchini/Cinnamon	*Cinnamomum verum* J.Presl*	Lauraceae	Bark, Leaf, Root	VU (LC)	Camphor, Eugenol, Cinnamaldehyde	7
113.	Avacado	*Persea americana* Mill.*	Lauraceae	Fruit	LC (CD)	-	14
114.	Tishi/Linseed**	*Linum usitatissimum* L.	Linaceae	Seed	(LC)	-	14
115.		*Cuphea carthagenensis* (Jacq.) J.F.Macbr.	Lythraceae	Leaf		-	46

116.	Queen's flower	*Lagerstroemia speciosa* (L.) Martyn	Lythraceae	Extract	LC (LC)	Corosolic acid	9
117.	Mehedi	*Lawsonia inermis* L.*	Lythraceae	Leaf	LC (LC)	Polyphenols	28
118.	Pomegranate/Dalim**	*Punica granatum* L.*	Lythraceae	Fruit, Leaf	LC	-	14
119.	Baobab	*Adansonia digitata* L.*	Malvaceae	Root, Bark	(Rare)	Flavonoids, Phenolic acids, Tannins	14
120.	Cotton tree	*Bombax ceiba* L.*	Malvaceae	Leaf, Bark	LC	Mangiferin	7
121.	Silk Cotton Tree	*Ceiba pentandra* (L.) Gaertn.*	Malvaceae	Bark	LC	-	14
122.	Tosha jute**	*Corchorus olitorius* L.	Malvaceae	Leaf		-	5
123.	Tamthar	*Grewia villosa* Willd.*	Malvaceae	Fruit	LC	-	14
124.	China rose	*Hibiscus rosa-sinesis* L.*	Malvaceae	Leaf	(LC)	-	5
125.	Roselle/Lalmesta	*Hibiscus sabdariffa* L.*	Malvaceae	Flower, Leaf	(NE)	Hydroxycitric acid, Anthocyanins	9
126.	Napa	*Malva parviflora* L.	Malvaceae	Aerial parts	(CD)	-	14
127.	Neem	*Azadirachta indica* A.Juss.*	Meliaceae	Leaf	LC (LC)	Total Phenolics, Flavonoids	14
128.	Spanish-cedar	*Cedrela odorata* L.	Meliaceae	Bark	VU (NE)	-	14
129.	Gurjo or Guduchi	*Tinospora cordifolia* (Willd.) Hook.f. & Thomson*	Meliaceae	Stem	(NT)	-	14
130.	Bread fruit	*Artocarpus altilis* (Parkinson) Fosberg*	Moraceae	Bark	(Rare)	-	14
131.	Tut/Mulberry	*Morus alba* L.*	Moraceae	Fruit, Leaf	(LC)	Quercetin, Hesperetin	12
132.	Tut/Black Mulberry	*Morus nigra* L.*	Moraceae	Fruit, Leaf	DD	Quercetin, Hesperetin	13
133.	Drumstick tree**	*Moringa oleifera* Lam.*	Moringaceae	Fruit, Root	LC (LC)	Fitotesrol (β-sitosterol)	46
134.	Nutmeg	*Myristica fragrans* Houtt.*	Myristicaceae	Whole plant	DD	-	41
135.	Viḍaṅga	*Embelia ribes* Burm.f.	Myrsinaceae	Fruit	(CD)	Embelin	41
136.	Guava**	*Psidium guajava* L.*	Myrtaceae	Leaf	LC (LC)	-	14
137.	Clove	*Syzygium aromaticum* (L.) Merr. & L.M.Perry*	Myrtaceae	Flower bud		Eugenol	17
138.	Jam/Java plum	*Syzygium cumini* (L.) Skeels*	Myrtaceae	Leaf, Seed, Root	LC (LC)	-	14
139.	Indian lotus/Poddo	*Nelumbo nucifera* Gaertn.*	Nelumbonaceae	Whole shoot	DD (LC)	Phenolic compounds	7
140.	Punarnava	*Boerhavia diffusa* L.*	Nyctaginaceae	Root	(LC)	Punarnavine, Boeravinone B	23
141.	Beli	*Jasminum sambac* (L.) Aiton*	Oleaceae	Flower	(LC)	-	13
142.	Kuding tea	*Ligustrum robustum* (Roxb.) Blume	Oleaceae	Leaf	LC (DD)	Ohenylpropanoid glycosides	5
143.	Vanilla	*Vanilla planifolia* Andrews*	Orchidaceae (M)	Whole plant	EN	-	14
144.	Opium poppy	*Papaver* L.*	Papaveraceae	Stem, Flower	LC (NE)	-	14
145.	Passion fruit	*Passiflora edulis* Sims*	Passifloraceae	Fruit	(LC)	-	5
146.	Giant Gandalia	*Passiflora quadrangularis* L.	Passifloraceae	Fruit	(NE)	-	14
147.	Sweet leaf bush	*Breynia androgyna* (L.) Chakrab. & N.P.Balakr.	Phyllanthaceae	Fruit	LC	-	41
148.	Indian gooseberry	*Phyllanthus emblica* L.*	Phyllanthaceae	Fruit	LC	Terpenoids	15
149.	Pan/Betel vine	*Piper betle* L.*	Piperaceae	Leaf	(LC)	-	28
150.	Long pepper	*Piper longum* L.*	Piperaceae	Fruit	(LC)	Piperlongumine	9
151.	Black pepper	*Piper nigrum* L.*	Piperaceae	Fruit	(LC)	Piperine	9
152.	Chitrak	*Plumbago zeylanica* L.*	Plumbaginaceae	Root	(NE)	-	41
153.	Oat**	*Avena sativa* L.	Poaceae (M)	Seed	(CD)	β-glucan	13
154.	Dedhaan	*Coix lacryma-jobi* L.*	Poaceae (M)	Seed	(LC)	-	46
155.	Lemon grass**	*Cymbopogon citratus* (DC.) Stapf*	Poaceae (M)	Leaf	(CD)	-	14
156.	Durba ghass	*Cynodon dactylon* (L.) Pers.*	Poaceae (M)	Whole plant	(LC)	-	19
157.	Shama grass	*Echinochloa crus-galli* (L.) P.Beauv.*	Poaceae (M)	Seed	LC (LC)	-	13

158.	Maize**	*Zea mays* L.	Poaceae (M)	Leaf, Style	LC (CD)	-	14
159.	Water-pepper	*Persicaria hydropiper* (L.) Delarbre*	Polygonaceae	Leaf	LC (LC)	Flavonoids	46
160.	Fennel**	*Nigella sativa* L.	Ranunculaceae	Fruit, Leaf	(LC)	Polyphenols	11
161.	Jujube/Boroi**	*Ziziphus jujuba* Mill.*	Rhamnaceae	Leaf, Fruit, Root	LC (LC)	-	14
162.	Mountain pomegranate	*Catunaregam spinosa* (Thunb.) Tirveng.	Rubiaceae	Whole plant	LC (LC)	Flavonoids, Alkaloids, Tannins	14
163.	Coffea	*Coffea arabica* L.*	Rubiaceae	Seed extract	EN (NE)	Caffeine	7
164.	Papra	*Gardenia latifolia* Aiton*	Rubiaceae	Leaf	LC (VU)	-	14
165.	Noni	*Morinda citrifolia* L.*	Rubiaceae	Fruit, Leaf	LC (LC)	Catechin	8
166.	Bel**	*Aegle marmelos* (L.) Corr^ea*	Rutaceae	Unripe fruit, Leaf	NT (LC)	Umbelliferone, Esculetin	14
167.	Kagagilebu/Lime**	*Citrus aurantiifolia* (Christm.) Swingle*	Rutaceae	Fruit	(LC)	Essential oils	13
168.	Pumelo	*Citrus aurantium* L.	Rutaceae	Fruit	(LC)	Sinefrin, Oktopamine	11
169.	Lemon**	*Citrus limon* (L.) Osbeck*	Rutaceae	Fruit	(LC)	Polyphenols	17
170.	Pomelo	*Citrus maxima* (Burm.) Merr.*	Rutaceae	Leaf, Fruit peel	LC (LC)	Hesperidin	46
171.	Citron	*Citrus medica* L.	Rutaceae	Fruit	LC (LC)	-	14
172.	Marsh/Grapefruit	*Citrus paradisi* Macfad.	Rutaceae	Fruit		-	14
173.	Malta**	*Citrus sinensis* (L.) Osbeck*	Rutaceae	Fruit		-	14
174.	Chhoto Kamini	*Murraya koenigii* (L.) Spreng.*	Rutaceae	Leaf	LC (LC)	-	14
175.	Gaira/Tejovati	*Zanthoxylum armatum* DC.	Rutaceae	Seed	LC	-	14
176.	Ashphal, Katlitchu	*Dimocarpus longan* Lour.*	Sapindaceae	Fruit	DD (NT)	Polysaccharides	54
177.	Green peper**	*Capsicum* spp.	Solanaceae	Fruit	LC (LC)	Capsaicin, Capsaicinoids	7
178.	Tobacco**	*Nicotiana tabacum* L.	Solanaceae	Leaf	(LC)	-	14
179.	Tomato**	*Solanum lycopersicum* L.	Solanaceae	Fruit	(LC)	Tomatine	17
180.	Brinjal**	*Solanum melongena* L.	Solanaceae	Fruits	(LC)	Flavonoids	44
181.	Kata Begun	*Solanum nigrum* L.*	Solanaceae	Whole plant	(NE)	-	14
182.	Ashvagandhā	*Withania somnifera* (L.) Dunal*	Solanaceae	Leaf, Root	DD (CD)	Withaferin A	41
183.	Tea	*Camellia sinensis* (L.) Kuntze*	Theaceae	Leaf	DD (LC)	Catechins, Cinnamic acid	7
184.	Agnimanthā	*Clerodendrum multiflorum* (Burm. f.) Kuntze*	Verbenaceae	Stem, Leaf	(LC)	-	41
185.	Harjora/Veld Grape	*Cissus quadrangularis* L.*	Vitaceae	Fruit	(LC)	CQR-300	44
186.	Grapevine	*Vitis vinifera* L.*	Vitaceae	Fruit/Seed	LC	Total Phenolics, Flavonoids	41
187.	Turmeric**	*Curcuma longa* L.	Zingiberaceae (M)	Root	DD (LC)	Curcumin	7
188.	Ginger**	*Zingiber officinale* Roscoe	Zingiberaceae (M)	Rhizome	DD (LC)	Gingerols	41

* Conserved at BAU Botanical Garden; ** Cultivated on BAU campus; (M) Monocotyledons