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Ethnopharmacological Approach of Anti-obesity Medicinal Plants: A Review

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Abstract
Obesity is a global epidemic that has shown a steady increase in morbimortality indicators; it is considered a social problem and entails serious health risks. It is most prevalent health problem affecting all age groups, and leads to many complications in the form of chronic heart disease, diabetes mellitus type 2 and stroke. Alternative treatment of obesity is the traditional use of medicinal plants, which supports the research and development of obesity phototherapy. In this review 30 plant species data analyzed on the basis of taxonomy, chemical - biological studies and geographical distribution. A systematic review about safety and efficacy of herbal medicines in the management of obesity in human was carried out through references from PubMed, Scopus, Google Scholar, Web of Science and Iran Medex online database.

Keywords: Obesity; anti-obesity medicines; medicinal plants; traditional medicine

Introduction
Obesity is becoming one of the most prevalent health concerns among all populations and age groups worldwide, resulting into a significant increase in mortality and morbidity related to coronary heart diseases, diabetes type 2, metabolic syndrome, stroke and cancers [1]. Prevention and treatment of this problem are an important deal for health systems, whose aim is to reduce the obesity and overweight prevalence, and related complications over the world [2].
Obesity is a global epidemic and is recognized as an energetic imbalance caused mainly by increased consumption of high-calorie foods, physical inactivity and socioeconomic and environmental changes, particularly rising purchasing power [3]. Obesity is associated with dyslipidemias, diabetes, musculoskeletal disturbances, particularly osteoarthritis, and some types of cancer, such as endometrial, breast and colon cancer [4-5].
Obese individuals also have cardiac risk factors that manifest hypertension, insulin resistance, glucose intolerance and an elevated body mass index (BMI) [6]. Since 1980, morbidity and mortality rates have been increased [7], becoming a social problem and the focus on objectives of governments policies [8].
Many integrative and complementary practices attempted to reduce risk of morbidity and mortality, including dietary programs, physical activity, surgical interventions, behavioral therapy, lifestyle modification, medicinal therapies, drug addiction treatments, hypnosis, acupuncture and the use of medicinal plants [9, 10].
Pharmacological strategies are recommended for the treatment of obesity, mainly because they are non-invasive. However, use of anti-obesity drugs, especially in patients with cardiovascular disorders, because they possible may aggravate the symptoms [2, 11].
When conventional medicinal treatments are unable to address chronic diseases effectively and without eventual adversities, attention is diverted towards non-conventional therapies which are plant-based medications that may contribute to satiety, increased metabolism and accelerated weight loss [12].
In this context, plant species have become indispensable in providing extracts and isolated chemical compounds that serve as raw material for the development of obesity treatments [13]. However, all the variables that mark a plant as alternative therapy for the treatment of diseases must be rigorously assessed to guarantee robust, safe and reliable results [14].

Material and Methods
Databases used for this study to search include PubMed, Scopus, Google Scholar, Web of Science, and Iran Medex database. Search of literatures was focused on human or animal drug trails and adverse effects of herbal extracts to treat obesity. Abstracts of publications on plants used to evaluate the activity on human, animals, cell lines studies with the main outcome as mentioned above were included.

Due to large number of reference articles, articles of similar outcomes were eliminated. The review includes active components and its mechanism of action against obesity and geographical locations across world is presented in Table 1.

Sr No	Herb taxonomy and its part/s	Phytochemical constitutions	Ethnopharmacological properties	Mechanism	Geographical distributions
1	*Adenophora triphylla Hara* (Campanulaceae); *Root* [15]	Saponins, triterpenes, β-Sitosterol and lupenone.	Antifungal, carditonic, expectorant and antiadepogenic effect.	Anti-obesity effect of *A. triphylla*is mediated by increasing adipocytes adiponectin and activating pathway like AMPK, and PPAR-α, and decreasing adipokines TNF-α, GPDH, and PPAR-α. It also actively expresses low-density lipoprotein [LDL] receptor and cholestorl 7α-hydroxylase (CYA7A1) and inhibits expression of 3 hydroxy-3 methyl glutaryl - CoA (HMG-CoA) reductase.	Korea, Japan, China, Taiwan and Russia.
2	*Bergenia crassifolia (L.) Fritsch (Saxifragaceae); Leaves* [16]	Tannins, benzanoids flavonoids, sugar, terpenes and aldehydes.	Adaptogenic, antiinflammatory, antihypertensive, antimicrobial, antioxidant, antiobesity, cerebro-protective, hepatoprotective, immunomodulating, and diuretic.	Galloylbergenin derivatives 3,11-Di-O-galloylbergenin and 4,11- di-O-galloylbergenin are found to be present in B. crassifolia moderates anti-lipid accumulation activities.	Central Asia, Northern Mongolia, N Korea and Russia.
3	*Bursera grandiflora (Schltdl.) Engl (Burseraceae); Roots* [17]	Alkaloids, cardiac glycosides, flavonoids, saponins, terpenes and steroids.	Diaphoretic, stimulant and tonic. It is used in the treatment of malaria and rheumatism.	B. grandiflora exerts anti-obesity activity by decreasing in the plasma-triglyceride levels.	Southwestern United States to Peru, Red Sea Hills of Eastern Sudan.
4	*Cheilanthes albomarginata C.B. Clarke (Pteridaceae); Rhizome* [18]	Flavonoids (Rutin and quercetin) and phenols.	Antioxidant, antiinflammatory, antiadipogenic and antiobesity	Extract of C. albomarginata lowers plasma triglyceride activity as well as reduces weight of adipose tissue.	Nepal, India, Pakistan and Bhutan.
5	*Cordia ecalyculata Vell (Boraginaceae); Whole plant* [19]	Terpenoids, flavonoids and tannins.	Antimicrobial, antifertility antiinflammatory, anthelmintic, analgesic, diuretic, digestive system, respiratory, urogenital, cardiac, vascular, snake bite, hypolipidemic, antioxidant and.immunomodulatory.	Anti-obesity activity of the C. ecalyculata is medicated by anorectic central action, facilitating binding to adenosine receptors promoting an extension of adrenalin.	Florida, Caribbean, Central America Northeastern South America and Asia.
6	*Eucommia ulmoides Oliv (Eucommiaceae); Leaves, Bark* [20]	Flavonoid, lactones, coumarins, alkaloids and polysaccharide.	Hypertension, hyperlipemia, diabetes, obesity, sexual dysfunction, osteoporosis, alzheimer's disease, aging, lupus-like syndrome and immunoregulation.	Asperuloside increases ATP production in white adipose tissues and increases use of ketone bodies/ glucose in skeletal muscle.	Europe, North America and China.
7	*Geranium thunbergii Siebold ex Lindl. & Paxton (Geraniaceae); Leaf* [21]	Tannins, flavonoids and phenolic acids	Antibacterial, antifungal, Antioxidant, antiparasitic, cancer, arsenic poisoning, astringent, bladder inflammation, bleeding, Crohn's disease, depression, diarrhea, diuretic, epilepsy, gastrointestinal inflammation, gum disease, hemorrhoids, herpes, hormonal disorders, influenza, kidney dysfunction, menorrhagia, nose bleed, skin care and sleep disorders.	The extract ameliorates high-fat diet-induced obesity by altering the adipokine levels and down regulates expression of transcription factors and lipogenic enzymes involved in lipid metabolism.	North America, E. Asia - China, Japan, Korea.
8	*Gymnema sylvestre (Retz.) R.Br. ex Sm (Apocynaceae); Leaves* [22]	Triterpene saponins known as gymnemic acids, gymnemasaponins, and a polypeptide, gurmarin.	Obesity, arthritis, hyperlipidemia, Parkinsonism, hypercholesterolemia, antimicrobial, anti-inflammatory and anticancer.	Control serum lipids, leptin, insulin, glucose, apolipoprotein B and LDH levels while it increases the HDL-cholesterol, apolipoprotein A1 and antioxidant enzymes levels.	East Africa to Saudi Arabia, India, Sri Lanka, Vietnam, China, Japan, Philippines, Malaysia, Indonesia and Australia.

9	*Hunteria umbellata (K.Schum.) Hallier f. (Apocynaceae); Seed* [23]	Saponin, saponin glycosides, steroid, tannins, volatile oils, phenols and copious amount of alkaloids.	Antiobesity, antilipogenic, antidiabetic, antihypertensive and antioxidants.	The extract reduces weight gain pattern and causes dose related reductions in the serum lipids, Coronary artery risk index.	Sierra Leone, Liberia, Ivory Coast, Ghana, Benin, Nigeria, Cameroon, Gabon,Congo Africa and Southeast Asia.
10	*Hypericum philonotis Schltdl. & Cham. (Hypericaceae); Leaves* [24]	Flavonoids and acylphloroglucinol.	Antiobesity	Decreases weight and serum glucose, total cholesterol, triglycerides and HDL-cholesterol without changing LDL.	Southern México
11	*Ligustrum lucidum W.T. Aiton (Oleaceae; Fruits* [25]	Acetophenone and phenyl ethanol.	Tinnitus, vertigo, premature graying of the hair and soreness/weakness of the lower back and knees.	Treatment with the extract decreases high fat diet-induced obesity, mainly by improving metabolic use of fats and triglycerides.	Spain, Italy, Canary, Algeria, Islands, N Zealand, South Africa, Japan, Korea and Australia.
12	***Lithocarpus*** *polystachyus (Wall. ex A.DC.) Rehder (Fagaceae); Leaves* [26]	Phloridzin, phloretin, glucopyranoside, daucossterol, beta-sitosterol, quercetin, luteolin, quercitrin and oleanolic acid	Antiobesity, hypoglycemic and antilipidemic activity	Decreases levels of serum lipids, attenuates body weight gain and lowers circulating leptin and insulin levels, decreases oxidative stress, raise serum adiponectin, reduce circulating CRP and depresses expressions of PPARγ and C/EBPα.	India, Japan, Thailand and North America
13	*Nelumbo nucifera Gaertn. (Nelumbonaceae); Seed epicarp, leaves, seed, petals* [27]	Alkaloids, glycosides, terpene, steroids, flavonoids and tannins.	Antiobesity, anticancer, antifungal, antipyretic, emollient, diuretic cardiotonic, antiaging, hyperglycemic, anti-inflammatory and antipyretic.	The extracts effective in inhibiting preadipocyte differentiation. The flavonoids inhibits effect on both adipocyte differentiation and pancreatic lipase activity, accumulation and decreases expression PPARγ, GLUT4, and leptin in cultured human adipocytes, indicating that it inhibits the differentiation of pre-adipocytes into adipocytes.	Central and northern India, northern Indochina and East Asia, Sri Lanka, Southeast Asia, Australia.
14	*Nitraria retusa (Forssk.) Asch. (Nitrariaceae); Shoot* [28]	Carbohydrates, tannins, sterols, saponins, alkaloids and flavonoids,	Antiobesity, Antioxidant, antimicrobial, and anticancer	The extract reduces body and fat mass and decreases triglycerides and LDL-cholesterol. Enhances gene expression related to lipid homeostasis in liver showing anti-obesity actions.	North Africa, Sinai, Palestine, Syria, Jordan, Iraq, Arabia, Iran and Pakistan.
15	*Orthosiphon aristatus (Blume) Miq (Lamiaceae); Whole plant* [29]	Monoterpenes, diterpenes, triterpenes, saponins, organic_acid and flavonoids.	Antidiabetic, antiinflammatory, antioxidant, hepatoprotective, analgesic and nephroprotective.	Betulinic acid, the active constituent suppresses hypothalamic protein tyrosine phosphatase 1B in mice and enhances the antiobesity effect of leptin in obese rat	Asia and tropical Australia
16	*Phaseolus vulgaris L. (Leguminosae); Bean* [30]	Polyphenolic compounds, alkaloids, fibre, saponins, steroids, lectins and terpenoids.	Decrease Glycemic index, anti-lipase, anticancer, lowering of the plasma cholesterol levels and antioxidant.	It reduces food intake and body weight in an animal model of obesity resulting in suppression of glycaemia.	East Asia, Mexico, Central America, and South America.
17	*Phyllostachys edulis (Carrière) J. Houz. (Poaceae); Leaves* [31]	Amino acids, carbohydrate, minerals and vitamins	Cholesterol lowering activity, antiobesity	The extract ameliorates elevated MCP-1 concentration in the blood	China,Taiwan, Japan, south of Hokkaido.
18	*Platycodon grandiflorum (Campanulaceae); Roots* [32]	Saponins, flavonoids, polyacetylenes, sterols and phenolics.	Antiinflammatory, antitumor, anti-oxidant, antidiabetic, antiobesity, hepatoprotective and immunomodulatory effects.	Platycodin-enriched diets can lower circulating and whole body cholesterol contents.	China, Japan, Mongolia, and Korea.
19	*Polygonum aviculare L. (Polygonaceae);*	Tannins, saponins, flavonoids, alkaloids and sesquiterpenes.	Antiobesity and antioxidant.	Suppresses the elevated mRNA expression levels of sterol regulatory element-	Turkey, Great Britain, Ireland and

	Aerial Parts [33]			binding protein-1c, peroxisome PPAR-γ, fatty acid synthase, and adipocyte protein 2 in the white adipose tissue of obese mice.	Scandinavia.
20	*Populus balsamifera L. (Salicaceae); Whole Plant* [34]	Phenolic glycosides, condensed tannins, nitrogen, soluble protein and starch.	Antiobesity, metabolic diseases and antioxidants.	Salicortin reduces whole body and retroperitoneal fat and hepatic triglyceride accumulation.	Canada
21	*Rubus fruticosus L. (Rosaceae); Fruit* [35]	Alkaloids, tannins, flavonoids, saponins, glycosides, sterols and terpenoids.	Antioxidant, antimicrobial, anticancer, antioxidant, antidiabetic and antidiarrheal.	Blueberry anthocyanins improve body weight and reduce obesity in mice.	Kashmir, Assam, and Tamilnadu
22	*Sapindus emarginatus Vahl (Sapindaceae); Pericarp of flower* [36]	Flavonoids, Triterpenoids, glycosides, carbohydrates, fatty acids, phenols, fixed oil and saponins.	Antiinflamatory, antipruritic, antihyperlipidemic, bactericidal, CNS diseases, emetic, hair tonic, nasal insufflations.	Methanolic extract decreases body weight, BMI, Blood glucose levels, total cholesterol, LDL-C, HDL-C and Triglycerides.	Gangetic Plains, Western Ghats, and Deccan Plateau in India
23	*Sasa quelpaertensis Nakai (Poaceae); Leaves* [37]	Polysaccharides, amino acids, and polyphenols.	Antidiabetic, anticancer, diuretic antiinflamatory, antiobesity, antitumor, antioxidant and antipyretic.	Adipogenesis is inhibited by downregulating expressions of CCAAT/enhancer-binding protein α, peroxisome PPAR-γ, SREBP-1c, and aP2. It also decreases the expression of fatty acid synthase and adiponectin mRNAs in differentiating adipocytes.	China, Japan, Korea, and Russia
24	*Schisandra chinensis (Turcz.) Baill. (Schisandraceae); Peel* [38]	Lignans schisandrin, deoxyschisandrin, gomisins, and pregomisin.	Hepatoprotective, antioxidant, adaptogenic, nervine tonic and mild antidepressant.	It decreases expression of C/EBPβ, C/EBPα or PPARγ, and resultant down-regulation of the terminal marker gene, aP2 during differentiation of 3T3-L1 preadipocytes into adipocytes. Akt and GSK3β phosphorylation are down-regulated blocking adipogenesis and adipocyte differentiation.	East Asia, Northern China and Russian.
25	*C. siamea (Lam.) H.S.Irwin & Barneby (Leguminosae); Roots* [39]	Flavonoids, polyphenols and aluminum trichloride,	Antibacterial, laxative and antiobesity.	Active constituents includes chrysophanol, physcion, emodin, cassiamin A, friedelin and cycloart-25-en-3,24- diol exhibits pancreatic lipase inhibitory activity	Indian states of Tamil Nadu, Andhra Pradesh and Karnataka.
26	*Shorea robusta Gaertn (Diptercarpaceae); Leaves* [40]	Avonoids, saponins, steroids, tannins, phenols, tri-terpenoids.	Analgesic, antipyretic, antiulcer, antiinflammatory, antiobesity, Antibacterial, antimicrobial and wound healing activity.	It decreases serum glucose, triglyceride, cholesterol, LDL-C, HDL-C, VLDL-C and atherogenic index.	Myanmar, Bangladesh, and Nepal. East India.
27	*Sida rhombifolia L. (Malvaceae); Leaf* [41]	Chlorophyll derivatives, flavonoids, alkaloids, β-phenylethylamines, and carboxylated tryptamines	Antirheumatic, analgesic, diuretic, antipyretic, antiviral, antiasthmatic, anticongestant, hypoglycaemic laxative, aphrodisiac, and hepatoprotective.	Up-regulation of PPARγ 2 and SREBP-1c expression in the epididymal adipose tissue, leading to attenuation of adipogenesis.	India, Australia, Americas and Africa.
28	*Solanum lycopersicum L. (Solanaceae); Fruit* [42]	Vitamins C and E, lycopene, β-carotene, lutein and flavonoids such as quercetin, aromatic amino acids, carbohydrate, sucrose.	Anticancer, antiobesity and antioxidant.	AMP-activated protein kinase and acetyl-CoA carboxylase phosphorylation in liver is elevated, and HMG-CoA reductase expression is decreased. It strongly decreases expression of peroxisome PPAR-γ, CCAAT/enhancer binding protein alpha and perilipin in the adipose tissue.	All over the world.
29	*Vigna angularis (Willd.) Ohwi & H. Ohashi (Leguminosae); Seed* [43]	Polyphenol,phenolic acid, flavonoid, furanylmethyl glycosides.	Antiobesity, antioxidant and antiinflamatory.	It reduces total hepatic lipid accumulation and lipid secretion into the feces. Incubation of adipocytes with the extract significantly	East Asian countries like China, Japan, and Korea, Himalayas,

				decreases triglyceride accumulation, glycerol phosphate dehydrogenase activity and inflammatory responses without affecting cell viability.	Northeast Asia
30	*Vitis vinifera L. (Vitaceae); Seed flours, peel, roots, fruit* [44-46]	Flavonoids, polyphenols, anthocyanins, proanthocyanidins, procyanidines.	Antioxidant, antiinflamatory, antimicrobial, cardio-hepatic, and neuroprotective effects.	By up-regulating hepatic genes related to cholesterol (CYP51) and bile acid (CYP7A1) synthesis as well as LDL cholesterol uptake. The extract treatment decreases expression of aP2, Fas, and TNFa, known markers of adipogenesis. Expression of PPAR-γ in liver and adipose tissue is lowered by regulating the lipid metabolism and suppressed obesity.	Southern Europe and Western Asia.

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