

Review of Medicinal Plants for Anti-Obesity Activity

Satyajit Patra¹, S Nithya²,
B Srinithya² and
Meenakshi SM²

Abstract

Obesity is a complex health issue to address, it is a serious and chronic disease that can have a negative effect on many systems in your body. Overweight and obesity may increase the risk of many health problems, including diabetes, heart disease, osteoarthritis and certain cancers. Obesity is increasing at an alarming rate throughout the world. Today it is estimated that there are more than 300 million obese people world-wide. Obesity is regarded as a disorder of lipid metabolism and the enzymes involved in this process could be targeted selectively for the development of antiobesity drugs. However, most of the anti-obesity drugs that were approved and marketed have now been withdrawn due to serious adverse effects. The naturopathic treatment for obesity has been explored extensively since ancient times and gaining momentum in the present scenario. Traditional medicinal plants and their active phytoconstituents have been used for the treatment of obesity and their associated secondary complications. Some active medicinal plants and their respective bioactive compounds were also tested by clinical trials and are effective in treatment of obesity. This review focus on natural phytoextracts with their mechanism of action and their preclinical experimental model for further scientific research.

Keywords: Obesity; Antiobesity drugs; Medicinal plants

Received: August 20, 2015; **Accepted:** December 01, 2015; **Published:** December 04, 2015

Introduction

In the present scenario, obesity is the major public health problem with about 1.9 billion adults (18 years and older) worldwide are overweight and about 600 million of them are clinically obese [1]. Obesity is characterized by increase in adipose cell size which is determined by amount of fat accumulated in the cytoplasm of adipocytes [2]. This change in the metabolism in the adipocytes is regulated by various enzymes such as fatty acid synthase, lipoprotein lipase and adipocyte fatty acid-binding protein [3].

Obesity results from an imbalance between energy intake and expenditure. It is caused by altered lipid metabolic processes including lipogenesis and lipolysis [4]. Lipogenesis is the process that stores free fatty acids in the form of triglyceride (TG) [5]; similarly, lipolysis is the process whereby the TG stored is metabolized to free fatty acids and glycerol [6]. Obesity accompanied by hyperlipidemia which is indicated by abnormally high concentration of lipids in blood [7]. The adipose tissue, an endocrine organ, has a major role in the regulation of metabolism and homeostasis, through the secretion of several biologically active adipokines [8]. During adipose tissue development, three

major transcription factors, peroxisome proliferator-activated receptor (PPAR) γ , CCAAT/enhancer binding protein (C/EBP) α , and sterol regulatory element-binding protein (SREBP) 1c, regulate the expression of these lipid-metabolizing enzymes [9]. 5' AMP-activated protein kinase (AMPK) plays a major role in glucose and lipid metabolism by inactivating acetyl-CoA carboxylase (ACC) and stimulates fatty acid oxidation by up-regulating the expression of carnitine palmitoyltransferase-1 (CPT-1), PPAR α , and uncoupling protein [10].

Nowadays, changes in human lifestyle and high energy diet have increased the incidence of obesity and even have become a risk factor to the population of children [11,12]. There are several pharmacologic substances available as antiobesity drugs, however they have hazardous side effects and hence natural products have been used for treating obesity in many Asian countries [13]. The potential of natural products for the treatment of obesity is still largely unexplored and can be an excellent alternative for the safe and effective development of antiobesity drugs [14].

Currently drugs available in the market for treatment of obesity can be divided into two major classes one being orlistat, which

- 1 Division of Biochemistry and Genetics, American International Medical University, Saint Lucia, WI, USA
- 2 Department of Biotechnology, School of Chemical & Biotechnology, SASTRA University, Thirumalaisamudram, Thanjavur, Tamilnadu, India – 613401

Corresponding author: Dr. Satyajit Patra

 dr.patra@aimu-edu.us

Division of Biochemistry and Genetics,
American International Medical University,
Saint Lucia, WI, USA.

Tel: 1-758-488-0322

Citation: Patra S, Nithya S, Srinithya B, et al. Review of Medicinal Plants for Anti-Obesity Activity. *Transl Biomed.* 2015, 6:3.

reduces fat absorption through inhibition of pancreatic lipase and the second is subutramine which is an anorectic or appetite suppressant. Both drugs have adverse effects including increased blood pressure, headache, drymouth, insomnia, and constipation [15,16]. In 1990 Fenfluramine and Dexfenfluramine were withdrawn from the market because of heart valve damage [17]. The US FDA in 1997 approved subutramine drug as a treatment for obesity. But later in October 2010 the drug was withdrawn from the market due to increased cardiovascular events and strokes [18,19]. In February 2011 the US FDA rejected approval of contrive which is a combination of bupropion/naltrexone due to concerns over potential cardiovascular risks [20]. Certain drugs have potential for abuse such as phentermine and diethylpropion and hence are approved for short term use [21].

At present, because of high cost and potentially hazardous side effects, the need for natural products against obesity is under exploration which may be an alternative strategy for developing effective, safe antiobesity drugs [22]. In 2000, Moro and Basile reported the use of certain well known medicinal plants that had claimed to be useful in treating obesity. The antiobesity effects of natural products from more diverse sources [23]. The aim of the present review was to update data on potential antiobesity herbal plants.

Methods

Databases used for this study to search include PubMed, Scopus, Google Scholar, Web of Science, and IranMedex with information reported between September 2, 2006 to September 22, 2014. Search of literatures was focused on human or animals investigating the benefits and harms of herbal medicines to treat obesity. The search terms were “obesity” and (“herbal medicine” or “plant”, “plant medicinal” or “medicine traditional”) without narrowing or limiting search items. Publications with abstract from the mentioned databases were used to prepare this review. The main outcome measures were defined as body weight, body fat, including fat mass/fat weight or fat percentage/visceral adipose tissue weight, waist or hip circumference, triceps thickness and appetite, and the amount of food/energy intake. 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. In vitro studies, review articles and letters to the editor were excluded. Two reviewers reviewed the articles for abstracts and title. Due to our inclusion and exclusion criteria, the duplicate articles were eliminated. The review includes active components and mechanism of action against obesity in animals and presented in **Table 1**. Some of the plants are tested for their activity against obesity in cell lines listed in **Table 2** and plants that were tested on human volunteers or clinical trails are listed in **Table 3**. In some instances scientist have evaluated the anti-obesity activity in isolated cell organelles, isolated cellular enzymes specifically pancreatic lipase are listed in **Tables 3** and **4** respectively. **Table 4** present the plant which was studied for its activity against obesity in an *in silico* model.

Discussion

In this review, we have report the antiobesity effects of different herbal plants or compounds containing minerals or chemical extracts of plants. Plants having reported antiobesity effects are listed in **Table 1** with information about their active components and their effects. From the review it was suggested that, plant showing anti-obesity potential mainly belongs to the family Leguminoseae, Lamiaceae, Liliaceae, Cucurbitaceae, Asteraceae, Moraceae, Rosaceae and Araliaceae. Majority of the studies indicates decrease in body weight or body weight gain in animals and humans with or without changes in body fat indicating antiobesity effects. The antiobesity effects such as body weight reduction, decrease in the levels of triglycerides, total cholesterol, and low density lipoprotein cholesterol with simultaneous increase in high density lipoprotein cholesterol was observed in the animals treated with the plants [1,15,29,31,39,54,60,78,79,83,85,98,100,101,133,145,152,165,190,196,201]. In one study [41], it has been reported that a compound chakasaponin II, suppressed mRNA levels of neuropeptide Y (NPY) and enhanced the release of serotonin (5-HT) that suppressed the appetite signals in the hypothalamus of the mice. Clinical trials were conducted on humans for various plant extracts [45,49,135] which showed a significant decrease in body weight and body fat reduction. There

Table 1. Anti-obesity effect of natural occurring plants with mechanism of action studied on animal models

	Plant name	Part(s)	Mechanism	Experimental model	Reference
1	<i>Achyranthes aspera</i> Linn (Amaranthaceae)	Seed	The plant lowers total cholesterol, total triglyceride, and LDL-cholesterol, and increases HDL cholesterol level.	High-fat-fed male Swiss albino mice	[24]
2	<i>Acorus calamus</i> Linn (Araceae)	Rhizome, roots and leaves	Ethyl acetate extarct of <i>A. calamus</i> inhibits α -glucosidase activity.	Glucose challenged mice.	[25]
3	<i>Achyranthes bidentata</i> Blume (Amaranthaceae)	Root	The drug affects on differentiation of adipocyte and decrease of phospho-Akt expression.	Male Sprague-Dawley fed with a high-fat diet	[26]
4	<i>Actinidia polygama</i> Max (Actinidiaceae)	Fruits	Serum levels of aspartate decreased in the mice treated with the extract without changes in serum levels of alanine transaminase blood urea nitrogen and creatinine.	Mice with high-fat diet induced obesity	[27]
5	<i>Adenophora triphylla</i> Hara (Campanulaceae)	Root	Anti-obesity effect of <i>A. triphylla</i> 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 cholesterol 7 α - hydroxylase (CYA7A1) and inhibits expression of 3 hydroxy-3 methyl glutaryl - CoA (HMG-CoA) reductase.	High fat diet (HFD)- C57B2/6 mice	[28,29]

6	<i>Aegle marmelos</i> Linn (Rutaceae)	Leaves	The active chemical constituents of <i>A. marmelos</i> for anti-adipogenic activity are halfordinol, ethyl ether aegeline and esculetin were responsible for the decrease in adipocyte accumulation. Active compounds umbelliferone and esculetin depletes lipid content in the adipocytes and by decreasing the hyperlipidemia.	High fat diet induced obese male Sprague Drawly rat	[30,31]
7	<i>Allium cepa</i> Linn (Amaryllidaceae)	Peel	The mRNA levels of activating protein (AP2) is down-regulated by <i>A. cepa</i> and those of carnitine palmitoyl transferase-1 α (CPT-1 α) and fatty acid binding protein 4 (FABP4) are up-regulated. It is also proposed that <i>A. cepa</i> increases level of PPAR- γ 2 mRNA (mesenteric fats) and IL-6 mRNA levels (perirenal and mesenteric fats).	High fat-fed rats, Diet-induced obese Male Sprague-Dawley rats	[32,33]
8	<i>Allium fistulosum</i> Linn (Liliaceae)	Root	Significant reduction in body weight and adipose tissue weight as well as adipocyte size. Genes involved in lipogenesis are down-regulated by <i>A. fistulosum</i> .	High fat diet- induced mice	[34]
9	<i>Allium nigrum</i> Linn (Amaryllidaceae)	Bulb	Extract of <i>A. nigrum</i> upregulates AMPK, FOXO1, Sirt1, ATGL, HSL, perilipin, ACO, CPT-1, and UCP1 in the adipose tissues, whereas it downregulates CD36.	High-fat diet induced obese mice	[35]
10	<i>Allium sativum</i> Linn (Amaryllidaceae)	Stem, Bulb and Roots	It increases antioxidant enzymes and suppresses glutathione depletion and lipid peroxidation in hepatic tissue. Oil isolated from <i>A. sativum</i> down regulates sterol regulatory element binding protein-1c, acetyl-coA carboxylase, fatty acid synthase, and 3-hydroxy-3-methylglutaryl-coenzyme A reductase.	High-fat diet-induced obese C57BL/6J mice	[36,37]
11	<i>Alpinia galanga</i> Linn (Zingiberaceae)	Rhizome	Galangin, the principal component of <i>A. galangal</i> decreases serum lipids, liver weight, lipid peroxidation and accumulation of hepatic TGs.	Obesity induced in female rats by feeding cafeteria diet	[38]
12	<i>Alpinia officinarum</i> Hance (Zingiberaceae)	Root	The drug controls and improves lipid profile in animals by lowering serum Total-C, TG, and LDL-C concentrations, leptin content.	Obesity in mice fed a high-fat diet	[39,40]
13	<i>Angelica gigas</i> Nakai (Apiaceae)	Roots	Decursin, the active constituent of <i>A. gigas</i> improves glucose tolerance. Decursin along with the HFD significantly reduces secretion adipocytokines such as leptin, resistin, IL-6 and MCP-1.	Mice fed a high-fat diet	[41]
14	<i>Argyreia nervosa</i> Bojer (Convolvulaceae)	Root	Serum contents of leptin, total cholesterol, LDL, and triglycerides are reduced by <i>A. speciosa</i> .	Diet- induced obesity rats	[42]
15	<i>Artemisia iwayomogi</i> (Compositae)	Whole Plant	It downregulates adipogenic transcription factors PPAR γ 2 and C/EBP α and their target genes CD36, aP2, and FAS. The extract decreases gene expression of proinflammatory cytokines including TNF α , MCP1, IL-6, IFN α , and INF β in epididymal adipose tissue and reduces plasma levels of TNF α and MCP1.	Mice fed a high-fat diet.	[43]
16	<i>Atractylodes lancea</i> (Thunb.) DC (Compositae)	Rhizome	It inhibits human pancreatic lipase. A new polyacetylene, <i>syn</i> -(5 <i>E</i> ,11 <i>E</i>)-3-acetoxy-4-O-(3-methylbutanoyl)-1,5,11-tridecatriene-7,9-diyne-3,4-diol has been isolated and identified and exhibits lipase inhibitory activity.	High-fat diet-induced obesity mice	[44]
17	<i>Aster pseudoglehni</i> Lim, Hyun & Shin (Asteraceae)	Leaves	It suppresses expression of adipogenesis-related genes including PPAR γ , C/EBP α , and SREBP1c.	High fat diet induced-male C57BL/6J mice	[45]
18	<i>Bauhinia variegata</i> Linn (Leguminosae)	Stem and root barks	Extract of <i>E. variegata</i> increases brain serotonin level and high-density lipoprotein with a concomitant decrease in total cholesterol, triglycerides and low-density lipoprotein.	Hypercaloric diet - induced mice	[46]
19	<i>Bergenia crassifolia</i> (L.) Fritsch (Saxifragaceae)	Leaves	Galloylbergenin derivatives 3,11-Di-O-galloylbergenin and 4,11-di-O-galloylbergenin are found to be present in <i>B. crassifolia</i> moderates anti-lipid accumulation activities.	Rats with high-calorie diet-induced obesity	[47]

20	<i>Boehmeria nivea</i> (L.) Gaudich (Urticaceae)	Leaf	The extracts reduces adipose tissue weight serum alkaline aminotransferase and lactate dehydrogenase activities. Serum triglyceride, total cholesterol, LDL-cholesterol level, atherogenic index and cardiac risk factors are decreased in animals fed with leaf powder and serum HDL -cholesterol levels are increased.	High fat/ cholesterol diet-induced Male Sprague-Dawley rats.	[48]
21	<i>Boerhaavia diffusa</i> L. (Nyctaginaceae)	Root	The phytoconstituents compounds sitosterol found in this plant which is structurally similar to cholesterol has been suggested to reduce cholesterol by lowering the level of LDL-cholesterol and cholesterol level decreased significantly in plasma without any side effects.	High fat diet in female Sprague-Dawley rats	[49]
22	<i>Bombax ceiba</i> L. (Malvaceae)	Stem bark	The extract and active constituent gemfibrozil reverses the effects of HFD treatment on serum parameters. This activity may be due to the inactivation of acetyl-coA carboxylase, as a result of AMPK activation that mediates thermogenesis and FAS inhibition.	Male, Wistar albino rats	[50]
23	<i>Anredera cordifolia</i> (Ten.) Steenis (Basellaceae)	Leaves	The extract suppresses lipid accumulation and down-regulates PPAR γ , CCAAT/enhancer binding protein α , SREBP, and their target genes. It also increases phosphorylation of AMPK.	High-fat diet-induced obese rats	[51]
24	<i>Brassica rapa</i> L. (Brassicaceae)	Root	Lipolysis-related genes including β_3 -adrenergic receptor, hormone-sensitive lipase, adipose triglyceride lipase, and uncoupling protein are induced in white adipocytes of animals treated with extract of <i>B. campestris</i> .	High fat diet induced mice	[52]
25	<i>Buddleja officinalis</i> Maxim (Scrophulariaceae)	Whole Plant	The extract reduces body weight gain induced through adipocyte differentiation.	High-fat diet to C57BL/6 mice	[53]
26	<i>Bursera grandiflora</i> (Schltdl.) Engl (Burseraceae)	Roots	<i>B. grandiflora</i> exerts anti-obesity activity by decreasing in the plasma-triglyceride levels.	Mice of the C57B1/6 strain with hypercaloric diet.	[54]
27	<i>Calanus finmarchicus</i> (Calanidae)	Wax	<i>C. finmarchicus</i> reduces macrophage infiltration and downregulates expression of proinflammatory genes including tumor necrosis factor- α , interleukin-6, and monocyte chemoattractant protein-1, whereas up-regulates adiponectin expression.	C57BL/6J mice with high-fat diet	[55]
28	<i>Camellia japonica</i> L. (Theaceae)	Leaves	<i>C. japonica</i> control insulin which is a modulator of lipid synthesis via sterol regulatory element binding protein-1c (SREBP-1c), decreased levels of insulin affects hepatic triglyceride synthesis.	High fat diet induced Sprague-Dawley rats	[56]
29	<i>Camellia oleifera</i> Abel (Theaceae)	Fruit hull	<i>Serum levels of total cholesterol and triacylglycerols are decreased but high-density lipoprotein cholesterol increased. Activity of fatty acid in animal liver is lowered by.</i>	Male ICR mice were fed a HFD	[57]
30	<i>Camellia sinensis</i> (L.) Kuntze (Theaceae)	Leaves, twigs and stems, flower buds	<i>C. sinensis</i> attenuates the gene expression of (SREBP-1c), fatty acid synthase and CCAAT/enhancer binding protein α . Extract found to reduce sICAM-1 release followed by nonpharmacological HGTE supplementation in db/db mice causing no adiponectin-inducing or antiadipogenic effects, reduced sICAM-1 release. Chakasaponin II from flower bud, suppresses mRNA levels of neuropeptide Y (NPY). The mRNA levels of adipogenic genes such as PPAR- γ , C/EBP- α , SREBP-1c, adipocyte fatty acid-binding protein, lipoprotein lipase and fatty acid synthase are decreased in <i>C. Sinensis</i> treated animals.	Albino rats fed on high-fat diet, diet-induced obesity in Female ddY mice, high fat induced- C57BL/6J-Lepob/ob mice, high fat diet- induced C57BL/6J mice	[58-64]
31	<i>Cheilanthes albomarginata</i> C.B. Clarke (Pteridaceae)	Rhizome	Extract of <i>C. albomarginata</i> lowers plasma triglyceride activity as well as reduces weight of adipose tissue.	High fat diet induced obese male Sprague Dawleyrats	[65]

32	<i>Chenopodium quinoa</i> Willd (Amaranthaceae)	Seeds	<i>C. quinoa</i> extract attenuate mRNA levels of several inflammation markers including monocyte chemotactic protein-1, CD68 and insulin resistance osteopontin, plasminogen activator inhibitor-1 and it also reverses the effects of HF-induced downregulation of the uncoupling protein(s) mRNA levels in muscle.	Mice fed with standard low-fat or a high-fat diet	[66]
33	<i>Cirsium brevicaule</i> A. Gray (Compositae)	Leaves	<i>C. brevicaule</i> inhibits fatty acid synthase and suppress the differentiation and lipid accumulation and affecting transcription factors such as SREBP-1c, C/EBP α , and PPAR γ known to control the fatty acid synthase expression.	C57BL/6 mice that were fed a high-fat diet	[67]
34	<i>Citrus reticulata</i> Blanco (Rutaceae)	Peel	mRNA expression levels of lipogenesis related genes such as SREBP1c, FAS and ACC1 in the liver are lowered and the size of adipocytes are reduced.	High fat diet induced mice	[68]
35	<i>Citrus sunki</i> (Hayata) Yu.Tanaka (Rutaceae)	Peel	Phosphorylation levels of AMPK and acetyl-CoA carboxylase are decreased.	High-fat diet induced obese C57BL/6 mice	[69]
36	<i>Clerodendrum phlomidis</i> L. f. (Lamiaceae)	Roots	It inhibits pancreatic lipase activity. The extract contains β -sitosterol.	High fat diet induced obesity in C57BL/6J mice	[70]
37	<i>Coccinia grandis</i> (L.) Voigt (Cucurbitaceae)	Fruit	Reduces body weight, food intake, organ and fat pads weight and serum GLU, CHO, TRG, LDL and VLDL cholesterol levels and increases HDL levels.	Cafeteria diet and Atherogenic diet induced obesity in female rats.	[71]
38	<i>Codonopsis lanceolata</i> (Siebold & Zucc.) Benth. & Hook.f. ex Trautv (Campanulaceae)	Roots	Reduces weight of adipose pads and the serum levels of triglycerides, total cholesterol, and low density lipoprotein cholesterol.	High-calorie/high-fat-diet induced obesity Sprague-Dawley male rats	[72]
39	<i>Coffea arabica</i> L. (Rubiaceae)	Seed	<i>C. arabica</i> diet supplementation can impair glucose tolerance, hypertension, cardiovascular remodeling, and nonalcoholic fatty liver disease.	High-carbohydrate, high-fat diet-fed Wistar male rats	[73]
40	<i>Coleus forskohlii</i> (Willd.) Briq. (Lamiaceae).	Root	<i>C. forskohlii</i> act as anti-obesity drug by inhibiting dyslipidemia.	Diet-induced obesity in rats	[74,75]
41	<i>Corchorus olitorius</i> L. (Malvaceae)	Leaves	Liver tissue gene expression of gp91phox (NOX2) involved in oxidative stress is down-regulated by <i>C. olitorius</i> and genes related to the activation of β -oxidation like PPAR α and CPT1A are up-regulated by the plant.	High fat diet - induced LDL receptor deficient mice	[76]
42	<i>Cordia ecalyculata</i> Vell (Boraginaceae)	Whole plant	Anti-obesity activity of the <i>C. ecalyculata</i> is mediated by anorectic central action, facilitating binding to adenosine receptors, thereby promoting an extension of adrenalin.	Mice (albino, swiss strain) treated with cyclophosphamide	[77]
43	<i>Cornus officinalis</i> Siebold & Zucc. (Cornaceae)	Rhizome	Platycodin D is the major component effective to activate AMPK- α . The extract reduces serum levels of aspartate transaminase and alanine transaminase.	C57BL/6J mice were fed a HF diet	[78]
44	<i>Cucumis melo</i> L. (Cucurbitaceae)	Fruit peel	<i>C. melo</i> reduces gain in body weight, serum lipid profile like total cholesterol, triglyceride, LDL-C level, atherogenic index and increases serum HDL-C levels.	High cholesterol diet induced in rats	[79]
45	<i>Cyamopsis tetragonoloba</i> (L.) Taub (Leguminosae)	Beans	It decreases adipose triglyceride accompanied by enhancing activity of hormone-sensitive lipase-facilitating mobilization of depot fat.	High-fat-fed Wistar rats	[80]
46	<i>Dimocarpus longans</i> Leenh (Sapindaceae)	Flower	By combined effect of decreased exogenous lipid absorption, normalization of hepatic PPAR- γ gene expression, suppression of pancreatic activity and SREBP-1c and FAS gene expression, and higher fecal triglyceride output.	Hyper caloric diet- male Sprague-Dawley rats.	[81]
47	<i>Dioscoreae tokoronis</i> Linn (Dioscoreaceae)	Root	It decreases triglyceride, total plasma cholesterol, and low-density lipoprotein-cholesterol. It suppresses the expression of SREBP-1 as well as that of fatty acid synthase in adipose and liver tissues.	High fat diet - induced mice	[82]

48	<i>Eucommia ulmoides</i> Oliv (Eucommiaceae)	Leaves, Bark	Asperuloside increases adenosine 5'-triphosphate production in WAT and increases use of ketone bodies/ glucose in skeletal muscle.	Obesity induced by ovariectomy in female Wistar rats, rats fed a high-fat diet.	[83,84]
49	<i>Fraxinus excelsior</i> L. (Oleaceae)	Seed	Secoiridoids present enhances fat metabolism through β -oxidation, inhibit adipocyte differentiation during animal growth and limit fat accumulation.	High fat diet induced mice	[85]
50	<i>Garcinia cowa</i> Roxb. ex Choisy (Clusiaceae)	Fruit, commercially available tablet	Inhibits the enzyme ATP-dependent citrate lyase, which catalyzes the cleavage of citrate to oxaloacetate and acetyl-CoA. Serum apo A1 levels are increased by the plant and the serum total cholesterol levels.	Female Sprague-Dawley rats fed atherogenic diet	[86,87]
51	<i>Geranium thunbergii</i> Siebold ex Lindl. & Paxton (Geraniaceae)	Leaf	The extract ameliorates high-fat diet-induced obesity by altering the adipokine levels and downregulates expression of transcription factors and lipogenic enzymes involved in lipid metabolism.	High fat diet - induced mice	[88]
52	<i>Glycine max</i> (L.) Merr. (Leguminosae)	Bean	Reductions glucose-6-phosphate dehydrogenase, malic enzyme, fatty acid synthetase, as well as acetyl-CoA carboxylase. The extract decreases appetite and HF diet-induced body weight gain through leptin-like STAT3 phosphorylation and AMPK activation.	Diet-induced obese mice	[89,90]
53	<i>Gymnema sylvestre</i> (Retz.) R.Br. ex Sm (Apocynaceae)	Leaves	Inhibits serum lipids, leptin, insulin, glucose, apolipoprotein B and LDH levels while it increases the HDL-cholesterol, apolipoprotein A1 and antioxidant enzymes levels.	High fat diet-induced obesity in wistar rats	[91-93]
54	<i>Hibiscus cannabinus</i> L. (Malvaceae)	Leaves	It decreases serum cholesterol, triglycerides, LDL-C, SGOT and SGPT activities.	High cholesterol diet induced obesity in female albino rats	[94]
55	<i>Hibiscus sabdariffa</i> L. (Malvaceae)	Leaf	Promotes LXR α /ABCA1 pathway, stimulating cholesterol removal from macrophages, delaying atherosclerosis. Also, the extract treatment attenuated liver steatosis, downregulated SREBP-1c and PPAR- γ , blocked the increase of IL-1, TNF- α mRNA and lipoperoxidation and increased catalase mRNA.	High fat diet-induced obese C57BL/6NHsd mice	[95,96]
56	<i>Holoptelea integrifolia</i> (Roxb.) Planch. (Ulmaceae)	Bark	HMG-CoA reductase activity is reduced and cholesterol biosynthesis and increase in lecithin, cholesterol acyltransferase activity.	Diet-induced obese rat	[97]
57	<i>Humulus lupulus</i> L. (Cannabaceae)	Female inflorescence	Hepatic fatty acid synthesis is reduced through the reduction of hepatic SREBP1c mRNA expression in the rats fed a high-fat diet.	High-fat diet induced obese rat, male C57BL/6J mice fed a HF diet	[98,99]
58	<i>Hunteria umbellata</i> (K.Schum.) Hallier f. (Apocynaceae)	Seed	The extract reduces weight gain pattern and causes dose related reductions in the serum lipids, Coronary artery risk index. Also, pre-treatment significantly improves triton-induced hepatic histological lesions.	High fat diet- induced rats	[100]
59	<i>Hypericum philonotis</i> Schltdl. & Cham. (Hypericaceae)	Leaves	Decreases body weight and serum glucose levels. It also decreases total cholesterol, triglycerides and high-density lipoprotein-cholesterol without changing low-density lipoprotein-cholesterol, AI, AST and ALT level.	Male Wistar rats fed with high fat diet	[101]
60	<i>Hypericum silenoides</i> Juss. (Hypericaceae)	Leaves	Body weight and serum glucose levels of the rats decreased. The drug also has effect on total cholesterol, triglycerides and high-density lipoprotein-cholesterol.	Male Wistar rats fed with high fat diet	[101]
61	<i>Ilex paraguariensis</i> A.St.-Hil. (Aquifoliaceae)	Leaves and unripe fruits	Down-regulates expression of Creb-1 and C/EBP α , and up-regulates expression of Dlk1, Gata2, Gata3, Klf2, Lrp5, Ppar γ_2 , Sfrp1, Tcf7l2, Wnt10b, and Wnt3a. The mRNA levels of PPAR- γ_2 were downregulated.	High fat diet- induced mice, male Wistar rats fed diet	[102-105]
62	<i>Ipomoea batatas</i> (L.) Lam (Convolvulaceae)	Fruit	Expression of SREBP-I, Acyl-CoA Synthase, Glycerol-3-Phosphate Acyltransferase, HMG-CoA Reductase and Fatty Acid Synthase in liver tissue in mice is altered.	Mice fed with high-fat diet	[106]
63	<i>Saccharina japonica</i> (Phaeophyceae)	Whole Plant	Expression of the fat intake-related gene ACC2 and lipogenesis-related genes are reduced. It increases phosphorylation of AMPK and its direct downstream protein, acetyl coenzyme A carboxylase.	High-fat-diet-induced obese male Sprague-Dawley rats	[107,108]

64	<i>Larix laricina</i> (Du Roi) K.Koch (Pinaceae)	Whole Plant	Stimulates glucose uptake, potentiated adipogenesis, activated AMPK, and acted as mitochondrial uncoupler/ inhibitor (on normal isolated mitochondria).	Diet-induced obese C57BL/6 mice	[109]
65	<i>Ligularia fischeri</i> (Ledeb.) Turcz. (Compositae)	Leaves	Polyphenols present in the extract exhibits antiobesity effects by inhibiting pancreatic lipase.	C57BL/6 mice	[110]
66	<i>Ligustrum lucidum</i> W.T.Aiton (Oleaceae)	Fruits	Treatment with the extract decreases HFD-induced obesity, mainly by improving metabolic parameters, such as fats and triglycerides.	High fat-diet-induced C58BL/6J obese mice	[111]
67	<i>Lithocarpus polystachyus</i> (Wall. ex A.DC.) Rehder (Fagaceae).	Leaves	Decreases levels of serum lipids, attenuates body weight gain and lowers circulating leptin and insulin levels, ameliorate the state of oxidative stress, raise serum adiponectin, reduce circulating CRP and resistin levels, and depresses expression of PPAR γ and C/EBP α .	High fat diet-induced obese rats	[112]
68	<i>Lithospermum erythrorhizon</i> Siebold & Zucc. (Boraginaceae)	Roots	Reduces high-fat diet-induced increases in body weight, white adipose tissue mass, serum triglyceride and total cholesterol levels, and hepatic lipid levels and decreases lipogenic and adipogenic gene expression. Acetylshikonin, active constituent of <i>L. erythrorhizon</i> suppresses adipocyte differentiation and attenuates adipogenic transcription factor expression.	C57BL/6J mice were fed a normal or high-fat diet	[113,114]
69	<i>Morinda citrifolia</i> L. (Rubiaceae)	Fruit	Reduces body weight and fat mass. It increases glucose tolerance and reduced plasma triglycerides level.	High-fat diet-induced obesity in mice	[115]
70	<i>Morus alba</i> L. (Moraceae)	Fruit, leaves	The hepatic peroxisome PPAR-R and carnitine palmitoyltransferase-1 are elevated, while fatty acid synthase and 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase are reduced. It decreases hepatic lipids, fatty acid synthase and 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase and elevates hepatic peroxisome PPAR- α and carnitine palmitoyltransferase-1.	High fat diet- induced mice, 6-week-old male hamsters.	[116]
71	<i>Morus australis</i> Poir (Moraceae)	Fruit	Reduces resistance to insulin, associated with leptin.	Male C57BL/6 mice fed with high-fat diet	[117]
72	<i>Morus nigra</i> L. (Moraceae)	Fruit, leaves,	Proinflammatory cytokines MCP-1 and TNF- α , plasma triglyceride, liver lipid peroxidation levels and adipocyte size are decreased. Inflammatory markers (monocyte chemoattractant protein-1, inducible nitric oxide synthase, C-reactive protein, tumour necrosis factor- α and interleukin-1) in liver and adipose tissue are increased.	Adenovirus 36-induced obesity in mice, high-fat (HF) diet-induced obese mice.	[116-120]
73	<i>Murraya koenigii</i> (L.) Spreng. (Rutaceae)	Leaves	Reduces body weight gain, plasma total cholesterol and triglyceride levels in mice.	High fat diet -induced mice	[121]
74	<i>Myrciaria dubia</i> (Kunth) McVaugh (Myrtaceae)	Fruit	Reduces animal body weights of the fat in white adipose tissues, glucose, total cholesterol, triglycerides, and LDL-c and insulin blood levels. An increase in HDL-c levels also seen.	Wistar rats with obesity induced by subcutaneous injection of monosodium glutamate	[122]
75	<i>Myrtus communis</i> L. (Myrtaceae)	Leaves	The body weight reduced by 32 % when administered with sibutramine, while it was reduced by 21 % and 24 % when administered with the methanolic extract of <i>M. communis</i> /kg body weight.	High-fat diet induced obese mice	[123]
76	<i>Nelumbo nucifera</i> Gaertn. (Nelumbonaceae)	Seed epicarp, leaves, seed, petals	The extracts effective in inhibiting preadipocyte differentiation. The flavonoids inhibits effect on both adipocyte differentiation and pancreatic lipase activity, accumulation and decreases expression PPAR γ , GLUT4, and leptin in cultured human adipocytes, indicating that it inhibits the differentiation of pre-adipocytes into adipocytes. The methanol extract inhibits lipase activity and suppresses the expression of fatty acid synthase, acetyl-CoA carboxylase, and HMGCoA reductase and increases the phosphorylation of AMP-activated protein kinase in the liver.	High fat diet- induced mice Male Sprague-Dawley rats were fed with a normal diet and a high-fat diet, High fat diet - induced C57BL/6 mice.	[124-127]

77	<i>Nephelium lappaceum</i> L. (Sapindaceae)	Fruit	The expression of Igf-1 and Igf-1R were reduced on obese rat model treated with extract of <i>N. lappaceum</i> .	Rat fed with high calorie diet and treated with ellagic acid	[128]
78	<i>Nitraria retusa</i> (Forssk.) Asch. (Nitrariaceae)	Shoot	The extract suppresses increase in body and fat mass weight, and decreases triglycerides and LDL-cholesterol levels and enhances gene expression related to lipid homeostasis in liver showing anti-obesity actions.	BKS.Cg-Dock7 ^m +/+ Lepr ^{db} /J mice model	[129]
79	<i>Olea europaea</i> L. (Oleaceae)	Leaves	The extract reverses HFD-induced upregulation of WNT10b- and galanin-mediated signaling molecules and key adipogenic genes (PPAR γ , C/EBP α , CD36, FAS, and leptin). It also induces downregulation of thermogenic genes involved in uncoupled respiration (SIRT1, PGC1 α , and UCP1) and mitochondrial biogenesis (TFAM, NRF-1, and COX2).	High-fat diet-induced obesity in mice	[130,131]
80	<i>Orthosiphon aristatus</i> (Blume) Miq (Lamiaceae)	Whole plant	Betulinic acid, the active constituent suppresses hypothalamic protein tyrosine phosphatase 1B in mice and enhances the antiobesity effect of leptin in obese rats	High-fat-fed mice	[132]
81	<i>Panax ginseng</i> C.A.Mey. (Araliaceae)	Root	Ginsam increases PPAR- γ expression and AMP-activated protein kinase phosphorylation in liver and muscle. The extracts strongly activates Hormone Specific Lipase via Protein Kinase A.	Insulin - resistant rat, high fat diet induced obese C57BL6/J mice	[133,134]
82	<i>Perilla frutescens</i> (L.) Britton (Lamiaceae)	Leaf	It decreases body weight gain, food efficiency ratio, and relative liver and epididymal fat mass.	High fat diet - induced rats	[135]
83	<i>Petasites japonicus</i> (Siebold & Zucc.) Maxim. (Compositae)	Flower buds	The extracts attenuate three adipogenetic transcription factors, peroxisome PPAR- γ 2, CCAAT/ enhancer- binding protein and sterol regulatory element- binding protein 1c.	Diet- induced obesity-prone mice.	[136]
84	<i>Phaseolus vulgaris</i> L. (Leguminosae)	Bean	It reduces food intake and body weight in an animal model of obesity resulting in suppression of glycaemia.	Genetically obese adult male Zucker fa/fa rats.	[137]
85	<i>Phyllostachys edulis</i> (Carrière) J.Houz. (Poaceae)	Leaves	The extract ameliorates elevated MCP-1 concentration in the blood.	High fat diet - induced C57BL/6J mice	[138]
86	<i>Pinus koraiensis</i> Siebold & Zucc (Pinaceae)	Leaves	Suppresses fat accumulation and intracellular triglyceride associated with downregulation of adipogenic transcription factor expression, including PPAR γ and CEBP α in the differentiated 3T3-L1 adipocytes. It attenuates expression of FABP and GPDH as target genes of PPAR γ during adipocyte differentiation.	High fat diet Male Sprague-Dawley rats	[139]
87	<i>Piper fragile</i> Benth (Piperaceae)	Seed	<i>P. fragile</i> rube oil shows significant reduction in body weight.	Male Sprague dawley mice were treated with high cholesterol diet	[140]
88	<i>Piper sarmentosum</i> Roxb. (Piperaceae)	leaves	<i>P. sarmentosum</i> group shows reduction in enzyme activity. Aqueous extract of <i>P. fragile</i> have the ability to reduce 11 β -HSD1 enzyme activity.	Ovariectomy-Induced Obese Rats	[141]
89	<i>Platycodon grandiflorum</i> (Campanulaceae)	Roots	Platycodin feeding increases cholesterol absorption up to 60%, but not cholesterol synthesis. Platycodin-enriched diets can lower circulating and whole body cholesterol contents.	Golden Syrian hamsters	[142]
90	<i>Polygonum aviculare</i> L. (Polygonaceae)	Aerial Parts	Extract of <i>P. aviculare</i> suppresses the elevated mRNA expression levels of sterol regulatory element-binding protein-1c, peroxisome PPAR- γ , fatty acid synthase, and adipocyte protein 2 in the white adipose tissue of obese mice.	High-fat diet induced obese mice	[143]
91	<i>Populus balsamifera</i> L. (Salicaceae)	Whole Plant	Salicortin reduces whole body and retroperitoneal fat pad weights, as well as hepatic triglyceride accumulation. It also modulates key components in signaling pathways involved with glucose regulation and lipid oxidation in the liver, muscle, and adipose tissue.	C57Bl/6 mice subjected to high fat diet	[144]

92	<i>Premna integrifolia</i> Linn (Verbenaceae)	Roots	A significant decrease in the levels of serum glucose, triglyceride, total cholesterol, LDL and VLDL observed in the animals treated with the extract of <i>P. integrifolia</i> .	Female Swiss Albino mice, fed with cafeteria diet	[145]
93	<i>Prunus mume</i> (Siebold) Siebold & Zucc (Rosaceae)	Fruit	Increases CPT-1 expression and decreases FAS, ACC, and SREBP-1c in the liver and quadriceps muscles to resulting in reducing triglyceride accumulation. It also improves insulin sensitivity in OVX rats and prevents the impairment of energy, lipid, and glucose metabolism by OVX through potentiating hypothalamic leptin and insulin signaling.	High fat diet, ovariectomized rats	[114]
94	<i>Pueraria montana</i> var. <i>chinensis</i> (Ohwi) Sanjappa & Pradeep (Leguminosae)	Flower	It downregulates acetyl-CoA carboxylase expression. For adipose tissue, the expressions of hormone-sensitive lipase in white adipose tissue and uncoupling protein 1 in brown adipose tissue are upregulated.	Male C57BL/6J mice were fed a high-fat diet	[146]
95	<i>Punica granatum</i> L (Lythraceae)	Leaves, seed	Punicic acid binds and activates PPAR- α and γ , thus upregulating PPAR α and its responsive genes (Stearoyl-CoA desaturase-1, SCD1; Carnitine palmitoyltransferase 1, Cpt-1; and acyl-coenzyme A dehydrogenase) as well as PPAR γ -responsive genes expression (CD36 and Fatty Acid Binding Protein4, FABP4) in intra-abdominal white adipose tissue while suppressing expression of the inflammatory cytokine TNF- α and NF- κ B activation.	High-fat diet induced obese mice	[147,148]
96	<i>Rheum palmatum</i> L. (Polygonaceae)	Root	It inhibits peroxisome PPAR- γ transactivity and the expression of its target genes, suggesting that rhein acts as a PPAR γ antagonist.	Diet-induced obese female C57BL/6 mice	[108,149, 150]
97	<i>Rosmarinus officinalis</i> L. (Lamiaceae)	Leaves	It decreases circulating tumor necrosis factor alpha, IL-1 β , and leptin, and upregulated adiponectin. The extract also induces phase I and phase II gene expression and the peroxisome PPAR- γ coactivator 1-alpha. Serum triglycerides, cholesterol and insulin levels are also decreased in the lean animals.	Lean (Le, <i>fa</i> /+) and obese (Ob, <i>fa</i> / <i>fa</i>) female Zucker rats	[151]
98	<i>Rubus fruticosus</i> L. (Rosaceae)	Fruit	Purified blueberry anthocyanins have been shown to improve body weight and body composition and reduce obesity in mice.	C57BL/6J mice fed a high-fat diet	[152]
99	<i>Sapindus emarginatus</i> Vahl (Sapindaceae)	Pericarp of flower	Methanolic extract decreases body weight, BMI, Blood glucose levels, total cholesterol, LDL-C, HDL-C, Triglycerides, SGOT, and SGPT.	Monosodium glutamate induced obesity in wistar albino rats	[153]
100	<i>Sasa quelpaertensis</i> Nakai (Poaceae)	Leaves	Adipogenesis is inhibited by this drug by downregulating the expression 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. It increases AMPK and acetyl-CoA carboxylase phosphorylation.	High-fat diet-induced obese C57BL/6 mice	[154,155]
101	<i>Schisandra chinensis</i> (Turcz.) Baill. (Schisandraceae)	Peel	It decreases expression of C/EBP β , C/EBP α or PPAR γ , and resultant down-regulation of the terminal marker gene, aP2 during differentiation of 3T3-L1 preadipocytes into adipocytes. Akt and GSK3 β phosphorylation are down-regulated blocking adipogenesis and adipocyte differentiation.	HFD-induced obese rats	[156]
102	<i>Senna siamea</i> (Lam.) H.S.Irwin & Barneby (Leguminosae)	Roots	Active constituents includes chrysophanol, physcion, emodin, cassiamin A, friedelin and cycloart-25-en-3,24-diol exhibits pancreatic lipase inhibitory activity.	Alloxan induced diabetes rats.	[157]
103	<i>Shorea robusta</i> Gaertn (Diptercarpaceae)	Leaves	It decreases serum glucose, triglyceride, cholesterol, LDL-C, HDL-C, VLDL-C, atherogenic index, SGPT and SGOT.	Monosodium glutamate induced obesity in albino rats	[158]
104	<i>Sida rhombifolia</i> L. (Malvaceae)	Leaf	Up-regulation of PPAR γ 2 and SREBP-1c expression in the epididymal adipose tissue, leading to attenuation of adipogenesis.	High fat diet- induced C57BL/6J mice	[159]
105	<i>Solanum lycopersicum</i> L. (Solanaceae)	Fruit	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.	High-fat-diet-induced obesity in C57BL/6 mice	[160,161]

106	<i>Syzygium aromaticum</i> (L.) Merr. & L.M.Perry (Myrtaceae)	Flower buds	The extract suppresses expression of lipid metabolism-related proteins, including SREBP-1, FAS, CD36 and PPAR γ in the liver and WAT, in addition to downregulates mRNA levels of transcription factors including SREBP and PPAR- γ .	High fat diet fed mice	[162]
107	<i>Tamarindus indica</i> L. (Leguminosae)	Fruit pulp, pulp, seed coat	Levels of plasma total cholesterol, lowdensity lipoprotein, and triglyceride is decreased and it increases high-density lipoprotein, with the concomitant reduction of body weight.	Diet-induced obese Sprague-Dawley rats	[163-165]
108	<i>Tecomella undulata</i> (Sm.) Seem.	Bark	The extract shows a significant increase in SIRT1 and adiponectin levels and decrease in PPAR, C/EBP, E2F1, leptin and LPL levels in preadipocytes and adipocytes and shows improvement in lipid profile and glucose levels.	High Fat Diet obese mice.	[166]
109	<i>Vaccinium corymbosum</i> L. (Ericaceae)	Peel	It inhibits lipid accumulation and decreases expression of C/EBP β , as well as the C/EBP α and PPAR γ genes during the differentiation of preadipocytes into adipocytes. It down-regulates adipocyte-specific genes such as aP2 and FAS.	High-fat diet-induced obese rats	[167]
110	<i>Veratrum nigrum</i> L. (Melanthiaceae)	Whole plant	It reduces weight gain and the fat pad weight in high fat diet-induced obese mice.	High-fat diet-induced obese mice	[134]
111	<i>Vigna angularis</i> (Willd.) Ohwi & H. Ohashi (Leguminosae)	Seed	It reduces total hepatic lipid accumulation and lipid secretion into the feces. Incubation of adipocytes with the extract significantly decreases triglyceride accumulation, glycerol phosphate dehydrogenase activity and inflammatory responses without affecting cell viability.	High fat diet-induced obesity in rats	[168]
112	<i>Vigna nakashimae</i> (Ohwi) Ohwi & H. Ohashi (Leguminosae)	Seeds	It decreases expression of peroxisome proliferator activated receptor and its target genes. It enhances the phosphorylation of AMP-activated protein kinase (AMPK) and acetyl CoA carboxylase (ACC), and increases the expression of fatty acid oxidation genes.	High-fat diet fed mice	[169]
113	<i>Viscum album</i> L. (Santalaceae)	Leaves, stems, and fruits	Body and epididymal fat pad weights are, and histological examination indicates an amelioration of fatty liver. It potently induces mitochondrial activity by activating thermogenesis and improving endurance capacity and also inhibited adipogenic factors in vitro.	Male C57Bl/6 mice fed a high-fat diet	[170]
114	<i>Vitis thunbergii</i> Siebold & Zucc (Vitaceae)	Roots	Activation of AMPK activating glucose and lipid metabolism.	High-fat diet-fed C57BL/6JNarl mice	[171]
115	<i>Vitis vinifera</i> L. (Vitaceae)	Seed flours, peel, roots, fruit	By up-regulating hepatic genes related to cholesterol (CYP51) and bile acid (CYP7A1) synthesis as well as LDL-cholesterol uptake. Lipid metabolism-associated genes Mlxp1, Stat5a, Hsl, Plin1, and Vdr were down-regulated. The extract treatment decreases expression of aP2, Fas, and Tnfa, known markers of adipogenesis, as measured by real-time polymerase reaction. Expression of PPAR- γ in liver and adipose tissue is lowered by regulating the lipid metabolism and suppressed obesity.	Male Golden Syrian hamsters fed high-fat (HF) diets, high fat diet - induced C57BL/6J mice	[54,171-178]
116	<i>Zanthoxylum bungeanum</i> Maxim. (Rutaceae)	Fruit	It reduces weight gain, white adipose tissue mass, and serum triglyceride and cholesterol levels. It also decreased lipid accumulation and PPAR γ , C/EBP α , SREBP-1, and FAS protein and mRNA levels in the liver.	Obese C57BL/6 mice fed a high-fat diet	[179]
117	<i>Ziziphus mauritiana</i> Lam (Rhamnaceae)	Bark	It reduces body weight, fat mass and pancreatic lipase activity.	High Fat Diet induced obesity in Wistar rats	[180]
118	<i>Dohaekseunggi-tang</i> traditional plant-based medicine (Taohe Chengqi Tang: Chinese)	Commercial formula	<i>Dohaekseunggi-tang</i> consists of five herbs including <i>Glycyrrhizae uralensis</i> Fischer (40 g), <i>Rheum undulatum</i> Linne (80 g), <i>Prunus persica</i> Linne (60 g), <i>Cinnamomum cassia</i> Presl (40 g), and Natrii Sulfas (40 g) mixed. The extract decreased serum total cholesterol, LDL-cholesterol, triglyceride, glucose, and leptin concentrations, and increased HDL-cholesterol and adiponectin levels and increased mRNA expression of peroxisome proliferator activated receptor- γ , uncoupling protein-2, and adiponectin in visceral adipose tissue of HFD mice	High-fat diet induced obese mice	[181]

Table 2. Anti-obesity effect of plants with mechanism of action studied on cell line as model.

1	<i>Acorus calamus</i> Linn (Araceae)	Rhizome, roots and leaves	Ethyl acetate extract of <i>A. calamus</i> inhibits α -glucosidase activity.	HTT-T15 cell line	[25]
2	<i>Aegle marmelos</i> Linn (Rutaceae)	Leaves	Active compounds umbelliferone and esculetin depletes lipid content in the adipocytes and by decreasing the hyperlipidemia in obese rats fed with high-fat diet.	3T3-L1 preadipocytes	[30,31]
3	<i>Agrimonia pilosa</i> Ledeb (Rosaceae)	Aerial parts	Active constituent 1beta-hydroxy-2-oxopomolic acid inhibits adipocyte differentiation and expression of adipogenic marker genes, such as PPAR- γ , C/EBPalpha, GLUT4, adiponectin, aP2, ADD1/SREBP1c, resistin, and fatty acid synthase. It also inhibits adipocyte differentiation through downregulation of various adipocytokines by blocking PPAR- γ and C/EBPalpha expression.	3T3-L1 preadipocytes	[182]
4	<i>Alnus hirsuta</i> (Spach) Rupr. (Betulaceae)	Leaves	Platyphyllonol-5-O- β -D-xylopyranoside suppresses the induction of PPAR γ and C/EBP α protein expression, and inhibits adipocyte differentiation.	3T3-L1 preadipocyte cells	[183]
5	<i>Amomum cardamomum</i> L. (Zingiberaceae)	Seeds	By regulating the C/EBP α , C/EBP β and PPAR γ gene and protein expressions.	3T3-L1 Cell lines.	[184]
6	<i>Bauhinia variegata</i> L. (Fabaceae)	Flowers, flower buds, stem, roots, stem bark, seeds, leaves	it reduces increased level of total cholesterol, triglycerides, LDLP and increases the level of HDLP, brain serotonin level. β -sitosterol in the stem induces secretion of serotonin in brain and in turn exhibits anti-obesity activity.	Human neutrophils.	[185]
7	<i>Brassica rapa</i> L. (Brassicaceae)	Root	Lipolysis-related genes including β_3 -adrenergic receptor, hormone-sensitive lipase, adipose triglyceride lipase, and uncoupling protein are induced in white adipocytes of animals treated with extract of <i>B. campestris</i> . Activation of cyclic AMPK, HSL, and extracellular signal-regulated kinase are induced in EBR-treated 3T3-L1 cells.	3T3 adipocytes.	[52]
8	<i>Caesalpinia sappan</i> L. (Leguminosae)	Heartwood	Brazilein inhibits intracellular lipid accumulation during adipocyte differentiation in 3T3-L1 cells and suppresses the induction of peroxisome PPAR- γ (PPAR γ).	Postconfluent 3T3-L1 preadipocytes	[186]
9	<i>Citrus aurantium</i> L. (Rutaceae)	Fruits, leaves	It inhibits Akt activation and GSK3 β phosphorylation, which induces the down-regulation of lipid accumulation and lipid metabolizing genes, ultimately inhibiting adipocyte differentiation.	3T3-L1 preadipocytes	[22,187,188]
10	<i>Coptis chinensis</i> Franch. (Ranunculaceae)	Rhizome	It inhibits lipid accumulation in 3T3-L1 cells. The five alkaloids present in this plant significantly reduces expression levels of several adipocyte marker genes including proliferator activated receptor and CCAAT/enhancer-binding protein. Isolated alkaloids found to inhibit adipogenesis.	3T3-L1 adipocytes cells	[189]
11	<i>Cucurbita moschata</i> Duchesne (Cucurbitaceae)	Stems	Reduces expression of peroxisome PPAR- γ , CCAAT/enhancer-binding protein α , fatty acid-binding protein 4, sterol response element-binding protein-1c and stearoyl-coenzyme A desaturase-1, and decreases lipid accumulation.	Primary mouse embryonic fibroblasts	[190]
12	<i>Curcuma longa</i> L. (Zingiberaceae)	Rhizomes	Increase hormone-sensitive lipase and adipose triglyceride lipase mRNA levels and decreases perilipin mRNA level via AMPK, resulting in lipolysis. In adipose tissue, curcumin inhibits macrophage infiltration and nuclear factor κ B activation induced by inflammatory agents.	3T3-L1 adipocytes	[191,192]
13	<i>Cyclopia falcata</i> (Harv.) Kies (Leguminosae)	Stem	Flavonoid, phloretin-3',5'-di-C-glucoside inhibits intracellular triglyceride and down regulates PPAR2 expression and in <i>in vitro</i> condition it can inhibit adipogenesis.	3T3-L1 mouse pre-adipocytes	[193]
14	<i>Cyclopia maculata</i> (Andrews) Kies (Leguminosae)	Stems	Mangiferin, hesperidin inhibits intracellular triglyceride and fat accumulation, and decreases PPAR2 expression and in <i>in vitro</i> it can inhibit adipogenesis.	3T3-L1 mouse pre-adipocytes	[193]

15	<i>Dalbergia sissoo</i> DC. (Leguminosae)	Leaves	Inhibits pancreatic lipase and can be used as an anti-obesity agent in suitable form.	Chicken pancreas	[194]
16	<i>Dioscorea oppositifolia</i> L. (Dioscoreaceae)	Rhizome	Decreases expression of PPAR- γ . Batatasin I compound from the extract was found to increase p-AMPK and CPT-1 in 3T3-L1 adipocytes, resulting in inhibiting adipogenesis.	Mouse embryo preadipocyte (3T3-L1) cell lines	[195]
17	<i>Eremochloa ophiuroides</i> (Munro) Hack (Poaceae)	Whole Plant	Expression of C/EBP and PPAR, the central transcriptional regulators of adipogenesis. Moreover, this plant down-regulates phosphorylation levels of Akt and GSK3.	Mouse 3T3-L1 preadipocytes	[196]
18	<i>Glycine max</i> (L.)Merr. (Leguminosae)	Bean	It inhibits adipocyte differentiation in 3T3-L1 preadipocyte cells. Accumulation of triglycerides is inhibited and activation of AMPK.	3T3-L1 preadipocyte cells	[89,90]
19	<i>Houttuynia cordata</i> Thunb. (Saururaceae)	Leaf	Attenuates expression of fatty acid synthase, sterol regulatory element-binding protein-1 and glycerol 3-phosphate acyltransferases. The extract inhibits the elevation of plasma TG levels in mice. The extracts possibly suppress the uptake of NEFA and glycerol by blocking FAT/CD 36 and also suppress aquaprin-7.	Human HepG2 hepatocytes	[197,198]
20	<i>Ilex paraguariensis</i> A.St.-Hil. (Aquifoliaceae)	Leaves and unripe fruits	A modulatory effect on the expression of genes related to the adipogenesis as PPAR2, leptin, TNF and C/EBP are also seen.	3T3-L1 cell line	[102-105]
21	<i>Ipomoea batatas</i> (L.) Lam (Convolvulaceae)	Fruit	Expression of SREBP-I, Acyl-CoA Synthase, Glycerol-3-Phosphate Acyltransferase, HMG-CoA Reductase and Fatty Acid Synthase in liver tissue.	Murine 3T3-L1 adipocytes	[106]
22	<i>Irvingia gabonensis</i> (Aubry-Lecomte ex O'Rorke) Baill. (Irvingiaceae)	Seed	Inhibits adipogenesis in adipocytes. The effect appears to be mediated through the down regulated expression of adipogenic transcription factors (PPAR- γ) and adipocyte-specific proteins (leptin), and by upregulated expression of adiponectin.	Murine 3T3-L1 adipocytes	[199]
23	<i>Morus australis</i> Poir. (Moraceae)	Root	Increases lipolytic effects such as decreased intracellular triglyceride and the release of glycerol.	3T3-L1 adipocytes	[200]
24	<i>Nelumbo nucifera</i> Gaertn. (Nelumbaceae)	Seed epicarp, leaves, seed, petals	The extracts effective in inhibiting preadipocyte differentiation. The flavonoids inhibits effect on both adipocyte differentiation and pancreatic lipase activity, accumulation and decreases expression PPAR γ , GLUT4, and leptin in cultured human adipocytes, indicating that it inhibits the differentiation of pre-adipocytes into adipocytes.	3T3-L1 (adipocyte), NIH3T3 (mouse fibroblast, embryo), L-02 (normal hepatocyte) cells CHO-K1, and U2OS cells,	[124-127]
25	<i>Nepeta tenuifolia</i> Benth. (Lamiaceae)	Whole plant	Inhibits triglyceride accumulation in 3T3-L1 adipocytes, suggesting anti-obesity activity.	3T3-L1 cells	[201]
26	<i>Pericarpium zanthoxyli</i> (Rutaceae)	Seed	Decreases expression of the adipogenesis-related transcription factor, PPAR- γ and PPAR- γ -target genes, such as adipocyte protein 2 (aP2), fatty acid synthase (FAS) and other adipocyte markers and also decreases levels of CCAAT/enhancer-binding protein β (C/EBP β) in a dose-dependent manner.	OP9 cells	[202]
27	<i>Petasites japonicus</i> (Siebold & Zucc.)	Flower buds	The extracts attenuate three adipogenic transcription factors, peroxisome PPAR- γ 2, CCAAT/enhancer-binding protein and sterol regulatory element-binding protein 1c.	3T3-L1 murine preadipocytes	[136]
28	<i>Peucedanum japonicum</i> Thunb. (Apiaceae)	Leaves	Pteryxin down regulates genes SREBP-1c, fatty acid synthase, and acetyl-coenzyme A carboxylase-1 in treated 3T3-L1 adipocytes and HepG2 hepatocytes and up-regulates lipid catabolizing genes. In another study it was proved that the extract down-regulates a key lipogenic activator, SREBP1 c and adipocyte size marker gene, paternally expressed gene 1/mesoderm-specific transcript (PEG1/MEST) in adipose tissue in vivo.	Both 3T3-L1 and HepG2 cell lines, 3T3-L1 and HepG2 cells	[203,204]
29	<i>Rubus chingii</i> var. <i>suavissimus</i> (S.K.Lee) L.T.Lu (Rosaceae).	Leaves	The extract increases adipogenesis and increases expression of adiponectin and leptin. In the early phase of adipogenesis, extract increases the mRNA expression of adipogenic transcription factors CCAAT/enhancer binding protein α and PPAR- γ .	3T3-L1 preadipocytes	[205]

30	<i>Salicornia herbacea</i> L. (Amaranthaceae)	Whole plant	Isorhamnetin 3-O-β-D-glucopyranoside suppresses adipogenic differentiation by downregulation of peroxisome proliferator-activated receptor-γ, CCAAT/enhancer-binding proteins, SREBP1, and the adipocyte-specific proteins. Specific mechanism mediating the effects of isorhamnetin 3-O-β-D-glucopyranoside confirmed by activation of AMPK.	3T3-L1 preadipocytes	[206]
31	<i>Siegesbeckia pubescens</i> L. (Amaranthaceae)	Whole plant	The anti-obesity effect is modulated by cytidine-cytidine-adenosine-adenosine-thymidine/enhancer binding proteins, and peroxisome proliferator-activated receptor, gene and protein expressions.	3T3-L1 preadipocytes	[207]
32	<i>Smilax china</i> L. (Smilacaceae)	Leaves	Polyphenol and flavonoid, exhibits α-glucosidase and lipid accumulation inhibition properties.	3T3-L1 adipocytes	[208]
33	<i>Tetrapanax papyriferus</i> (Hook.) K.Koch (Araliaceae)	Whole plant	The anti-obesity effect is modulated by cytidine-cytidine-adenosine-adenosine-thymidine/enhancer binding proteins, and peroxisome proliferator-activated receptor, gene and protein expressions.	3T3-L1 preadipocytes	[207]
34	<i>Veratrum nigrum</i> L. (Melanthiaceae)	Whole plant	It decreases lipid accumulation and the expressions of two major adipogenesis factors, PPAR and C/EBP, in 3T3-L1 cells.	3T3-L1 cells	[134]
35	<i>Vitis labrusca</i> L. (Vitaceae)	Seed	The extract of <i>V. labrusca</i> inhibits lipid accumulation of C3H10T1/2 and 3T3-L1 cells in a dose-dependent manner. Inhibition is associated with reduced expression of PPAR-γ.	C3H10T1/2 and 3T3-L1 cells	[177]
36	<i>Vitis vinifera</i> L. (Vitaceae)	Seed flours, peel, roots, fruit	By up-regulating hepatic genes related to cholesterol (CYP51) and bile acid (CYP7A1) synthesis as well as LDL-cholesterol uptake. Lipid metabolism-associated genes <i>Mlxp1</i> , <i>Stat5a</i> , <i>Hsl</i> , <i>Plin1</i> , and <i>Vdr</i> were down-regulated. The extract treatment decreases expression of <i>aP2</i> , <i>Fas</i> , and <i>Tnfa</i> , known markers of adipogenesis, as measured by real-time polymerase reaction. Expression of PPAR-γ in liver and adipose tissue is lowered by regulating the lipid metabolism and suppressed obesity.	3T3-L1 preadipocytes, high fat diet- induced mice, murine 3T3-L1 adipocytes,	[54,171-178]
37	<i>Ziziphus jujube</i> Mill. (Rhamnaceae)	Fruit	Suppresses lipid accumulation and glycerol-3-phosphate dehydrogenase. Elicits the most inhibitory effect with attenuation of the expression of key adipogenic transcription factors, including PPAR-γ and CCAAT enhancer binding proteins (C/EBPs) at the protein level.	3T3-L1 preadipocytes	[209-211]
38	Germinated brown rice, germinated waxy brown rice, germinated black rice, and germinated waxy black rice	Seed	Extract of these seeds decreases body weight gain and lipid accumulation in the liver and epididymal adipose tissue. The mRNA levels of adipogenic transcriptional factors, such as CCAAT enhancer binding protein (C/EBP)-α, SREBP(SREBP)-1c, and peroxisome proliferator activated receptors (PPAR)-γ, and related genes (<i>aP2</i> , <i>FAS</i>) are decreased by the seed extract.	3T3-L1 murine adipocytes	[212]

Table 3 List of plants exhibiting anti-obesity activity studied on human volunteers.

1	<i>Carum carvi</i> L. (Apiaceae)	Seed	Reduces weight, body mass index, body fat percentage, and waist-to-hip ratio.	Human clinical trials	[213]
2	<i>Cissus quadrangularis</i> L. (Vitaceae)	Cylaris a formula contains a <i>C. quadrangulare</i> extract	Phytosterols and fiber extracts have anti-lipase, and anorexiant properties that reduce the absorption of dietary fats and enhance satiation by increasing serum serotonin levels.	Human clinical trials	[214]
3	<i>Citrus aurantium</i> L. (Rutaceae)	Fruits, leaves	The active constituent p-synephrine increases metabolic rate, energy expenditure and increase in weight loss. The leaf extract down-regulates the expression of C/EBPβ and subsequently inhibits the activation of PPARγ and C/EBPα. The anti-adipogenic activity of is mediated by the inhibition of Akt activation and GSK3β phosphorylation, which induces the down-regulation of lipid accumulation and lipid metabolizing genes, ultimately inhibiting adipocyte differentiation.	Human clinical trials	[22,187,188]

4	<i>Garcinia cowa</i> Roxb. ex Choisy (Clusiaceae)	Fruit, commercially available tablet	Inhibits the enzyme ATP-dependent citrate lyase, which catalyzes the cleavage of citrate to oxaloacetate and acetyl-CoA. Serum apo A1 levels are increased by the plant and the serum total cholesterol levels.	Human clinical trials	[86,87]
5	<i>Gynostemma pentaphyllum</i> (Thunb.) Makino (Cucurbitaceae)	Leaves	Activation of AMPK by 5-aminoimidazole-4-carboxamide-1- β -D-ribofuranoside (AICAR) inhibits adipogenesis by downregulating PPARc and CEBP1a as well as lipogenic factors including fatty acid binding protein 4 and lipoprotein lipase. AMPK activation directly inactivates ACC through Ser79 phosphorylation, leading to decreased fat synthesis by reducing the production of malonyl-CoA from acetyl-CoA.	Human clinical trials	[215]
6	<i>Nigella sativa</i> L. (Ranunculaceae)	Commercial <i>Nigella sativa</i> oil prepared by steam distillation.	<i>N. sativa</i> reduces total cholesterol, low density lipoprotein (LDL) and fasting blood glucose. The oil is effective as an add-on therapy in patients with metabolic syndrome.	Human Volunteer	[216,217]
7	<i>Salacia reticulata</i> Wight (Celastraceae)	Root	Significant weight and body-fat reduction was observed in <i>S. reticulata</i> treated animals and also BMI reduction is seen.	Human clinical trials	[218]
8	<i>Trigonella foenum-graecum</i> L. (Leguminosae)	Seed	Daily fat consumption, expressed as the ratio fat reported energy intake/total energy expenditure (fat-REI/ TEE), is decreased in overweight subjects administered the fenugreek seed extract. Significant decrease in the insulin/glucose ratio in subjects treated with fenugreek seed extract.	Clinical trials	[219]
9	<i>Turnera diffusa</i> Willd. ex Schult. (Passifloraceae)	Leaves	The herbal preparation capsules delays gastric emptying, reducing the time to perceived gastric fullness and induces weight loss.	Healthy volunteers	[220,221]
10	<i>Vernonia amygdalina</i> Delile (Compositae)	Leaf	Fat elimination usually occurred within 2 sec, 2 min of extract intake. The blood glucose lowers effects of <i>V. amygdalina</i> leaf extract were usually exerted in 2 sec, 2 min of extract intake by the patient.	Clinical trials	[222]
11	<i>Ziziphus jujube</i> Mill. (Rhamnaceae)	Fruit	The extract suppresses lipid accumulation and glycerol-3-phosphate dehydrogenase. <i>Z. jujuba</i> extract elicits the most inhibitory effect with attenuation of the expression of key adipogenic transcription factors, including PPAR- γ and CCAAT enhancer binding proteins (C/EBPs) at the protein level.	Human clinical trials	[209-211]

Table 4. Anti-obesity effect of plants with mechanism of action studied on isolated cell organelles.

1	<i>Verbesina persicifolia</i> DC (Compositae)	Aerial parts	4 β -cinnamoyloxy, 1 β , 3 α -dihydroxyeudesm-7,8-ene is the active constituent present in <i>V. persicifolia</i> induces bioenergetic collapse in rat liver mitochondria, demonstrating typical uncoupling agent. It acts as a mild uncoupler dropping $\Delta\psi$ and increases respiratory state 4. The energy collapse, mild uncoupling, and the fact that <i>V. persicifolia</i> is largely used in folk medicines, this plant may be viewed as a potentially effective anti-obesity drug.	Rat liver mitochondria	[223]
---	---	--------------	---	------------------------	-------

Table 5. Anti-obesity effect of plants with mechanism of action studied on isolated cell enzymes.

1	<i>Fraxinus chinensis</i> subsp. rhynchophylla (Hance) A.E.Murray (Oleaceae)	Stems and barks	Major active components are secoiridoids ligstroside, oleuropein, 2''-hydroxyoleuropein and hydroxyframoside B. These compounds significantly inhibit pancreatic lipase and hydroxyframoside B being the most active inhibitor in a mixed mechanism of competitive and noncompetitive manner.	Porcine pancreatic lipase	[224]
2	<i>Vitis vinifera</i> L. (Vitaceae)	Seed flours, peel, roots, fruit	By up-regulating hepatic genes related to cholesterol (CYP51) and bile acid (CYP7A1) synthesis as well as LDL-cholesterol uptake. Lipid metabolism-associated genes Mlxp1, Stat5a, Hsl, Plin1, and Vdr were down-regulated. The extract treatment decreases expression of aP2, Fas, and Tnfa, known markers of adipogenesis, as measured by real-time polymerase reaction. Expression of PPAR- γ in liver and adipose tissue is lowered by regulating the lipid metabolism and suppressed obesity.	Pure pancreatic lipase	[54,171-178]

was an increase in metabolic rate and energy expenditure. It was also reported that the clinical trials performed on humans for the plant extracts [151,165,226] showed an excess fat elimination, body mass index, fat percentage and blood glucose lowering effects. In another clinical trial study [148] the fenugreek seed

extract decreased the fat consumption and also insulin/glucose ratio. The essential oil from the plants [124,227] suppressed fat accumulation, intracellular triglyceride and decrease in body weight. Ginseng which is a popular Chinese herbal medicine significantly decreased the weight gain and improved glucose

tolerance [115,120]. *P. granatum* exhibits potential antiobesity mechanism including inhibition of pancreatic lipase activity and suppression of energy intake. Its effect on energy intake was similar to subutramine but with a different mechanism.

A study reported that Green tea possessed higher antioxidant activity than antiobesity activity due to its high concentration of catechins, including epicatechins, ECG and EGCG. It was proved that antiobesity activity of catechins resulted from the combined actions of appetite reduction, greater lipolytic activity, energy expenditure and adipocyte differentiation.

The active compounds umbelliferone and esculetin from the plant *Aegle marmelos* have shown marked effect by depleting the lipid content in the adipocytes and by decreasing the hyperlipidemia. Similarly, galangin a compound from *Alpinia galangal* showed a significant decrease in serum lipids, liver weight, lipid peroxidation and accumulation of hepatic Triglycerides. Decursin a compound from *Angelica gigas* significantly improved glucose tolerance and reduced the secretion of HFD-induced adipocytokines. The phytoconstituent compound sitosterol found in *Boerhaavia diffusa* is structurally similar to cholesterol has been suggested to reduce cholesterol by lowering the level of LDL-cholesterol. p-synephrine compound from the plant *Citrus aurantium* showed increased metabolic rate, energy expenditure and increase in weight loss. In *Nelumbo nucifera* flavonoids showed mild inhibitory effect on both adipocyte differentiation and pancreatic

lipase activity. Among the flavonoids, flavones without glucose inhibited pancreatic lipase activity, whereas flavone glycosides did not show inhibition. The presence of ephedrine and pseudo-ephedrine in the plant *Sida rhomboidea* induced appetite suppression that inhibits body weight gain.

Conclusion

Natural products identified from traditional medicinal plants have always paved the way for development of new types of therapeutics. Generally most of the compounds were isolated from natural sources despite which orlistat a semi-synthetic derivative of lipstatin have been approved by the US food and drug administration for the treatment of obesity. Orlistat is a potent inhibitor of pancreatic lipase (PL) which is a lipolytic enzyme which hydrolyses dietary fats in the initial step of lipid metabolism. There have been many reports on other effects such as anti-oxidative stress effects which may be important in the management of other diseases like cardiovascular diseases and diabetes. The antiobesity drugs are generally preferred based on high efficacy and effectiveness. The active exploration of natural sources has provided new developments based on the understanding of complex and redundant physiological mechanisms. Such exploration will lead to a safe and effective pharmacological treatment.

References

- 1 Centre WM (2015) Obesity and overweight. World Health Organization.
- 2 Devlin MJ, Yanovski SZ, Wilson GT (2000) Obesity: what mental health professionals need to know. *Am J Psychiatry* 157: 854-866.
- 3 Rosen ED, Walkey CJ, Puigserver P, Spiegelman BM (2000) Transcriptional regulation of adipogenesis. *Genes Dev* 14: 1293-1307.
- 4 Pagliassotti MJ, Gayles EC, Hill JO (1997) Fat and energy balance. *Ann N Y Acad Sci* 827: 431-448.
- 5 Mandrup S, Lane MD (1997) Regulating adipogenesis. *J Biol Chem* 272: 5367-5370.
- 6 Ducharme NA, Bickel PE (2008) Lipid droplets in lipogenesis and lipolysis. *Endocrinology* 149: 942-949.
- 7 Akiyama T, Tachibana I, Shirohara H, Watanabe N, Otsuki M (1996) High-fat hypercaloric diet induces obesity, glucose intolerance and hyperlipidemia in normal adult male Wistar rat. *Diabetes Res Clin Pract* 31: 27-35.
- 8 Yudkin JS (1999) C-reactive protein in healthy subjects: associations with obesity, insulin resistance, and endothelial dysfunction: a potential role for cytokines originating from adipose tissue? *Arterioscler Thromb Vasc Biol* 19: 972-978.
- 9 Freytag SO, Utter MF (1983) Regulation of the synthesis and degradation of pyruvate carboxylase in 3T3-L1 cells. *J Biol Chem* 258: 6307-6312.
- 10 Kim EJ, Jung SN, Son KH, Kim SR, Ha TY, et al. (2007) Antidiabetes and antiobesity effect of cryptotanshinone via activation of AMP-activated protein kinase. *Mol Pharmacol* 72: 62-72.
- 11 Klop B, Elte JW, Cabezas MC (2013) Dyslipidemia in obesity: mechanisms and potential targets. *Nutrients* 5: 1218-1240.
- 12 Kopelman PG (2000) Obesity as a medical problem. *Nature* 404: 635-643.
- 13 Matson KL, Fallon RM (2012) Treatment of obesity in children and adolescents. *J Pediatr Pharmacol Ther* 17: 45-57.
- 14 Bhutani KK, Birari RB, Kapat K (2007) Potential antiobesity and lipid lowering natural products: a review. *Nat. Prod. Commun* 2: 331-348.
- 15 Drew BS, Dixon AF, Dixon JB (2007) Obesity management: update on orlistat. *Vasc Health Risk Manag* 3: 817-821.
- 16 Tziomalos K, Krassas GE, Tzotzas T (2009) The use of sibutramine in the management of obesity and related disorders: an update. *Vasc Health Risk Manag* 5: 441-452.
- 17 Connolly HM, Crary JL, McGoon MD, Hensrud DD, Edwards BS, et al. (1997) Valvular heart disease associated with fenfluramine-phentermine. *N Engl J Med* 337: 581-588.
- 18 James WP, Caterson ID, Coutinho W, Finer N, Van Gaal LF, et al. (2010) Effect of sibutramine on cardiovascular outcomes in overweight and obese subjects. *N Engl J Med* 363: 905-917.
- 19 Kang JG, Park CY (2012) Anti-Obesity Drugs: A Review about Their Effects and Safety. *Diabetes Metab J* 36: 13-25.
- 20 Glazer G (2001) Long-term pharmacotherapy of obesity 2000: a review of efficacy and safety. *Arch Intern Med* 161: 1814-1824.
- 21 Mayer MA, Höcht C, Puyó A, Taira CA (2009) Recent advances in obesity pharmacotherapy. *Curr Clin Pharmacol* 4: 53-61.
- 22 Moro CO, Basile G (2000) Obesity and medicinal plants. *Fitoterapia* 71 Suppl 1: S73-82.
- 23 Han LK, Kimura Y, Okuda H (2005) Anti-obesity effects of natural products. *Studies in Natural Products Chemistry* 2005 30: 79-110.
- 24 Rani N, Sharma SK, Vasudeva N (2012) Assessment of Antiobesity Potential of *Achyranthes aspera* Linn. Seed. *Evid Based Complement Alternat Med* 2012: 715912.
- 25 Mythili Avadhani MN (2013) The Sweetness and Bitterness of Sweet Flag [*Acorus calamus* L.] – A Review. *Research Journal of Pharmaceutical, Biological and Chemical Sciences* 4: 598-610.
- 26 Oh SD, Kim M, Min BI, Choi GS, Kim SK, et al. (2014) Effect of *Achyranthes bidentata* Blume on 3T3-L1 Adipogenesis and Rats Fed with a High-Fat Diet. *Evid Based Complement Alternat Med* 2014: 158018.
- 27 Sung YY, Yoon T, Yang WK, Moon BC, Kim HK (2013) Anti-obesity effects of *Actinidia polygama* extract in mice with high-fat diet-induced obesity. *Mol Med Rep* 7: 396-400.
- 28 Hyun-Jin C, Mi Ja C, Seung-Shi H (2010) Antiobese and hypocholesterolaemic effects of an *Adenophora triphylla* extract in HepG2 cells and high fat diet-induced obese mice. *Food Chemistry* 119: 437-444.
- 29 Lee SE, Lee EH, Lee TJ, Kim SW, Kim BH (2013) Anti-obesity effect and action mechanism of *Adenophora triphylla* root ethanol extract in C57BL/6 obese mice fed a high-fat diet. *Biosci Biotechnol Biochem* 77: 544-550.
- 30 Karmase A, Birari R, Bhutani KK (2013) Evaluation of anti-obesity effect of *Aegle marmelos* leaves. *Phytomedicine* 20: 805-812.
- 31 Karmase A, Jagtap S, Bhutani KK (2013) Anti adipogenic activity of *Aegle marmelos* Correa. *Phytomedicine* 20: 1267-1271.
- 32 Kim OY, Lee SM, Do H, Moon J, Lee KH, et al. (2012) Influence of quercetin-rich onion peel extracts on adipokine expression in the visceral adipose tissue of rats. *Phytother Res* 26: 432-437.
- 33 Moon J, Do HJ, Kim OY, Shin MJ (2013) Antiobesity effects of quercetin-rich onion peel extract on the differentiation of 3T3-L1 preadipocytes and the adipogenesis in high fat-fed rats. *Food Chem Toxicol* 58: 347-354.
- 34 Sung YY, Yoon T, Kim SJ, Yang WK, Kim HK (2011) Anti-obesity activity of *Allium fistulosum* L. extract by down-regulation of the expression of lipogenic genes in high-fat diet-induced obese mice. *Mol Med Rep* 4: 431-435.
- 35 Chen YC (2014) Methanolic extract of black garlic ameliorates diet-induced obesity via regulating adipogenesis, adipokine biosynthesis, and lipolysis. *Journal of Functional Foods* 9: 98-108.
- 36 Kim I, Kim HR, Kim JH, Om AS (2013) Beneficial effects of *Allium sativum* L. stem extract on lipid metabolism and antioxidant status in obese mice fed a high-fat diet. *J Sci Food Agric* 93: 2749-2757.
- 37 Lai YS (2014) Garlic essential oil protects against obesity-triggered nonalcoholic fatty liver disease through modulation of lipid metabolism and oxidative stress. *J Agric Food Chem* 62: 5897-5906.
- 38 Kumar S, Alagawadi KR (2013) Anti-obesity effects of galangin, a pancreatic lipase inhibitor in cafeteria diet fed female rats. *Pharm Biol* 51: 607-613.
- 39 Jung CH, Jang SJ, Ahn J, Gwon SY, Jeon TI, et al. (2012) *Alpinia officinarum* inhibits adipocyte differentiation and high-fat diet-induced obesity in mice through regulation of adipogenesis and lipogenesis. *J Med Food* 15: 959-967.

- 40 Xia DZ, Yu XF, Wang HM, Ren QY, Chen BM (2010) Anti-obesity and hypolipidemic effects of ethanolic extract from *Alpinia officinarum* Hance (Zingiberaceae) in rats fed high-fat diet. *J Med Food* 13: 785-791.
- 41 Hwang JT (2012) Decursin, an active compound isolated from *Angelica gigas*, inhibits fat accumulation, reduces adipocytokine secretion and improves glucose tolerance in mice fed a high-fat diet. *Phytother Res* 26: 633-638.
- 42 Kumar S, Alagawadi KR, Rao MR (2011) Effect of *Argyrea speciosa* root extract on cafeteria diet-induced obesity in rats. *Indian J Pharmacol* 43: 163-167.
- 43 Choi Y, Yanagawa Y, Kim S, Whang WK, Park T (2013) *Artemisia iwayomogi* Extract Attenuates High-Fat Diet-Induced Obesity by Decreasing the Expression of Genes Associated with Adipogenesis in Mice. *Evid Based Complement Alternat Med* 2013: 915953.
- 44 Jiao P, Tseng-Crank J, Corneliusen B, Yimam M, Hodges M, et al. (2014) Lipase inhibition and antiobesity effect of *Atractylodes lancea*. *Planta Med* 80: 577-582.
- 45 Lee HM, Yang G, Ahn TG, Kim MD, Nugroho A, et al. (2013) Antiadipogenic Effects of *Aster glehni* Extract: In Vivo and In Vitro Effects. *Evid Based Complement Alternat Med* 2013: 859624.
- 46 Balamurugan G, Muralidharan P (2010) Antiobesity effect of *Bauhinia variegata* bark extract on female rats fed on hypercaloric diet. *Bangladesh Journal of Pharmacology* 5: 8-12.
- 47 Shikov AN, Pozharitskaya ON, Makarova MN, Makarov VG, Wagner H (2014) *Bergenia crassifolia* (L.) Fritsch--pharmacology and phytochemistry. *Phytomedicine* 21: 1534-1542.
- 48 Lee JJ (2011) Effects of Ramie Leaves on Improvement of Lipid Metabolism and Antiobesity Effect in Rats Fed a High Fat/High Cholesterol Diet. *Korean Journal of Food Science and Technology* 43: 83-90.
- 49 Khalid M, Siddiqui HH (2012) Evaluation of weight reduction and anti-cholesterol activity of *Punarnava* root extract against high fat diets induced obesity in experimental rodent. *Asian Pacific Journal of Tropical Biomedicine* 2: S1323-S1328.
- 50 Gupta P, Goyal R, Chauhan Y, Sharma PL (2013) Possible modulation of FAS and PTP-1B signaling in ameliorative potential of *Bombax ceiba* against high fat diet induced obesity. *BMC Complement Altern Med* 13: 281.
- 51 Kim H, Choung SY (2012) Anti-obesity effects of *Boussingaulti gracilis* Miers var. *pseudobaselloides* Bailey via activation of AMP-activated protein kinase in 3T3-L1 cells. *J Med Food* 15: 811-817.
- 52 An S, Han JI, Kim MJ, Park JS, Han JM, et al. (2010) Ethanolic extracts of *Brassica campestris* spp. rapa roots prevent high-fat diet-induced obesity via beta(3)-adrenergic regulation of white adipocyte lipolytic activity. *J Med Food* 13: 406-414.
- 53 Roh C, Park MK, Shin HJ, Jung U, Kim JK (2012) *Buddleja officinalis* Maximowicz extract inhibits lipid accumulation on adipocyte differentiation in 3T3-L1 cells and high-fat mice. *Molecules* 17: 8687-8695.
- 54 Aguilar Santamaría L (2012) Effect of *Bursera grandiflora* on body weight and lipemia in obese mice. *Efecto de Bursera grandiflora sobre el peso corporal y lipemia en ratones obesos* 11: 138-146.
- 55 Höper AC, Salma W, Sollie SJ, Hafstad AD, Lund J, et al. (2014) Wax esters from the marine copepod *Calanus finmarchicus* reduce diet-induced obesity and obesity-related metabolic disorders in mice. *J Nutr* 144: 164-169.
- 56 Tamaru S, Ohmachi K, Miyata Y, Tanaka T, Kubayasi T, et al. (2013) Hypotriglyceridemic potential of fermented mixed tea made with third-crop green tea leaves and camellia (*Camellia japonica*) leaves in Sprague-Dawley rats. *J Agric Food Chem* 61: 5817-5823.
- 57 Chen Q (2014) Polyphenol-rich extracts from *Oiltea camellia* prevent weight gain in obese mice fed a high-fat diet and slowed the accumulation of triacylglycerols in 3T3-L1 adipocytes. *Journal of Functional Foods* 9: 148-155.
- 58 Abd El-Moneim RA, Abd El-Mouaty HM (2013) A comparative histological, immunohistochemical, and biochemical study of the effect of green tea extracts or chromium picolinate administration on the white visceral adipose tissue and liver in albino rats fed on high-fat diet. *The Egyptian Journal of Histology* 36: 882-898.
- 59 Hamao M, Matsuda H, Nakamura S, Nakashima S, Semura S, et al. (2011) Anti-obesity effects of the methanolic extract and chakasaponins from the flower buds of *Camellia sinensis* in mice. *Bioorg Med Chem* 19: 6033-6041.
- 60 Kim HJ, Jeon SM, Lee MK, Jung UJ, Shin SK, et al. (2009) Antilipogenic effect of green tea extract in C57BL/6J-Lep ob/ob mice. *Phytother Res* 23: 467-471.
- 61 Lee MS, Kim CT, Kim Y (2009) Green tea (-)-epigallocatechin-3-gallate reduces body weight with regulation of multiple genes expression in adipose tissue of diet-induced obese mice. *Ann Nutr Metab* 54: 151-157.
- 62 Li Q, Liu Z, Huang J, Luo G, Liang Q, et al. (2013) Anti-obesity and hypolipidemic effects of Fuzhuan brick tea water extract in high-fat diet-induced obese rats. *J Sci Food Agric* 93: 1310-1316.
- 63 Oi Y, Hou IC, Fujita H, Yazawa K (2012) Antiobesity effects of Chinese black tea (Pu-erh tea) extract and gallic acid. *Phytother Res* 26: 475-481.
- 64 Wein S, Schrader E, Rimbach G, Wolfram S (2013) Oral green tea catechins transiently lower plasma glucose concentrations in female db/db mice. *J Med Food* 16: 312-317.
- 65 Lamichhane R, Kim SG, Poudel A, Sharma D, Lee KH, et al. (2014) Evaluation of in vitro and in vivo biological activities of *Cheilanthes albomarginata* Clarke. *BMC Complement Altern Med* 14: 342.
- 66 Foucault AS, Mathé V, Lafont R, Even P, Dioh W, et al. (2012) Quinoa extract enriched in 20-hydroxyecdysone protects mice from diet-induced obesity and modulates adipokines expression. *Obesity (Silver Spring)* 20: 270-277.
- 67 Inafuku M, Nugara RN, Kamiyama Y, Futenma I, Inafuku A, et al. (2013) *Cirsium brevicaulis* A. GRAY leaf inhibits adipogenesis in 3T3-L1 cells and C57BL/6 mice. *Lipids Health Dis* 12: 124.
- 68 Lee YS, Cha BY, Saito K, Choi SS, Wang XX, et al. (2011) Effects of a *Citrus depressa* Hayata (shiiikuwasa) extract on obesity in high-fat diet-induced obese mice. *Phytomedicine* 18: 648-654.
- 69 Kang SI, Shin HS, Kim HM, Hong YS, Yoon SA, et al. (2012) Immature *Citrus sunki* peel extract exhibits antiobesity effects by β -oxidation and lipolysis in high-fat diet-induced obese mice. *Biol Pharm Bull* 35: 223-230.
- 70 Chidrawar VR (2012) Pre-clinical evolutionary study of *Clerodendrum phlomidis* as an anti-obesity agent against high fat diet induced C57BL/6J mice. *Asian Pacific Journal of Tropical Biomedicine* 2: S1509-S1519.
- 71 Ahmed SM, Manoj J (2012) Antiobesity activity of *Coccinia indica* in female rats fed with cafeteria and atherogenic diets. *Der Pharmacia Lett* 4: 1480-1485.

- 72 Choi HK, Won EK, Jang YP, Choung SY (2013) Antiobesity Effect of *Codonopsis lanceolata* in High-Calorie/High-Fat-Diet-Induced Obese Rats. *Evid Based Complement Alternat Med* 2013: 210297.
- 73 Panchal SK, Poudyal H, Waanders J, Brown L (2012) Coffee extract attenuates changes in cardiovascular and hepatic structure and function without decreasing obesity in high-carbohydrate, high-fat diet-fed male rats. *J Nutr* 142: 690-697.
- 74 Shivaprasad HN, Gopalakrishna S, Mariyanna B, Thekkoot M, Reddy R, et al. (2014) Effect of *Coleus forskohlii* extract on cafeteria diet-induced obesity in rats. *Pharmacognosy Res* 6: 42-45.
- 75 Shivaprasad HN (2014) Ethnopharmacological and phytomedical knowledge of *Coleus forskohlii*: An approach towards its safety and therapeutic value. *Oriental Pharmacy and Experimental Medicine* 14: 301-312.
- 76 Wang L, Yamasaki M, Katsube T, Sun X, Yamasaki Y, et al. (2011) Antiobesity effect of polyphenolic compounds from *molokheiya* (*Corchorus olitorius* L.) leaves in LDL receptor-deficient mice. *Eur J Nutr* 50: 127-133.
- 77 Araldi RP, Rechiutti BM, Mendes TB, Ito ET, Souza EB (2014) Mutagenic potential of *Cordia ecalyculata* alone and in association with *Spirulina maxima* for their evaluation as candidate anti-obesity drugs. *Genet Mol Res* 13: 5207-5220.
- 78 Kim HL (2013) Corni Fructus Containing Formulation Attenuates Weight Gain in Mice with Diet-Induced Obesity and Regulates Adipogenesis through AMPK. *Evid Based Complement Alternat Med* 2013: 423741.
- 79 Bidkar JS, Ghanwat DD, Bhujbal MD, Dama GY (2012) Anti-hyperlipidemic activity of *Cucumis melo* fruit peel extracts in high cholesterol diet induced hyperlipidemia in rats. *J Complement Integr Med* 9: Article 22.
- 80 Pande S, Srinivasan K (2012) Potentiation of hypolipidemic and weight-reducing influence of dietary tender cluster bean (*Cyamopsis tetragonoloba*) when combined with capsaicin in high-fat-fed rats. *J Agric Food Chem* 60: 8155-8162.
- 81 Yang DJ, Chang YY, Hsu CL, Liu CW, Lin YL, et al. (2010) Antiobesity and hypolipidemic effects of polyphenol-rich longan (*Dimocarpus longans* Lour.) flower water extract in hypercaloric-dietary rats. *J Agric Food Chem* 58: 2020-2027.
- 82 Song MY, Lv N, Kim EK, Kwon KS, Yoo YB, et al. (2009) Antiobesity activity of aqueous extracts of *Rhizoma Dioscoreae Tokoronis* on high-fat diet-induced obesity in mice. *J Med Food* 12: 304-309.
- 83 Hirata T (2014) Chapter 8 - The Chemistry and Bioactivity of *Eucommia ulmoides* Oliver Leaves, in *Studies in Natural Products Chemistry*, R. Atta ur, Editor 225-260.
- 84 Lee TN (2013) The principle of symmetry in acupuncture and its clinical applications. *Am J Chin Med* 41: 1223-1231.
- 85 Ibarra A, Bai N, He K, Bily A, Cases J, et al. (2011) *Fraxinus excelsior* seed extract *FraxiPurea*,[®] limits weight gains and hyperglycemia in high-fat diet-induced obese mice. *Phytomedicine* 18: 479-485.
- 86 Altiner A (2012) Effect of the antiobesity agent *garcinia cambogia* extract on serum lipoprotein (a), apolipoproteins a1 and b, and total cholesterol levels in female rats fed atherogenic diet. *The Journal of Animal and Plant Sciences* 22: 872-877.
- 87 Márquez F, Babio N, Bulló M, Salas-Salvadó J (2012) Evaluation of the safety and efficacy of hydroxycitric acid or *Garcinia cambogia* extracts in humans. *Crit Rev Food Sci Nutr* 52: 585-594.
- 88 Sung YY, Yoon T, Yang WK, Kim SJ, Kim HK (2011) Anti-obesity effects of *Geranium thunbergii* extract via improvement of lipid metabolism in high-fat diet-induced obese mice. *Mol Med Rep* 4: 1107-1113.
- 89 Kim HJ (2014) The inhibitory effect of saponin derived from *Cheonggukjang* on adipocyte differentiation *In vitro*. *Food Science and Biotechnology* 23: 1273-1278.
- 90 Singh BP, Vij S, Hati S (2014) Functional significance of bioactive peptides derived from soybean. *Peptides* 54: 171-179.
- 91 Kumar V, Bhandari U, Tripathi CD, Khanna G (2012) Evaluation of antiobesity and cardioprotective effect of *Gymnema sylvestre* extract in murine model. *Indian J Pharmacol* 44: 607-613.
- 92 Kumar V, Bhandari U, Tripathi CD, Khanna G (2013) Anti-obesity effect of *Gymnema sylvestre* extract on high fat diet-induced obesity in Wistar rats. *Drug Res (Stuttg)* 63: 625-632.
- 93 Reddy RM, Latha PB, Vijaya T, Rao DS (2012) The saponin-rich fraction of a *Gymnema sylvestre* R. Br. aqueous leaf extract reduces cafeteria and high-fat diet-induced obesity. *Z Naturforsch C* 67: 39-46.
- 94 Karthik M, Gayathri C (2013) Effect of ethanolic extract of *Hibiscus cannabinus* leaf on high cholesterol diet induced obesity in female albino rats. *Asian Journal of Pharmaceutical and Clinical Research. Asian J Pharm Clin Res* 6: 65-67.
- 95 Patel S (2014) *Hibiscus sabdariffa*: An ideal yet under-exploited candidate for nutraceutical applications. *Biomedicine & Preventive Nutrition* 4: 23-27.
- 96 Villalpando-Arteaga EV, Mendieta-Condado E, Esquivel-Solís H, Canales-Aguirre AA, Gálvez-Gastélum FJ, et al. (2013) *Hibiscus sabdariffa* L. aqueous extract attenuates hepatic steatosis through down-regulation of PPAR- β and SREBP-1c in diet-induced obese mice. *Food Funct* 4: 618-626.
- 97 Subash AK, Augustine A (2013) Hypolipidaemic effects of methanol extract of *Holoptelea integrifolia* (Roxb.) Planchon bark in diet-induced obese rats. *Appl Biochem Biotechnol* 169: 546-553.
- 98 Sumiyoshi M, Kimura Y (2013) Hop (*Humulus lupulus* L.) extract inhibits obesity in mice fed a high-fat diet over the long term. *Br J Nutr* 109: 162-172.
- 99 Yui K, Kiyofuji A, Osada K (2014) Effects of xanthohumol-rich extract from the hop on fatty acid metabolism in rats fed a high-fat diet. *J Oleo Sci* 63: 159-168.
- 100 Adeneye AA, Adeyemi OO, Agbaje EO (2010) Anti-obesity and antihyperlipidaemic effect of *Hunteria umbellata* seed extract in experimental hyperlipidaemia. *J Ethnopharmacol* 130: 307-314.
- 101 García-de la Cruz L, Galvan-Goiz Y, Caballero-Caballero S, Zamudio S, Alfaro A, et al. (2013) *Hypericum silenoides* Juss. and *Hypericum philonotis* Cham. & Schlecht. extracts: in-vivo hypolipidaemic and weight-reducing effects in obese rats. *J Pharm Pharmacol* 65: 591-603.
- 102 Arçari DP, Bartchewsky W, dos Santos TW, Oliveira KA, Funck A, et al. (2009) Antiobesity effects of yerba maté extract (*Ilex paraguariensis*) in high-fat diet-induced obese mice. *Obesity (Silver Spring)* 17: 2127-2133.
- 103 Arçari DP, Santos JC, Gambero A, Ribeiro ML (2013) The in vitro and in vivo effects of yerba mate (*Ilex paraguariensis*) extract on adipogenesis. *Food Chem* 141: 809-815.
- 104 Gosmann G, Barlette AG, Dhamer T, Arçari DP, Santos JC, et al. (2012) Phenolic compounds from maté (*Ilex paraguariensis*) inhibit adipogenesis in 3T3-L1 preadipocytes. *Plant Foods Hum Nutr* 67: 156-161.

- 105 Resende PE, Verza SG, Kaiser S, Gomes LF, Kucharski LC, et al. (2012) The activity of mate saponins (*Ilex paraguariensis*) in intra-abdominal and epididymal fat, and glucose oxidation in male Wistar rats. *J Ethnopharmacol* 144: 735-740.
- 106 Ju JH, Yoon HS, Park HJ, Kim MY, Shin HK, et al. (2011) Anti-obesity and antioxidative effects of purple sweet potato extract in 3T3-L1 adipocytes in vitro. *J Med Food* 14: 1097-1106.
- 107 Jang WS, Choung SY (2013) Antiobesity Effects of the Ethanol Extract of *Laminaria japonica* Areshoung in High-Fat-Diet-Induced Obese Rat. *Evid Based Complement Alternat Med* 2013: 492807.
- 108 Oh J (2015) The herbal composition GGEx18 from *Laminaria japonica*, *Rheum palmatum*, and *Ephedra sinica* inhibits visceral obesity and insulin resistance by upregulating visceral adipose genes involved in fatty acid oxidation. *Pharm Biol* 53: 301-312.
- 109 Harbilas D (2012) *Larix laricina*, an Antidiabetic Alternative Treatment from the Cree of Northern Quebec Pharmacopoeia, Decreases Glycemia and Improves Insulin Sensitivity In Vivo. *Evid Based Complement Alternat Med* 2012: 296432.
- 110 Cha KH (2012) Inhibition of gastrointestinal lipolysis by green tea, coffee, and gomchui (*Ligularia fischeri*) tea polyphenols during simulated digestion. *J Agric Food Chem* 60: 7152-7157.
- 111 Liu Q, Kim SH, Kim SB, Jo YH, Kim ES, et al. (2014) Anti-obesity effect of (8-E)-niizhenide, a secoiridoid from *Ligustrum lucidum*, in high-fat diet-induced obese mice. *Nat Prod Commun* 9: 1399-1401.
- 112 Zhou CJ, Huang S, Liu JQ, Qiu SQ, Xie FY, et al. (2013) Sweet tea leaves extract improves leptin resistance in diet-induced obese rats. *J Ethnopharmacol* 145: 386-392.
- 113 Gwon SY (2012) *Lithospermum erythrorhizon* suppresses high-fat diet-induced obesity, and acetylshikonin, a main compound of *Lithospermum erythrorhizon*, inhibits adipocyte differentiation. *J Agric Food Chem* 60: 9089-9096.
- 114 Ko BS (2013) *Prunus mume* and *Lithospermum erythrorhizon* Extracts Synergistically Prevent Visceral Adiposity by Improving Energy Metabolism through Potentiating Hypothalamic Leptin and Insulin Signalling in Ovariectomized Rats. *Evid Based Complement Alternat Med* 2013: 750986.
- 115 Saminathan M (2013) Systematic review on anticancer potential and other health beneficial pharmacological activities of novel medicinal plant *Morinda citrifolia* (Noni). *Int J Pharmacol* 9: 462-492.
- 116 Yang Y, Yang X, Xu B, Zeng G, Tan J, et al. (2014) Chemical constituents of *Morus alba* L. and their inhibitory effect on 3T3-L1 preadipocyte proliferation and differentiation. *Fitoterapia* 98: 222-227.
- 117 Wu T, Qi X, Liu Y, Guo J, Zhu R, et al. (2013) Dietary supplementation with purified mulberry (*Morus australis* Poir) anthocyanins suppresses body weight gain in high-fat diet fed C57BL/6 mice. *Food Chem* 141: 482-487.
- 118 Lim HH, Lee SO, Kim SY, Yang SJ, Lim Y (2013) Anti-inflammatory and antiobesity effects of mulberry leaf and fruit extract on high fat diet-induced obesity. *Exp Biol Med (Maywood)* 238: 1160-1169.
- 119 Na HN, Park S, Jeon HJ, Kim HB, Nam JH (2014) Reduction of adenovirus 36-induced obesity and inflammation by mulberry extract. *Microbiol Immunol* 58: 303-306.
- 120 Peng CH, Liu LK, Chuang CM, Chyau CC, Huang CN, et al. (2011) Mulberry water extracts possess an anti-obesity effect and ability to inhibit hepatic lipogenesis and promote lipolysis. *J Agric Food Chem* 59: 2663-2671.
- 121 Birari R, Javia V, Bhutani KK (2010) Antiobesity and lipid lowering effects of *Murraya koenigii* (L.) Spreng leaves extracts and mahanimbine on high fat diet induced obese rats. *Fitoterapia* 81: 1129-1133.
- 122 Nascimento OV, Boleti AP, Yuyama LK, Lima ES (2013) Effects of diet supplementation with Camu-camu (*Myrciaria dubia* HBK McVaugh) fruit in a rat model of diet-induced obesity. *An Acad Bras Cienc* 85: 355-363.
- 123 Ahmed AH (2013) Flavonoid Content and Antiobesity Activity of Leaves of *Myrtus communis*. *Asian Journal of Chemistry* 25: 6818-6826.
- 124 Ahn JH, Kim ES, Lee C, Kim S, Cho SH, et al. (2013) Chemical constituents from *Nelumbo nucifera* leaves and their anti-obesity effects. *Bioorg Med Chem Lett* 23: 3604-3608.
- 125 Du H (2010) Antiobesity and hypolipidemic effects of lotus leaf hot water extract with taurine supplementation in rats fed a high fat diet. *J Biomed Sci* 17: S42.
- 126 Velusami CC, Agarwal A, Mookambeswaran V (2013) Effect of *Nelumbo nucifera* Petal Extracts on Lipase, Adipogenesis, Adipolysis, and Central Receptors of Obesity. *Evid Based Complement Alternat Med* 2013: 145925.
- 127 You JS, Lee YJ, Kim KS, Kim SH, Chang KJ (2014) Anti-obesity and hypolipidaemic effects of *Nelumbo nucifera* seed ethanol extract in human pre-adipocytes and rats fed a high-fat diet. *J Sci Food Agric* 94: 568-575.
- 128 Zhao YX, Liang WJ, Fan HJ, Ma QY, Tian WX, et al. (2011) Fatty acid synthase inhibitors from the hulls of *Nephelium lappaceum* L. *Carbohydr Res* 346: 1302-1306.
- 129 Zar Kalai F, Han J, Ksouri R, Abdelly C, Isoda H (2014) Oral administration of *Nitraria retusa* ethanolic extract enhances hepatic lipid metabolism in db/db mice model 'BKS.Cg-Dock7(m)/+Lepr(db/J)' through the modulation of lipogenesis-lipolysis balance. *Food Chem Toxicol* 72: 247-256.
- 130 Poudyal H, Campbell F, Brown L (2010) Olive leaf extract attenuates cardiac, hepatic, and metabolic changes in high carbohydrate-, high fat-fed rats. *J Nutr* 140: 946-953.
- 131 Vogel P, Kasper Machado I, Garavaglia J, Zani VT, de Souza D, et al. (2014) Polyphenols benefits of olive leaf (*Olea europaea* L) to human health. *Nutr Hosp* 31: 1427-1433.
- 132 Choi YJ, Park SY, Kim JY, Won KC, Kim BR, et al. (2013) Combined treatment of betulinic acid, a PTP1B inhibitor, with *Orthosiphon stamineus* extract decreases body weight in high-fat-fed mice. *J Med Food* 16: 2-8.
- 133 Lim S, Yoon JW, Choi SH, Cho BJ, Kim JT, et al. (2009) Effect of ginsam, a vinegar extract from *Panax ginseng*, on body weight and glucose homeostasis in an obese insulin-resistant rat model. *Metabolism* 58: 8-15.
- 134 Park J, Jeon YD, Kim HL, Lim H, Jung Y, et al. (2013) Interaction of *Veratrum nigrum* with *Panax ginseng* against Obesity: A Sang-ban Relationship. *Evid Based Complement Alternat Med* 2013: 732126.
- 135 Kim MJ, Kim HK (2009) *Perilla* leaf extract ameliorates obesity and dyslipidemia induced by high-fat diet. *Phytother Res* 23: 1685-1690.
- 136 Watanabe T, Hata K, Hiwatashi K, Hori K, Suzuki N, et al. (2010) Suppression of murine preadipocyte differentiation and reduction of visceral fat accumulation by a *Petasites japonicus* ethanol extract in mice fed a high-fat diet. *Biosci Biotechnol Biochem* 74: 499-503.

- 137 Carai MA, Fantini N, Loi B, Colombo G, Gessa GL, et al. (2011) Multiple cycles of repeated treatments with a *Phaseolus vulgaris* dry extract reduce food intake and body weight in obese rats. *Br J Nutr* 106: 762-768.
- 138 Higa JK, Liu W, Berry MJ, Panee J (2011) Supplement of bamboo extract lowers serum monocyte chemoattractant protein-1 concentration in mice fed a diet containing a high level of saturated fat. *Br J Nutr* 106: 1810-1813.
- 139 Ko HS (2013) Essential Oil of *Pinus koraiensis* Exerts Antiobesic and Hypolipidemic Activity via Inhibition of Peroxisome Proliferator-Activated Receptors Gamma Signaling. *Evid Based Complement Alternat Med* 2013: 947037.
- 140 Darusman LK, Batubara II (2014) U.M. R., Fractionation of active components from *Piper cf. fragile* essential oil as aromatherapy for anti-obesity. *Acta Horticulturae* 1023: 23-28.
- 141 Suhana Mohd Ramli E, Nirwana Soelaiman I, Othman F, Ahmad F, Nazrun Shuib A, et al. (2012) The effects of piper sarmentosum water extract on the expression and activity of 11 β -hydroxysteroid dehydrogenase type 1 in the bones with excessive glucocorticoids. *Iran J Med Sci* 37: 39-46.
- 142 Zhao HL, Harding SV, Marinangeli CP, Kim YS, Jones PJ (2008) Hypocholesterolemic and anti-obesity effects of saponins from *Platycodon grandiflorum* in hamsters fed atherogenic diets. *J Food Sci* 73: H195-200.
- 143 Sung YY, Yoon T, Yang WK, Kim SJ, Kim DS, et al. (2013) The Antiobesity Effect of *Polygonum aviculare* L. Ethanol Extract in High-Fat Diet-Induced Obese Mice. *Evid Based Complement Alternat Med* 2013: 626397.
- 144 Harbilas D (2013) *Populus balsamifera* Extract and Its Active Component Salicortin Reduce Obesity and Attenuate Insulin Resistance in a Diet-Induced Obese Mouse Model. *Evid Based Complement Alternat Med* 2013: 172537.
- 145 Mali PY, Bigoniya P, Panchal SS, Muchhandi IS (2013) Anti-obesity activity of chloroform-methanol extract of *Premna integrifolia* in mice fed with cafeteria diet. *J Pharm Bioallied Sci* 5: 229-236.
- 146 Kamiya T, Sameshima-Kamiya M, Nagamine R, Tsubata M, Ikeguchi M, et al. (2012) The crude extract from *puerariae* flower exerts antiobesity and antifatty liver effects in high-fat diet-induced obese mice. *Evid Based Complement Alternat Med* 2012: 272710.
- 147 Adnyana IK (2014) Anti-obesity effect of the pomegranate leaves ethanol extract (*Punica granatum* L.) in high-fat diet induced mice. *International Journal of Pharmacy and Pharmaceutical Sciences* 6: 626-631.
- 148 Viladomiu M, Hontecillas R, Lu P, Bassaganya-Riera J (2013) Preventive and prophylactic mechanisms of action of pomegranate bioactive constituents. *Evid Based Complement Alternat Med* 2013: 789764.
- 149 Shin SS, Park D, Lee HY, Hong Y, Choi J, et al. (2012) The herbal composition GGEx18 from *Laminaria japonica*, *Rheum palmatum*, and *Ephedra sinica* reduces obesity via skeletal muscle AMPK and PPAR α . *Pharm Biol* 50: 506-515.
- 150 Zhang Y, Fan S, Hu N, Gu M, Chu C, et al. (2012) Rhein Reduces Fat Weight in db/db Mouse and Prevents Diet-Induced Obesity in C57Bl/6 Mouse through the Inhibition of PPAR γ Signaling. *PPAR Res* 2012: 374936.
- 151 Romo Vaquero M, Yáñez-Gascón MJ, García Villalba R, Larrosa M, Fromentin E, et al. (2012) Inhibition of gastric lipase as a mechanism for body weight and plasma lipids reduction in Zucker rats fed a rosemary extract rich in carnolic acid. *PLoS One* 7: e39773.
- 152 Kaume L, Howard LR, Devareddy L (2012) The blackberry fruit: a review on its composition and chemistry, metabolism and bioavailability, and health benefits. *J Agric Food Chem* 60: 5716-5727.
- 153 Suneetha DS, Divya TB, Ali F (2013) Antiobesity values of methanolic extract of *Sapindus emarginatus* on monosodium glutamate induced model in rats. *International Journal of Pharmacognosy and Phytochemical Research* 5: 267-270.
- 154 Kang SI, Shin HS, Kim HM, Hong YS, Yoon SA, et al. (2012) Anti-obesity properties of a *Sasa quelpaertensis* extract in high-fat diet-induced obese mice. *Biosci Biotechnol Biochem* 76: 755-761.
- 155 Kang SW, Kang SI, Shin HS, Yoon SA, Kim JH, et al. (2013) *Sasa quelpaertensis* Nakai extract and its constituent p-coumaric acid inhibit adipogenesis in 3T3-L1 cells through activation of the AMPK pathway. *Food Chem Toxicol* 59: 380-385.
- 156 Park HJ (2012) Anti-obesity effect of *Schisandra chinensis* in 3T3-L1 cells and high fat diet-induced obese rats. *Food Chemistry* 134: 227-234.
- 157 Kumar D, Karmase A, Jagtap S, Shekhar R, Bhutani KK (2013) Pancreatic lipase inhibitory activity of cassiamin A, a bianthraquinone from *Cassia siamea*. *Nat Prod Commun* 8: 195-198.
- 158 Supriya KSK, Vrushabendra Swamy BM, Archana Swamy P, Vishwanath KM1 Anti-Obesity Activity of *Shorea robusta* G. Leaves Extract on Monosodium Glutamate Induced Obesity in Albino Rats. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*.
- 159 Thounaojam MC, Jadeja RN, Ramani UV, Devkar RV, Ramachandran AV (2011) *Sida rhomboidea*. Roxb leaf extract down-regulates expression of PPAR γ 2 and leptin genes in high fat diet fed C57BL/6J Mice and retards in vitro 3T3L1 pre-adipocyte differentiation. *Int J Mol Sci* 12: 4661-4677.
- 160 Choi KM, Lee YS, Shin DM, Lee S, Yoo KS, et al. (2013) Green tomato extract attenuates high-fat-diet-induced obesity through activation of the AMPK pathway in C57BL/6 mice. *J Nutr Biochem* 24: 335-342.
- 161 Perveen R (2015) Tomato (*Solanum lycopersicum*) Carotenoids and Lycopenes Chemistry; Metabolism, Absorption, Nutrition, and Allied Health Claims-A Comprehensive Review. *Crit Rev Food Sci Nutr* 55: 919-929.
- 162 Jung CH, Ahn J, Jeon TI, Kim TW, Ha TY (2012) *Syzygium aromaticum* ethanol extract reduces high-fat diet-induced obesity in mice through downregulation of adipogenic and lipogenic gene expression. *Exp Ther Med* 4: 409-414.
- 163 Azman KF, Amom Z, Azlan A, Esa NM, Ali RM, et al. (2012) Antiobesity effect of *Tamarindus indica* L. pulp aqueous extract in high-fat diet-induced obese rats. *J Nat Med* 66: 333-342.
- 164 Jindal V, Dhingra D, Sharma S, Parle M, Harna RK (2011) Hypolipidemic and weight reducing activity of the ethanolic extract of *Tamarindus indica* fruit pulp in cafeteria diet- and sulphuride-induced obese rats. *J Pharmacol Pharmacother* 2: 80-84.
- 165 Sasidharan SR, Joseph JA, Anandakumar S, Venkatesan V, Madhavan CN, et al. (2014) Ameliorative potential of *Tamarindus indica* on high fat diet induced nonalcoholic fatty liver disease in rats. *ScientificWorldJournal* 2014: 507197.
- 166 Alvala R, Alvala M, Sama V, Dharmarajan S, Ullas JV, et al. (2013) Scientific evidence for traditional claim of anti-obesity activity of

- Tecomella undulata bark. *J Ethnopharmacol* 148: 441-448.
- 167 Song Y, Park HJ, Kang SN, Jang SH, Lee SJ, et al. (2013) Blueberry peel extracts inhibit adipogenesis in 3T3-L1 cells and reduce high-fat diet-induced obesity. *PLoS One* 8: e69925.
- 168 Kitano-Okada T, Ito A, Koide A, Nakamura Y, Han KH, et al. (2012) Anti-obesity role of adzuki bean extract containing polyphenols: in vivo and in vitro effects. *J Sci Food Agric* 92: 2644-2651.
- 169 Son Y, Nam JS, Jang MK, Jung IA, Cho SI, et al. (2013) Antiobesity activity of *Vigna nakashimae* extract in high-fat diet-induced obesity. *Biosci Biotechnol Biochem* 77: 332-338.
- 170 Jung HY, Kim YH, Kim IB, Jeong JS, Lee JH, et al. (2013) The Korean Mistletoe (*Viscum album coloratum*) Extract Has an Antiobesity Effect and Protects against Hepatic Steatosis in Mice with High-Fat Diet-Induced Obesity. *Evid Based Complement Alternat Med* 2013: 168207.
- 171 Hsu HM (2014) *Vitis thunbergii* supplementation demonstrates an anti-obesity effect in developing obese mice. *European Journal of Integrative Medicine* 6: 581-587.
- 172 Kim YM, Lee EW, Eom SH, Kim TH (2014) Pancreatic lipase inhibitory stilbenoids from the roots of *Vitis vinifera*. *Int J Food Sci Nutr* 65: 97-100.
- 173 Jeong YS (2012) Grape skin extract reduces adipogenesis- and lipogenesis-related gene expression in 3T3-L1 adipocytes through the peroxisome proliferator-activated receptor-gamma signaling pathway. *Nutr Res* 32: 514-521.
- 174 Jeong YS (2011) Anti-obesity effect of grape skin extract in 3T3-L1 adipocytes. *Food Sci and Biotechnology* 20: 635-642.
- 175 Kang JS, Lee WK, Lee CW, Yoon WK, Kim N, et al. (2011) Improvement of high-fat diet-induced obesity by a mixture of red grape extract, soy isoflavone and L-carnitine: implications in cardiovascular and non-alcoholic fatty liver diseases. *Food Chem Toxicol* 49: 2453-2458.
- 176 Kim H (2014) Dietary supplementation of chardonnay grape seed flour reduces plasma cholesterol concentration, hepatic steatosis, and abdominal fat content in high-fat diet-induced obese hamsters. *J Agric Food Chem* 62: 1919-1925.
- 177 Oh J (2013) Antioxidant and antiobesity activities of seed extract from campbell early grape as a functional ingredient. *Journal of Food Processing and Preservation* 37: 291-298.
- 178 Zhang XH, Huang B, Choi SK, Seo JS (2012) Anti-obesity effect of resveratrol-amplified grape skin extracts on 3T3-L1 adipocytes differentiation. *Nutr Res Pract* 6: 286-293.
- 179 Gwon SY, Ahn JY, Kim TW, Ha TY (2012) *Zanthoxylum piperitum* DC ethanol extract suppresses fat accumulation in adipocytes and high fat diet-induced obese mice by regulating adipogenesis. *J Nutr Sci Vitaminol (Tokyo)* 58: 393-401.
- 180 Deshpande MS (2013) Anti-obesity activity of *Ziziphus mauritiana*: A potent pancreatic lipase inhibitor. *Asian Journal of Pharmaceutical and Clinical Research* 6: 168-173.
- 181 Sung YY, Kim DS, Choi G, Kim SH, Kim HK (2014) Dohaekseunggi-tang extract inhibits obesity, hyperlipidemia, and hypertension in high-fat diet-induced obese mice. *BMC Complement Alternat Med* 14: 372.
- 182 Ahn EK, Lee JA, Seo DW, Hong SS, Oh JS (2012) 1 β -Hydroxy-2-oxopomolic acid isolated from *Agrimonia pilosa* extract inhibits adipogenesis in 3T3-L1 cells. *Biol Pharm Bull* 35: 643-649.
- 183 Lee M, Song JY, Chin YW, Sung SH (2013) Anti-adipogenic diarylheptanoids from *Alnus hirsuta* f. *sibirica* on 3T3-L1 cells. *Bioorg Med Chem Lett* 23: 2069-2073.
- 184 Park JA (2014) Anti-oxidative and anti-obesity effects of *Amomum cardamomum* L. Extract. *Korean Journal of Microbiology and Biotechnology* 42: 249-257.
- 185 Bansal V (2014) Phytochemical, Pharmacological Profile and Commercial Utility of Tropically Distributed Plant *Bauhinia variegata*. *Global Journal of Pharmacology* 8: 196-205.
- 186 Liang CH (2013) Brazilein from *Caesalpinia sappan* L. Antioxidant Inhibits Adipocyte Differentiation and Induces Apoptosis through Caspase-3 Activity and Anthelmintic Activities against *Hymenolepis nana* and *Anisakis simplex*. *Evid Based Complement Alternat Med* 2013: 864892.
- 187 Kim GS, Park HJ, Woo JH, Kim MK, Koh PO, et al. (2012) Citrus aurantium flavonoids inhibit adipogenesis through the Akt signaling pathway in 3T3-L1 cells. *BMC Complement Alternat Med* 12: 31.
- 188 Stohs SJ, Preuss HG, Shara M (2012) A review of the human clinical studies involving Citrus aurantium (bitter orange) extract and its primary protoalkaloid p-synephrine. *Int J Med Sci* 9: 527-538.
- 189 Choi JS, Kim JH, Ali MY, Min BS, Kim GD, et al. (2014) *Coptis chinensis* alkaloids exert anti-adipogenic activity on 3T3-L1 adipocytes by downregulating C/EBP- α and PPAR- γ . *Fitoterapia* 98: 199-208.
- 190 Lee J, Kim D, Choi J, Choi H, Ryu JH, et al. (2012) Dehydrodiconiferyl alcohol isolated from *Cucurbita moschata* shows anti-adipogenic and anti-lipogenic effects in 3T3-L1 cells and primary mouse embryonic fibroblasts. *J Biol Chem* 287: 8839-8851.
- 191 Bradford PG (2013) Curcumin and obesity. *Biofactors* 39: 78-87.
- 192 Ho JN (2013) Standardized Ethanol Extract of *Curcuma longa* L. Fermented by *Aspergillus oryzae* Promotes Lipolysis via Activation of cAMP-Dependent PKA in 3T3-L1 Adipocytes. *Journal of Food Biochemistry* 37: 595-603.
- 193 Dudhia Z, Louw J, Muller C, Joubert E, de Beer D, et al. (2013) *Cyclopia maculata* and *Cyclopia subternata* (honeybush tea) inhibits adipogenesis in 3T3-L1 pre-adipocytes. *Phytomedicine* 20: 401-408.
- 194 G RJN (2012) A Study on Ethanolic Extract of *Dalbergia sissoo* roxb. Leaves for Pancreatic Lipase Inhibition. *Journal of Pharmacy and Technology* 5: 497-500.
- 195 Yang MH, Chin YW, Chae HS, Yoon KD, Kim J (2014) Anti-adipogenic constituents from *Dioscorea opposita* in 3T3-L1 cells. *Biol Pharm Bull* 37: 1683-1688.
- 196 Park HJ, Chung BY, Lee MK, Song Y, Lee SS, et al. (2012) Centipede grass exerts anti-adipogenic activity through inhibition of C/EBP β , C/EBP α , and PPAR γ expression and the AKT signaling pathway in 3T3-L1 adipocytes. *BMC Complement Alternat Med* 12: 230.
- 197 Kang H, Koppula S (2014) *Houttuynia cordata* attenuates lipid accumulation via activation of AMP-activated protein kinase signaling pathway in HepG2 cells. *Am J Chin Med* 42: 651-664.
- 198 Miyata M, Koyama T, Yazawa K (2010) Water extract of *Houttuynia cordata* Thunb. leaves exerts anti-obesity effects by inhibiting fatty acid and glycerol absorption. *J Nutr Sci Vitaminol (Tokyo)* 56: 150-156.
- 199 Ngondi JL (2009) IGOB131, a novel seed extract of the West African plant *Irvingia gabonensis*, significantly reduces body weight and improves metabolic parameters in overweight humans in a randomized double-blind placebo controlled investigation. *Lipids Health Dis* 8: 7.

- 200 Kim YS, Lee YM, Kim H, Kim J, Jang DS, et al. (2010) Anti-obesity effect of *Morus bombycis* root extract: anti-lipase activity and lipolytic effect. *J Ethnopharmacol* 130: 621-624.
- 201 Roh C, Jung U (2012) *Nepeta japonica* Maximowicz extract from natural products inhibits lipid accumulation. *J Sci Food Agric* 92: 2195-2199.
- 202 Kim HR, Kim JM, Kim MS, Hwang JK, Yang SH, et al. (2014) Inhibitory effects of *Pericarpium zanthoxyli* extract on adipocyte differentiation. *Int J Mol Med* 33: 1140-1146.
- 203 Nugara RN, Inafuku M, Iwasaki H, Oku H (2014) Partially purified *Peucedanum japonicum* Thunb extracts exert anti-obesity effects in vitro. *Nutrition* 30: 575-583.
- 204 Nugara RN, Inafuku M, Takara K, Iwasaki H, Oku H (2014) Pteryxin: a coumarin in *Peucedanum japonicum* Thunb leaves exerts antiobesity activity through modulation of adipogenic gene network. *Nutrition* 30: 1177-1184.
- 205 Ezure T, Amano S (2011) *Rubus suavissimus* S. Lee extract increases early adipogenesis in 3T3-L1 preadipocytes. *J Nat Med* 65: 247-253.
- 206 Kong CS, Seo Y (2012) Antiadipogenic activity of isohamnetin 3-O- β -D-glucopyranoside from *Salicornia herbacea*. *Immunopharmacol Immunotoxicol* 34: 907-911.
- 207 Park JA (2013) Anti-oxidative and anti-obesity activities of *Tetrapanax papyriferus* and *Siegesbeckia pubescens* extracts and their synergistic anti-obesity effects. *Korean Journal of Microbiology and Biotechnology* 41: 341-349.
- 208 Kang YH (2013) Study on antioxidative, antidiabetic and antiobesity activity of solvent fractions of *Smilax china* L. leaf extract. *Journal of Nutrition and Health* 46: 401-409.
- 209 Gao QH, Wu CS, Wang M (2013) The jujube (*Zizyphus jujuba* Mill.) fruit: a review of current knowledge of fruit composition and health benefits. *J Agric Food Chem* 61: 3351-3363.
- 210 Mostafa UE, Labban L (2013) The Effect of *Zizyphus jujuba* on Serum Lipid Profile and Some Anthropometric Measurements. *Pakistan Journal of Nutrition* 12: 538-543.
- 211 Kubota H, Morii R, Kojima-Yuasa A, Huang X, Yano Y, et al. (2009) Effect of *Zizyphus jujuba* extract on the inhibition of adipogenesis in 3T3-L1 preadipocytes. *Am J Chin Med* 37: 597-608.
- 212 Ho JN, Son ME, Lim WC, Lim ST, Cho HY (2012) Anti-obesity effects of germinated brown rice extract through down-regulation of lipogenic genes in high fat diet-induced obese mice. *Biosci Biotechnol Biochem* 76: 1068-1074.
- 213 Kazemipoor M, Radzi CW, Hajifaraji M, Haerian BS, Mosaddegh MH, et al. (2013) Antiobesity effect of caraway extract on overweight and obese women: a randomized, triple-blind, placebo-controlled clinical trial. *Evid Based Complement Alternat Med* 2013: 928582.
- 214 Oben J, Kuate D, Agbor G, Momo C, Talla X (2006) The use of a *Cissus quadrangularis* formulation in the management of weight loss and metabolic syndrome. *Lipids Health Dis* 5: 24.
- 215 Park SH, Huh TL, Kim SY, Oh MR, Tirupathi Pichiah PB, et al. (2014) Antiobesity effect of *Gynostemma pentaphyllum* extract (actiponin): a randomized, double-blind, placebo-controlled trial. *Obesity (Silver Spring)* 22: 63-71.
- 216 Najmi A, Nasiruddin M, Khan RA, Haque SF (2008) Effect of *Nigella sativa* oil on various clinical and biochemical parameters of insulin resistance syndrome. *Int J Diabetes Dev Ctries* 28: 11-14.
- 217 Razavi BM, Hosseinzadeh H (2014) A review of the effects of *Nigella sativa* L. and its constituent, thymoquinone, in metabolic syndrome. *J Endocrinol Invest* 37: 1031-1040.
- 218 Ofner M, Tomaschitz A, Wonisch M, Litscher G (2013) Complementary treatment of obesity and overweight with *Salacia reticulata* and vitamin D. *Int J Vitam Nutr Res* 83: 216-223.
- 219 Chevassus H, Gaillard JB, Farret A, Costa F, Gabillaud I, et al. (2010) A fenugreek seed extract selectively reduces spontaneous fat intake in overweight subjects. *Eur J Clin Pharmacol* 66: 449-455.
- 220 Szweczyk K, Zidorn C (2014) Ethnobotany, phytochemistry, and bioactivity of the genus *Turnera* (Passifloraceae) with a focus on *damiana*--*Turnera diffusa*. *J Ethnopharmacol* 152: 424-443.
- 221 Andersen T, Fogh J (2001) Weight loss and delayed gastric emptying following a South American herbal preparation in overweight patients. *J Hum Nutr Diet* 14: 243-250.
- 222 Anastasia UU (2010) Anti-Carcinoma, Anti-Obesity, Antidiabetic and Immune Defence Effects of *Vernonia amygdalina* Leaf Extract and Leaf Powder, in Two Human Cancer Patients. *American Journal of Immunology* 6: 50-53.
- 223 Dalla Via L, García-Argáez AN, Braga A, Martínez-Vázquez M, Grancara S, et al. (2014) An eudesman derivative from *Verbesina persicifolia* D.C. as a natural mild uncoupler in liver mitochondria. A new potential anti-obesity agent? *Curr Pharm Des* 20: 253-261.
- 224 Ahn JH, Shin E, Liu Q, Kim SB, Choi KM, et al. (2013) Secoiridoids from the stem barks of *Fraxinus rhynchophylla* with pancreatic lipase inhibitory activity. *Nat Prod Res* 27: 1132-1135.
- 225 Gurudeeban S (2012) An in silico approach of alpha-ketoglutarate dependent dioxygenase FTO inhibitors derived from *Rhizophora mucronata*. *Drug Invention Today* 4: 594-598.
- 226 Romo Vaquero M (2014) A rosemary extract enriched in carnolic acid improves circulating adipocytokines and modulates key metabolic sensors in lean Zucker rats: Critical and contrasting differences in the obese genotype. *Mol Nutr Food Res* 58: 942-953.
- 227 Qi S, Zhou D (2013) Lotus seed epicarp extract as potential antioxidant and anti-obesity additive in Chinese Cantonese Sausage. *Meat Sci* 93: 257-262.