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Review Article

HERBS AND MEDICINAL PLANTS FOR CURING OBESITY AND RELATED COMPLICATIONS: A REVIEW

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ABSTRACT

Obesity is a very common global health problem, and it is known to be linked to cardiovascular and cerebrovascular diseases. Western medical treatments for obesity have numerous drawbacks, including effects on monoamine neurotransmitters and the impending for drug abuse and addiction. The safety of these medications requires development. Herbal medicine has been used for the treatment of disease for more than 2000 years, and it has proven effectiveness. Many studies have established that herbal medicine is successful in the treatment of obesity, but the mechanisms are not clear. This article will discuss the potential effects and mechanisms of herbal medicine treatments for obesity that have been reported in the past decade.

Keywords: Obesity, Antiobesity drugs, Medicinal plants.

1. INTRODUCTION

Obesity is a metabolic disorder characterized by a surplus accretion of fat in the body due to energy intake exceeding energy disbursement [1]. Obesity is an increasingly widespread phenomenon all over the world. Body mass index (BMI) is the most frequently used gauge to appraise the degree of obesity. In 2016, the AACE (the American Association of Clinical Endocrinologists) released new diagnostic criteria of obesity based on BMI combined with obesity-related complications [2]. The latest study, which analyzed data from 68.5 million persons between 1980 and 2015, found that a total of 107.7 million children and 603.7 million adults were obese in 2015 [3]. Obesity has turn out to be a worldwide epidemic, and the trend is becoming increasingly solemn. Obesity is an autonomous risk factor for metabolic syndrome; major medical problems associated with the expansion of hypertension, type 2 diabetes (T2DM), dyslipidemia, sleep apnea, and respiratory disorders; and ultimately life-threatening cardiovascular disease (CVD), stroke, and certain types of cancers [4-6].

The numeral of obese patients is growing globally [7]. Reducing body weight by lifestyle modification is advisable, but from time to time drug involvement is necessary [8]. Obesity drugs can be divided into five categories: central appetite suppressants, digestion and absorption blockers, metabolic promoters, obesity gene product inhibitors, and other drugs for the handling of obesity [9]. On the other hand, the weight loss drugs prescribed in conventional medicine induce many adverse reactions, primarily affecting monoamine neuro-transmitters, and causing drug abuse or confidence [10]. For example, sibutramine has been reported to commonly cause adverse events, including dry mouth, insomnia, anorexia, constipation, formation of thrombi, and neurological symptoms [11, 12]. Surgery is normally used in morbidly obese patients (BMI ≥ 40 kg/m2) or patients with co morbidities, such as hypertension, diabetes, and obstructive sleep apnea [13]. Common surgical complications include infection, postoperative anastomotic fistula, deep vein thrombosis, and long-term complications such as anemia and malnutrition [14, 15]. Given the dangers of obesity and the short comings of western medicine, substitute treatments should be additional investigated. This article examines the possible role of herbal medicines in the management of obesity and summarizes the scientific confirmation reported from 2007 to 2017. In the current scenario, obesity is the most important public health problem with about 1.9 billion adults (18 years and older) universal are overweight and about 600 million of them are clinically obese [16]. Obesity is characterized by an augment in adipose cell size which is determined by the amount of fat

accumulated in the cytoplasm of adipocytes [17]. This change in the metabolism in the adipocytes is regulated by a variety of enzymes such as fatty acid synthase, lipoprotein lipase, and adipocyte fatty acid-binding protein [18]. Obesity results from a disproportion between power intake and disbursement. It is caused by altered lipid metabolic processes as well as lipogenesis and lipolysis [19]. Lipogenesis is the process that stores free fatty acids in the form of triglyceride (TG) [20]; similarly, lipolysis is the process whereby the TG stored is metabolized to free fatty acids and glycerol [21]. Obesity is accompanied by hyperlipidemia which is indicated by an abnormally high concentration of lipids in blood [22]. 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 [23]. 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 [24]. 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), PPARα, and uncoupling protein [25].

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 [26].

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 accessible in the market for the management of obesity can be divided into two major classes one being or listed, which reduces fat absorption throughout inhibition of pancreatic lipase and the second is sibutramine which is an anorectic or appetite suppressant. Both drugs have adverse effects including increased blood pressure, headache, dry mouth, insomnia, and constipation [27-30]. In 1990 Fenfluramine and Dexfenfluramine were withdrawn from the market for the reason that of heart valve damage [31]. The US FDA in 1997 approved sibutramine drugs as a management for obesity. But later in October 2010, the drug was withdrawn from the market due to increased cardiovascular events and strokes [32, 33]. In February 2011 the US FDA rejected endorsement of contrive which is a combination of bupropion/naltrexone due to concerns over potential cardiovascular risks [34]. Certain drugs have the potential for abuse such as phentermine and diethylpropion and hence are approved for short-term use [35]. 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 [36]. 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 of different plant species which is used to treat obesity [37]. The present review aimed to update data on potential antiobesity herbal plants.

2. PATHOPHYSIOLOGY OF OBESITY

The pathophysiology of obesity and overweight in life is quite complex and involves the interaction of various factors including genetic, metabolic, environmental, and behavioral variables [38]. The total amount of energy needs decreases with increasing age. Resting metabolic rate, lean body mass, physical activity, and thermal effect of food decrease with increasing age [39]. The redistribution of body fat also increases with age, which leads to increased visceral fat and decreases subcutaneous fat. On the other hand, the level of hormones and cytokines altered, leading to the formation of adipose tissue throughout life [40]. These changes include decreased testosterone and growth hormone levels and reduced responsiveness to leptin and thyroid hormone. Decreased testosterone and growth hormone levels increase fat mass and reduce lean mass [41]. Oxidative metabolism decreases in aging. On the other hand, loss of response to leptin may cause a feeling of fullness in insufficient eating [41].

A research reported that Green tea possessed higher antioxidant activity than antiobesity activity due to its high attentiveness of catechins, including epicatechins, ECG, and EGCG. It was proved that the 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 effects by depleting the lipid content in the adipocytes and by

decreasing hyperlipidemia. Similarly, galanin a compound from *Alpinia galangal* showed a noteworthy 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 diminished cholesterol by lowering the level of LDL-cholesterol. The p-synephrine compound from the plant *Citrus aurantium* showed increased metabolic rate, energy expenditure, and increase in weight loss. *Nelumbo nucifera* flavonoids showed a 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.

Table 1: Anti-obesity potential medicinal plants

Plant name	Part(s)	Mechanism	Experimental model	Ref.
Achyranthes aspera 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]
Acorus calamus Linn (Araceae)	Rhizome, roots and leaves	Ethyl acetate extarct of *A. calamus* inhibits α-glucosidase activity	Glucose challenged mice	[25]
Achyranthes bidentata 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]
Actinidia polygama 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]
Adenophora triphylla Hara (Campanulaceae)	Root	Anti-obesity effect of *A. triphylla* is mediated by increasing adipocytes adiponectin and activating pathway like AMPK, and PPAR-α, and decreasing adipokines TNF-α, GPDH, and PPAR-α	High fat diet (HFD)-C57B2/6 mice	[28,29]
Aegle marmelos Linn (Rutaceae)	Leaves	The active chemical constituents of *A. marmelos* for anti- adipogenic activity are halfordinol, ethyl ether aegeline and esculetin were responsible for the decrease in adipocyte accumulation	High fat diet induced obese male Sprague Drawly rat	[30,31]
Allium cepa Linn (Amaryllidaceae)	Peel	The mRNA levels of activating protein (AP2) is down- regulated by *A. cepa* and those of carnitine palmitoyl transferase-1 α (CPT-1α) and fatty acid binding protein 4 (FABP4) are up-regulated	High fat-fed rats, Diet-induced obese Male Sprague-Dawley rats	[32,33]
Allium fistulosum Linn (Liliaceae)	Root	Significant reduction in body weight and adipose tissue weight as well as adipocyte size.	High fat diet- induced mice	[34]
Allium nigrum Linn (Amaryllidaceae)	Bulb	Extract of *A. nigrum* 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]
Allium sativum Linn (Amaryllidaceae)	Stem, Bulb and Roots	It increases antioxidant enzymes and suppresses glutathione depletion and lipid peroxidation in hepatic tissue	High-fat diet-induced obese C57BL/6J mice	[36,37]
Alpinia galanga Linn (Zingiberaceae)	Rhizome	Galangin, the principal compontent of *A. galangal* decreases serum lipids, liver weight, lipid peroxidation and accumulation of hepatic TGs	Obesity induced in female rats by feeding cafeteria diet	[38]

Alpinia officinarum 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]
Angelica gigas Nakai (Apiaceae)	Roots	Decursin, the active constituent of *A.gigas* improves glucose tolerance	Mice fed a high-fat diet	[41]
Argyreia nervosa Bojer (Convolvulaceae)	Root	Serum contents of leptin, total cholesterol, LDL, and triglycerides are reduced by *A. speciosa*.	Diet- induced obesity rats	[42]
Artemisia iwayomogi (Compositae)	Whole Plant	It down regulates adipogenic transcription factors PPARγ2 and C/EBPα and their target genes CD36, aP2, and FAS	Mice fed a high-fat diet.	[43]
Atractylodes lancea (Thunb.) DC (Compositae)	Rhizome	It inhibits human pancreatic lipase. A new polyacetylene, *syn*-(5*E*,11*E*)-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]
Aster pseudoglehni Lim, Hyun & Shin (Asteraceae)	Leaves	It suppresses expression of adipogenesis-related genes including PPARγ, C/EBPα, and SREBP1c	High fat diet induced-male C57BL/6J mice	[45]
Bauhinia variegata Linn (Leguminosae)	Stem and root barks	Extract of *E. variegata* increases brain serotonin level and high-density lipoprotein with a concomitant decrease in total cholesterol, triglycerides and low-density lipo protein	Hypercaloric diet - induced mice	[46]
Bergenia crassifolia (L.) Fritsch (Saxifragaceae)	Leaves	Galloylbergenin derivatives 3,11-Di-O-galloylbergenin and 4,11- di-O-galloylbergenin are found to be present in *B. crassifolia* moderates anti-lipid accumulation activities	Rats with high-calorie diet-induced obesity	[47]
Boehmeria nivea (L.) Gaudich (Urticaceae)	Leaf	The extract reduces adipose tissue weight serum alkaline aminotransferase and lactate dehydrogenase activities	High fat/cholestrol diet-induced Male Sprague-Dawley rats	[48]
Boerhaavia diffusa 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	High fat diet in female Sprague-Dawley rats	[49]
Bombax ceiba L. (Malvaceae)	Stem bark	The extract and active constituent gemfibrozil reverses the effects of HFD treatment on serum parameters	Male, Wistar albino rats	[50]
Anredera cordifolia (Ten.) Steenis (Basellaceae)	Leaves	The extract suppresses lipid accumulation and down-regulates PPARγ, CCAAT/enhancer binding protein α, SREBP, and their target genes	High-fat diet-induced obese rats	[51]
Brassica rapa 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 *B. campestris*.	High fat diet induced mice	[52]
Buddleja officinalis Maxim (Scrophulariaceae)	Whole Plant	The extract reduces body weight gain induced through adipocyte differentiation	High-fat diet to C57BL/6 mice	[53]

Bursera grandiflora (Schltdl.) Engl (Burseraceae)	Roots	*B. grandiflora* exerts anti-obesity activity by decreasing in the plasma-triglyceride levels	Mice of the C57B1/6 strain with hypercaloric diet	[54]
Calanus finmarchicus (Calanidae)	Wax	*C. finmarchicus* reduces macrophage infiltration and down regulates expression of pro inflammatory genes including tumor necrosis factor-α, interleukin-6, and monocyte	C57BL/6J mice with high-fat diet	[55]
Camellia japonica L. (Theaceae)	Leaves	*C. japonica* control insulin which is a modulator of lipid synthesis via sterol regulatory element binding protein- 1c (SREBP-1c)	High fat diet induced Sprague-Dawley rats	[56]
Camellia oleifera Abel (Theaceae)	Fruit hull	Serum levels of total cholesterol and triacylglycerols are decreased but high-density lipoprotein cholesterol increased	Male ICR mice were fed a HFD	[57]
Camellia sinensis (L.) Kuntze (Theaceae)	Leaves, twigs and stems, flower buds	*C. sinesis* attenuates the gene expression of (SREBP-1c), fatty acid synthase and CCAAT/enhancer binding protein α	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]
Chenopodium quinoa Willd (Amaranthaceae)	Seeds	*C. quinoa* extract attenuate mRNA levels of several inflammation markers including monocyte chemotactic protein-1, CD68 and insulin resistance osteopontin, plasminogen activator inhibitor-1	Mice fed with standard low-fat or a high-fat diet	[65-66]
Cirsium brevicaule A. Gray (Compositae)	Leaves	*C. brevicaule* inhibits fatty acid synthase and suppress the differentiation and lipid accumulation and affecting transcription factors such as SREBP-1c, C/EBPα	C57BL/6 mice that were fed a high-fat diet	[67]
Citrus reticulata Blanco (Rutaceae)	Peel	mRNA expression levels of lipogenesis rrelated 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]
Citrus sunki (Hayata) Yu.Tanaka (Rutaceae)	Peel	Phosphorylation levels of AMPK and acetyl-CoA carboxylase are decreased	High-fat diet induced obese C57BL/6 mice	[69]
Clerodendrum phlomidis L. f. (Lamiaceae)	Roots	It nhibits pancreatic lipase activity. The extract contains β-sitosterol	High fat diet induced obesity in C57BL/6J mice	[70]
Coccinia grandis (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]
Coffea arabica L. (Rubiaceae)	Seed	*C. arabica* diet supplementation can impair glucose tolerance, hypertension, cardiovascular remodeling, and nonalcoholic fatty liver disease	High-carbohydrate, high-fat diet-fed Wistar male rats	[72-73]
Coleus forskohlii (Willd.) Briq. (Lamiaceae).	Root	*C. forskohlii* act as anti-obesisity drug by inhibiting dyslipidemia	Diet-induced obesity in rats	[74,75]
Corchorus olitorius L. (Malvaceae)	Leaves	Liver tissue gene expression of gp91phox (NOX2) involved in oxidative stress is down-regulated by *C. olitorius* and genes related to the activation of β-oxidation like PPARα and CPT1A are up-regulated by the plant	High fat diet - induced LDL receptor deficient mice	[76]

Cordia ecalyculata Vell (Boraginaceae)	Whole plant	Anti-obesity activity of the *C. ecalyculata* is medicated by anorectic central action, facilitating binding to adenosine receptors, thereby promoting an extension of adrenalin	Mice (albino, swiss strain) treated with cyclophosphamide	[77]
Cornus officinalis 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]
Cucumis melo L. (Cucurbitaceae)	Fruit peel	*C. melo* 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]
Dimocarpus longans Leenh (Sapindaceae)	Flower	By combined effect of decreased exogenous lipid absorption, normalization of hepatic PPAR-γ gene expression	Hyper caloric diet- male Sprague-Dawley rats.	[80-81]
Dioscoreae tokoronis Linn (Dioscoreaceae)	Root	It decreases triglyceride, total plasma cholesterol, and low-density lipoprotein-cholesterol.	High fat diet - induced mice	[82]
Eucommia ulmoides 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]
Fraxinus excelsior 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	[84]
Garcinia cowa 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	Female Sprague-Dawley rats fed atherogenic diet	[85]
Glycine max (L.)Merr. (Leguminosae)	Bean	Reductions glucose-6-phosphate dehydrogenase, malic enzyme, fatty acid synthetase, as well as acetyl-CoA carboxylase	Diet-induced obese mice	[86]
Gymnema sylvestre (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	[87]
Hibiscus cannabinus L. (Malvaceae)	Leaves	It decreases serum cholesterol, triglycerides, LDL-C, SGOT and SGPT activities	High cholesterol diet induced obesity in female albino rats	[88]
Hibiscus sabdariffa L. (Malvaceae)	Leaf	Promotes LXRα/ABCA1 pathway, stimulating cholesterol removal from macrophages, delaying atherosclerosis	High fat diet-induced obese C57BL/6NHsd mice	[89-90]
Holoptelea integrifolia (Roxb.) Planch. (Ulmaceae)	Bark	HMG-CoA reductase activity is reduced and cholesterol biosynthesis and increase in lecithin, cholesterolacyltransferase activity	Diet-induced obese rat	[89]
Humulus lupulus 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	[90]

Hunteria umbellata (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	High fat diet- induced rats	[90]
Hypericum philonotis 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	[91]
Hypericum silenoides 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	[92]
Ilex paraguariensis A.St.-Hil. (Aquifoliaceae)	Leaves and unripe fruits	Down-regulates expression of Creb-1 and C/EBPa, and up-regulates expression of Dlk1, Gata2, Gata3, Klf2, Lrp5, Pparc$_2$, Sfrp1, Tcf7l2, Wnt10b, and Wnt3a. The mRNA levels of PPAR-γ2 were downregulated	High fat diet- induced mice, [102-105]male Wistar rats fed diet	[93]
Ipomoea batatas (L.) Lam (Convolvulaceae)	Fruit	Expression of SREBP-l, 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	[94]
Saccharina japonica (Phaeophyceae)	Whole Plant	Expression of the fat intake-related gene ACC2 and lipogenesis-related genes are reduced	High-fat-diet-induced obese male Sprague-Dawley rats	[95]
Larix laricina (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	[96]
Ligularia fischeri (Ledeb.) Turcz. (Compositae)	Leaves	Polyphenols present in the extract exhibits antiobesity effects by inhibiting pancreatic lipase	C57BL/6 mice	[97]
Ligustrum lucidum 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	[98]
Lithospermum erythrorhizon 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	C57BL/6J mice were fed a normal or high-fat diet	[99]
Morinda citrifolia 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	[100]
Morus alba 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	High fat diet- induced mice, [116]6-week-old male hamsters	[101]
Morus australis Poir (Moraceae)	Fruit	Reduces resistance to insulin, associated with leptin	Male C57BL/6 mice fed with high-fat diet	[101]

Morus nigra L. (Moraceae)	Fruit, leaves,	Proinflammatory cytokines MCP-1 and TNF-α, plasma triglyceride, liver lipid peroxidation levels and adipocyte size are decreased	Adenovirus 36-induced obesity in mice, high-fat (HF) diet-induced obese mice	[102]
Murraya koenigii (L.) Spreng. (Rutaceae)	Leaves	Reduces body weight gain, plasma total cholesterol and triglyceride levels in mice	High fat diet -induced mice	[102]

3. CONCLUSION

Plant derived product identified from traditional medicinal plants have always proof the way for the 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 has 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 that hydrolyses dietary fats in the initial step of lipid metabolism. There have been numerous reports on other effects such as anti-oxidative stress effects which may be important in the supervision of other diseases like cardiovascular diseases and diabetes. Anti-obesity drugs are generally preferred based on high usefulness and efficacy. The active investigation of natural sources has provided new developments based on the appreciative of complex and redundant physiological mechanisms. Such investigation will lead to a safe and effective pharmacological management.

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