Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 12 [11] October 2023 :289-295

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD

REVIEW ARTICLE **OPEN ACCESS**

Recapitulation of Dietary Phytonutrients and Its Associated Implications on Obesity

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ABSTRACT
Around the world, obesity and weight gain are becoming more and more prevalent. Numerous comorbidities, including cancer, diabetes, hypertension, cardiovascular diseases, and sleep disorders, are linked to obesity. The key to successful weight loss remains appropriate lifestyle and behavioral strategies, yet upholding such a balanced living is quite difficult. Thus, recently, lifestyle modifications are getting crucial. The main drivers of obesity are insufficient physical activity, immoderate fat and sugar intake, sleep deprivation, and excessive screen time. Considering the requirement to carefully examine natural products with the potential to treat obesity. Many plant products having polyphenols, terpenoids, organosulphur, and phytosterols have been investigated for governing obesity. One of the key contributions to the industry for dietary supplements' overall revenue is the weight loss sector. This article is made to explore the role of various efficient natural products in modifying obesity and their intended target pathways.
Keywords: *Phytochemical, Obesity, Polyphenols, Terpenoids, Organosulphurs, Phytosterols.*

Received 23.07.2023 Revised 13.08.2023 Accepted 28.09.2023

INTRODUCTION

Obesity is a concealing disorder involving excessive body fat buildup, which raises the possibility of health issues. The risk of several other disorders, including cardiovascular disease (CVD), sleep deprivation, type 2 diabetes mellitus, hypertension, numerous malignancies, etc., rises as a result of this disorder. Additionally, depression and other psychological issues are brought on by obesity (1). The probability of CVD was lower in normal-weight women with diabetes than it was in obese women with diabetes, and it was also lower in normal-weight men with diabetes than it was in obese men with diabetes (2). According to World Health Organization (WHO) 2016 data, more than 1.9 billion persons worldwide who are 18 years of age and older struggle with obesity and weight increase (3). Over 4 million people die each year as a consequence of being obese, compared to the worldwide significance of illness in 2017. This indicates that the issue has reached epidemic levels (4). Because of sedentary lifestyles and bad diets, obesity has recently reached epidemic levels in both industrialized and developing countries (5,6). Numerous hormones, pro-inflammatory cytokines, and anti-inflammatory cytokines change in concentration in the blood. The levels of digestive hormones, insulin, leptin, Tumor necrosis factor -α (TNF-α), adiponectin, visfatin, Interleukin (IL-6), IL-β, etc. are found to have undergone significant variations. Obesity has several pharmacological, psychological, and physical side effects. There are two types of obesity treatment options: pharmacological and non-pharmacological. Medications that interact with gut hormones, adipose tissue-secreted chemical receptors, and medicines that work on the periphery are examples of pharmacological interventions. Surgical procedures, physical activities or exercise, and the use of phytochemicals are examples of non-pharmacological therapies (7,8).

Target pathways of phytochemicals in combating obesity

There are various mechanisms of action through which different phytochemicals work. It is explained as follows:

Increase in energy consumption

Energy homeostasis is governed by diet, an increase in energy consumption, and genetic factors. The disparity in energy homeostasis occurs because of increasing adiposity. Excessive food intake is not

balanced by energy consumption causing disparity in homeostasis. When energy input exceeds consumption, the balance is positive leading to obesity and overweight. When energy is less than consumption, the negative balance leads to weight loss (9). Energy consumption can be categorized into three classes: (a) exercise (b) requisite energy consumption (c) thermogenesis. The primary thermogenic organ in the body is brown adipose tissue (thermogenin) (10).

Inhibitory effect on appetite

The sale of satiety-enhancing products has increased in the market because of the beneficial effect on weight control. Appetite and satiety mechanisms are connected by a complicated concurrence of hormonal and neurological signals (11). Enhanced satiety mechanisms involve augmentation in noradrenaline level and stimulation of the automatic nervous system, this results in craving suppressing effect, energy consumption, and boosting in fat oxidation (12). Through the reduction in energy intake by enhancing satiety, obesity can be treated by developing a product that acts on these neural signal peptides (13).

Inhibitory effect on lipase enzyme

One of the potential approaches for treating weight gain and obesity is where hindrance in the absorption of fats and carbohydrates occurs through the gastrointestinal tract. Phospholipase enzyme is secreted in pancreatic juice which aggravates the hydrolyzation of triglycerides into free fatty acids and monoglycerides in the intestine (14). Blocking phospholipase activity is considered a good approach to treating obesity. Orlistat, a saturated derivative of endogenous lipstatin separated from Streptomyces toxytricini, is a potent natural inhibitor of pancreatic lipase (15).

Governing effect on adipocyte differentiation

The balance of fats and energy is regulated mainly by adipocytes. The main role of adipocytes is the storage of triglycerides and breaking them down into free fatty acids when energy is required. The hampering of transcription factors such as C/EBPβ (CCAAT/enhancer binding protein beta) and PPARγ (peroxisome proliferator-activated receptor gamma) represses adipocyte differentiation (16). A shrub named Sibiraea angustata suppresses activity on the differentiation of adipocytes. Expressing these transcription factors, which are responsible for differentiation, represses in a way that leads to lesser deposition of fats in adipocyte cells (17).

Governing effect on metabolism of fats

Phytochemicals target lipolysis by hydroxylation of triglycerides and thus reduce storage. In this way, obesity is treated (18). Another way is to augment the oxidation of fatty acid and transport of glucose in skeletal muscle by stimulating adenosine monophosphate-activated protein kinase (AMPK) (19). It has been noted that flavonols (quercetin) stimulate lipoxygenase and reduce adipogenesis by AMPK pathway. By repression of the phosphorylation effect of signal-regulated kinases 1 and 2 (ERK1/2) and c-Jun N-terminal kinase (JNK) which are members to subfamilies of mitogen-activated protein kinase (MAPK), stimulates lysis of adipocytes (20).

Classification of phytochemicals

Depending on various target pathways where phytochemicals act to treat obesity are classified in detail in following segment.

Polyphenols

The family of phytochemicals with the greatest relevance and health advantages is the polyphenol family (21). Many preclinical investigations have shown that certain polyphenols have potent anti-pathological effects, notably against ailments brought on by oxidative stress, such as insulin resistance syndrome and cardiovascular diseases (CVD). Additionally, nutritional polyphenols' action of inhibiting angiogenesis and regulating the metabolism of adipose tissue may inhibit the growth of adipose tissue (22,23). Additional advantages of polyphenols include protection against cancer, infections, autoimmune diseases, and neurological conditions (24-27). One to numerous phenol groups with a hydroxyl-substituted aromatic ring can be found in polyphenols, including their functional derivatives i.e., esters and glycosides (28). Various phytochemicals belong to this class. Simple phenolic acids, chalcones, flavonoids, stilbenes, and curcuminoids (29,30). Out of the main phenolic components in rice bran oil, ferulic acid exhibits potent in vitro antioxidant properties (31,32). Other cereals like wheat and oats, as well as coffee beans, apples, artichokes, peanuts, oranges, and pineapples also have ferulic acid in them (33). Due to its hypolipidemic qualities, ferulic acid may be useful in reducing the risk of obesity brought on by a high-fat diet (34). Additionally, it lowers serum cholesterol levels, guard counter to liver damage, and, especially in vitro, is a strong inhibitor of tumor promotion (32,35). Stilbenes can be discovered as monomers, oligomers, and conjugated to sugars in a small number of plant species that naturally produce them. They are produced via the phenylpropanoid pathway (36). Having a resemblance in the structure of estrogen and interactions with estrogen receptors, these compounds are referred to as phytoestrogens (37). Red grapes, apples, peanuts, blueberries, and cranberries are the main sources of resveratrol; however, these foods only

contain trace amounts (38). Numerous studies have been conducted on this compound's powerful in vitro antioxidant characteristics, capacity to lower LDL cholesterol (39), hamper lipid peroxidation, and guard counter the emergence of atherosclerosis and heart attack, as well as its anti-platelet and estrogenic effects (40,41). By hindering cyclooxygenase (COXs) and several pro-inflammatory factors (42), resveratrol has actions that are consistent with its ability to connect with molecular mechanisms important throughout pathological conditions (43). It stimulates brain function and acts as a neuroprotector against amyloidal damage (44,45). Positive alterations in gene expression and the functioning of metabolic syndrome-related enzymes are brought about by resveratrol (43,46). By suppressing adipocyte-specific transcription factors and changing the expression of adipocyte-specific genes such as peroxisome proliferative-activated receptors (PPAR), CCAAT/enhancer binding protein (C/EBP), sterol-regulatory-binding protein-1c(SREBP-1c), fetal alcohol syndrome (FAS), lipoprotein lipase (LPL), and hormone-sensitive lipase (HSL), resveratrol reduces adipogenesis and viability in mature preadipocytes (47,48). In vitro, it boosts the activity of the calorie-restrictive enzymes sirtuin-3 S. Cerevisiae (SIRT3), uncoupling protein 1(UCP1), and mitofusin-2(MFN2) in maturing preadipocytes (49). Resveratrol enhances lipolysis, and induction of apoptosis, and decreases lipogenesis and growth in mature adipocytes, which helps to decrease lipid buildup in vitro (43,50,51). Resveratrol also inhibits TNF-α activated NF-κB signaling (36,47,52) and reverses TNF-α induced secretion, as well as the mRNA expression of PAI-1, IL-6, and adiponectin (51,53). It also decreases the expression of agents of the inflammatory response (TNF-, IL-6, and COX-2) in mature adipocytes. Additionally, resveratrol modifies the Serine/Threonine phosphorylation of insulin receptor substrate-1 and downstream protein kinase B(AKT) (51) in adipocytes, enhancing insulin sensitivity. Resveratrol boosted the insulin-stimulated absorption of glucose in mature human adipocytes, but it also hindered lipogenesis (54), restored IL-1-stimulated secretion, and suppressed the gene expression of the pro-inflammatory adipokines IL-6, IL-8, MCP-1, and PAI-1 (53). Two connected ferulic acid molecules make up the curcuminoids. Curcumin, demethoxycurcumin, and bisdemethoxycurcumin are the curcuminoids that are most prevalent. The Curcuma and Zingiber species, which are the origin of the spices turmeric and ginger, respectively, contain this non-toxic yellow pigment. The anti-inflammatory, anti-tumor, anti-arthritic, anti-viral, anti-amyloid, and antioxidant effects of dietary curcuminoids are just a few of their potentially advantageous traits. Curcuminoids have also been demonstrated to stop fat buildup in rats, which is significant (54). The most thoroughly researched curcumin is curcumin, which emanates from turmeric. Curcumin has the power to modulate a wide range of molecular targets, including protein kinases (mTOR, MAPK, Akt), other enzymes (COX2, 5-LOX), transcription factors (NF-B, STAT3, PPAR), growth factors (VEGF), inflammatory cytokines (TNF, IL-1, IL-6), and transcription factors (NF-B, STAT3, PPAR), as well as other mediators by AP-1, Bcl-2, Bcl-XL, caspases, IKK, EGFR, HER2, JNK, and Wnt/-catenin (55,56). The level of intracellular lipids is decreased by curcumin, which controls the expression of genes involved in lipid accumulation and energy consumption. Curcumin inhibits endothelial progenitor cells, which is required for tissue growth in fat tissues. Curcumin helps to reduce body fat and weight increase in addition to having an impact on adipocytes' lipid metabolism (56-58). Additionally, curcumin reduces the inflammation that is connected to obesity and the metabolic diseases that are related to it, including insulin resistance, hyperglycemia, hyperlipidemia, and hypercholesterolemia (59). Leptin, a hormone involved in regulating consumption and implicated in liver fibrosis (60), is controlled by curcumin to protect against liver damage by inhibiting LDL oxidation (61). Additionally, curcumin controls the expression of the SREBPs gene, which lowers intracellular cholesterol and lessens the enhancing effect of LDL and leptin on the activation of hepatic stellate cells (HSCs) (62). According to studies done on mice, curcumin improves some of the symptoms of leptin deficiency and diabetes (63,64). Additionally, curcumin therapy enhances adiponectin synthesis in adipose tissue, reduces hepatic NF-B activity and components of liver inflammation, and markedly inhibits macrophage infiltration of white adipose tissue (65). Through the stimulation of Wnt/-catenin signaling, curcumin causes the inhibition of adipogenic transformation (66). By activating AMPK, which is essential for the regulation of adipocyte transformation and cancer cell proliferation (67), curcumin seems to be helpful in managing adipocytes and malignant cells. Chemically speaking, Chalcones are made up of two phenyl rings connected by a three-carbon, unsaturated carbonyl system in open-chain flavonoids. Strong anti-inflammatory, anti-oxidative, and anti-cancerogenic substances have been described for them. The anti-estrogenic, non-proliferative, anti-microbial, and mitotic inhibiting activities of chalcones are further characteristics. The dihydrochalcone phlorizin, which is used to treat obesity and diabetes mellitus, belongs to this class (67,68). The main phenolic glucoside is found in apple trees (69), this flavonoid is abundant in the leaves of Sweet Tea (Lithocarpus polystachyus Rehd) (70). According to reports, this chalcone inhibits the generation of inflammatory mediators linked to the interaction of adipocytes and macrophages (71,72). However, naringenin chalcone restricts macrophage infiltration to enlarged adipocytes (73) and partially inhibits the breakdown of I-κB-α (72).

They are presently believed to have an impact on the signaling molecules proximate to TLR4 either directly or indirectly, independent of macrophage PPAR stimulation (74). A kind of phytoestrogen known as lignans is made up of two phenylpropane units. The two main lignan sources are flaxseed and grains. The highest dietary roots of lignans are flaxseed (linseed), which has high levels of secoisolariciresinol and low levels of matairesinol (75). Rye has been found to contain other lignans, such as pinoresinol, lariciresinol, isolariciresinol, and syringaresinol (76). Plant lignans and mammalian lignans are the two types of lignans. When ingested, the plant lignans secoisolariciresinol and matairesinol are transformed into the mammalian lignans enterodiol and enterolactone, which have a variety of biological activities, including antioxidant (significantly greater compared to alpha-tocopherol) and estrogen-like activities through which they might decrease the risk of chronic diseases, such as weight gain linked to hormones (75,77). Consumption of matairesinol is inversely correlated with all-cause mortality, cancer, coronary heart disease, and CVD (78). In studies using rabbits, secoisolariciresinol diglucoside was found to lower serum cholesterol and coronary artery disease (79). It also has antihypertensive effects (110) and lowers the prevalence of diabetes in numerous in-vivo models (77,80,81). Flaxseed has been shown to lower total and LDL serum cholesterol without affecting HDL or total TG in a number of human intervention studies (82).
Flavonoids are a vast family of over 6000 different phytochemicals with a common chemical structure that are found in fruits and vegetables. The focus of the current study is on their anti-inflammatory (84) and antioxidant (83) properties. Though flavonoids are typically thought of as non-nutritive substances, interest in them is developing due to their potential to play a part in the management of serious chronic diseases. They may offer protection from diseases like cancer, as well as digestive (85), cardiac (86), and neurological (87) conditions. The average content of flavonols is between 15 and 30 mg/kg of fresh weight. The foods highest in flavonols include blueberries, onions, curly kale, leeks, and broccoli. Moreover, the glycosylated form of flavonols is found in red wine and tea (88). Flavonols have positive effects on endothelial function, anti-inflammatory, antiproliferative, and antioxidant properties, and they hinder a lot of biochemical signaling pathways, which affects both anatomical and disease processes (89,90). Individual influence studies using isolated flavonols show a reduction in hypertension. The consumption of flavonols and flavones has an inverse relationship with coronary heart disease and stroke, according to a meta-analysis of research studies (89). Quercetin, specifically, inhibits ex-vivo adipogenesis by triggering the AMPK signal pathway in preadipocytes and suppressing the expression of adipogenesis-related proteins (91). It has stronger anti-lipase activity than luteolin (92). By lowering mitochondrial function, inhibiting PARP and Bcl-2, activating caspase-3, Bax, and Bak (93), and facilitating caspase-3, Bax, and Bak in preadipocytes, quercetin causes apoptosis. It also causes apoptosis in mature adipocytes by altering the ERK and JNK pathways, which are important during apoptosis (92). Flavanols are generally monomers (catechins) and polymers (proanthocyanidins). Many different fruits contain catechins, with apricots being the ultimate source, and also red wine. However, green tea and chocolate are the market leading. According to a human investigation, an extract standardized at 0.25 amount of catechins reduces body weight by 4.6% and waist measurement by 4.48% after three months of treatment (94). This was said to work by preventing gastrointestinal lipases and boosting fat oxidation (95,96). It is observed that green tea catechins, particularly epigallocatechin gallate (EGCG), can decrease adipocyte differentiation and proliferation, lipid synthesis, visceral fat, body mass, lipid absorption, serum concentrations of TG, unsaturated fatty acids, lipids, sugars, insulin, and leptin, as well as elevate oxidation of fatty acids and thermogenesis in cell culture and animal models of obesity (97,98). They drastically lower intracellular fat buildup and inhibit the synthesis of lipids by the enzyme glycerol-3-phosphate dehydrogenase. Additionally, there was an inhibition of the transfer of glucose and fatty acids. Forkhead transcription factor class O1 underwent phosphorylation by the insulin signal as a result of EGCG induction (FoxO1). Through the inhibition of transcription factors O1 (FoxO1) and SREBP1c, which are involved in adipocyte differentiation and lipid synthesis, respectively, EGCG inhibits the development of adipocytes (99). Preadipocytes experienced apoptosis due to EGCG as well. The effects on apoptosis were Cdk2 and caspase-3 dependent and linked to a reduction in cell division. Green tea targets the liver, gut, skeletal muscle, and adipose tissue to exert its anti-obesity effects (97). Reduced fat absorption, reduced inflammation, and other ways might mediate these effects (100, 101). EGCG has been investigated in mice as an anti-obesity preventative drug (97, 102). There is evidence that suggests prolonged EGCG therapy slows the onset of weight gain, signs of metabolic syndrome, and fatty liver. In obese mice, EGCG administration appears to correct previously developed metabolic disorders brought on by high fat intake, and findings from human intervention trials suggest that consuming green tea catechins may diminish obesity and lipid. These substances may impact sympathetic nervous system activity, boosting calorie expenditure and encouraging fat burning, according to one proposed mechanism (98, 103). Green tea naturally contains caffeine, which affects automatic nervous system activity and may work in concert with it (104). When combined with

coffee, EGCG in humans can improve fat oxidation, increase energy consumption (105), and decrease overall stomach fat (106). Isoflavones are diphenolic substances that bind to estrogen receptors by having chemical structures the same as estradiol. They are also known as nonsteroidal estrogens or estrogen-like compounds. They may affect the metabolism of steroid hormones and activate both genomic and non-genomic estrogen signaling pathways (106). The adipogenic differentiation of mesenchymal stem cells generated from adipose tissue is suppressed by genistein and daidzein, which also block the expression of adipogenic markers PPAR, SREBP-1c, and Glut-4. The anti-adipogenic actions of genistein are assumed to primarily occur through the stimulation of Wnt signaling via ER-dependent pathways, such as Erk/JNK signaling and LEF/TCF4 co-activators (107). Genistein also reduces preadipocyte proliferation. In addition, genistein inhibited adipogenesis in murine and human adipocytes when combined with resveratrol and quercetin (108). Red hot peppers contain the alkaloid capsaicin, which gives them their spiciness. Although this phytochemical has long been thought to have pharmacological effects, substantial experiment has also been accomplished to identify precise uses for its functions. The digestive system, weight reduction, and pain killer effects are a few examples (109). Capsaicin can reduce inflammation brought on by obesity as well as metabolic and hepatic illnesses connected to obesity (110,111). Additionally, rats exposed to capsaicin experienced decreased food intake elevated energy expenditure and enhanced lipid oxidation [112,113]. When compared to a control meal, a substantial increase in energy expenditure was seen in humans after eating red pepper (114). Additionally, investigations on both humans and animals demonstrate that capsaicin can increase thermogenesis in response to adrenergic activation and, in rats, by enhancing catecholamine production from the adrenal medulla (115). The administration of capsaicin along with green tea and chicken aroma caused a decrease in body fat in two-week human research (116).

Terpenoids

One of the hugest groups of plant products, terpenoids (isoprenoids) includes more than 40,000 molecules from both primary and secondary metabolisms. Terpenoids are terpenes that have undergone chemical modification. Terpenoids can be divided into other groups according to the number of carbon atoms they contain. The majority of terpenoids are plant-based and can be found in fruits and vegetables. Consuming specific terpenoids regularly may help manage metabolic problems brought on by obesity, likewise type II diabetes, hyperlipidemia, insulin resistance, CVD, and a lower prevalence of metabolic syndrome (117). Plant-derived sesquiterpenes are a class of chemicals that have biological effects like anti-infectious, anti-inflammatory, pain reliever, and cytotoxic (118). Sesquiterpene interactions with the thiol groups of enzymes usually lead to these biological activities. Some medicinal plants' anti-inflammatory properties are brought on by the presence of one or more sesquiterpene lactones (119). A natural sesquiterpene called abscisic acid (ABA) has demonstrated effectiveness in the management of inflammation brought on by diabetes and obesity. fact, ABA shares structural similarities with common thiazolidinedione diabetic medications; the use of ABA in rats was observed to lower fasting plasma glucose levels (120). Unexpectedly, it has been claimed that ABA can increase the release of insulin from pancreatic cells and that it is an intrinsic pro-inflammatory cytokine in human granulocytes (121). Additional support for prospective treatments of inflammatory and immune-mediated disorders is provided by the ABA's effect on the expression of many genes associated with inflammation, metabolic activity, and signal transduction (122). Tetraterpenoids contain lipophilic tints called carotenoids. The core region of the molecule contains a prolonged string of conjugated double bonds that make them particularly susceptible to oxidation and cis-trans isomerization. This provides them with their structure, susceptibility to chemicals, and capacity to absorb light (123). Carotenoids may help to prevent the onset of inflammatory disorders like obesity and atherosclerosis, according to research studies (124,125). Lycopene is a red carotenoid that is predominantly found in tomatoes, red bell peppers, and some fruits. Lycopene is fat-soluble, therefore heating food increases its absorption (126). The strong singlet oxygen quencher of the natural carotenoids, lycopene has a significant tendency to withdraw free radicals and has an elevated concentration of conjugated dienes (127). Lycopene-rich diets have been linked to a lower incidence of CVD. According to some theories, lycopene works by suppressing lipid peroxidation and LDL degradation (128,129).

Organosulphurs

Allium vegetables including garlic, onion, scallion, chive, shallot, and leek, which contain bioactive chemicals like allicin, allixin, and allyl sulfides, are particularly rich in organosulfur compounds (130). These compounds are responsible for the unique flavor and aroma of these plants as well as their numerous alleged therapeutic properties. Organosulfurs from onions and garlic have been shown to have a variety of physiological impacts on obesity. They lessen the production of cholesterol by hepatocytes by inhibiting Hydroxymethylglutaryl-coenzyme A reductase (HMG-CoA), an essential enzyme in the route that produces cholesterol. Additionally, organosulfur reduces blood pressure and boosts general immunity They are hailed as potent anti-diabetic, lipid-reducing, and anti-platelet aggregating drugs. Additionally, they inhibit

platelet aggregation and have been linked to liver protective and immune system-boosting effects (131, 132). In vitro, it has been discovered that organosulfur compounds produced from garlic reduce the expression of inducible nitric oxide synthase (iNOS) in phagocytes and prevent the action of the inflammatory enzymes that cyclooxygenase and lipoxygenase. Additionally, it has been observed that human whole blood and cultured macrophages both produce fewer inflammatory signaling molecules in response to organosulfur compounds (131). Last but not least, ajoene, a product of garlic, has been found to have effects specifically on adipocytes, even though the fact that the positive benefits of organosulfur have been mostly attributed to their antioxidant and anti-carcinogenic qualities (133). Particularly, garlic extracts may reduce the number of fat cells, indicating a potential obesity treatment.

Phytosterols

Phytosterols are organic substances that resemble cholesterol found in mammalian cells in terms of structure (134). These natural products contain sterols and stanols, the latter of which is the type that is more frequently found in nature (135). Unrefined vegetable oils, seeds, grains, nuts, and legumes are the best food sources of phytosterols, which come in esterified and free alcohol forms (136). Diosgenin, campesterol, brassicasterol, sitosterol, stigmasterol, and guggulsterone are phytosterols that may have an impact on obesity. High doses of these substances can also lower serum total and LDL cholesterol levels (138) and prevent atherosclerosis (137). In the intestinal lumen, phytosterols compete with cholesterol for micelle production, preventing cholesterol from being absorbed. Phytosterols are important regulators of metabolism and cholesterol transport in the expression of liver genes due to their impact on intestinal genes and transcription factors (134, 139). The primary component of the rhizomes of Dioscorea gracillima, the protodioscin investigated for its lipid lowering agent activity, is furostanol saponin in terms of phytotherapy. When protodioscin was given to hyperlipidemic rats, the amount of TG, cholesterol, and low- and high-density lipoproteins in the blood considerably decreased (140). This bisdesmoside undergoes acid hydrolysis to produce diosgenin, a phytoestrogen that may be chemically changed into progesterone (141). Fenugreek and the roots of wild yam are just two examples of the numerous plants that contain diosgenin. Diosgenin has a variety of biological effects, including the ability to reduce inflammation without triggering PPARs (143) by up-regulating I-κB-α degradation and activating JNK (142). In HepG2 cells, diosgenin prevented TG buildup and lipogenic gene expression. Additionally, diosgenin is utilized to treat diabetes and hypercholesterolemia and has anti-thrombotic properties both ex vivo and in vivo (143). Additionally, diosgenin is utilized to treat diabetes and hypercholesterolemia and has anti-thrombotic properties both in vitro and in vivo (144).

CONCLUSIONS

Considering many factors like lifestyle, food habits, environmental exposures, and genetics that can cause obesity, which is a complex, chronic disorder, is well explained in this review article. The key components for weight loss are choices of healthy lifestyle, behavioral interventions, and treatments based on natural products which are broadly classified. This suggestively preferable and may be used as an adjunctive treatment for co-morbid diseases. Phytochemicals shows more promising effects and platform for treatment of obesity. Further investigations can be carried out where phytochemicals can be given with other anti-obesity drugs where it can show synergistic or can potentiate the pharmacological action.

Authors' contributions

CT is the main contributor of the manuscript, MK, NS, PS, and HSR helps in writing and editing and DT contributed in editing, and submission of the above review article. All authors have read and approved the manuscript for submission.

Competing interests

The authors declare that they have no competing interests.

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CITATION OF THIS ARTICLE

Chitrali Talele, Dipali Talele, Mamta Kumari, Niyati Shah, Hemraj Singh Rajput, Piyushkumar Sadhu, Chintan Aundhia. Recapitulation Of Dietary Phytonutrients and Its Associated Implications On Obesity Running Title: Phytochemicals for obesity. . Bull. Env.Pharmacol. Life Sci., Vol 12 [11] October 2023:307-317