VITAL POTENTIAL OF MULTIPLE HERBS IN PROPHYLAXIS OF OBESITY

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ABSTRACT

Objective: Allopathic medications are associated with several inconveniences such as drug dependency. More than 2000 herbal medicines have been proved to have a therapeutic effect in multiple disorders. The prominent aim of this review paper is to compute the therapeutic effect of herbal drug against obesity along with their different mechanisms.

Methods: Data have been selected by evaluating merger of specific review and research papers through filtering through data bases such as PubMed, and Google Scholar of last 10 years 2009–2019.

Results: On the basis of our interpretations, we have concluded that the herbal drugs constituting active constituents as tannins, alkaloids, resins, saponins, and flavonoids are effective in lowering the blood triglycerides level, lipid accumulation in liver, fat accumulation, adipocyte differentiation, and ultimately decrease body weight with almost negligible toxicity.

Conclusion: Obesity is highly related to elevated morbidity rate as well as has become cause of various disorders. Herbal drugs have potential to treat obesity through different mechanisms including lipid peroxidation, free-radical scavenging activity, and inhibition of fat accumulation.

Keywords: Obesity, Leptin, Herbal drugs, Triglycerides.

INTRODUCTION

Obesity is characterized at an extensive level in the world population in today's scenario. It is an outcome of certain atrocious behavior, hereditary factors, nutrition deficiency, and inadequacy of the physical exercise [1]. The main cause of central and visceral obesity is the storage of diet, having glut energy density. According to the World health organization, obesity, as well as overweight, is defined as "odd and exaggerated aggregation of fat which influences health." A person is said to be obese if assessing BMI rate 30 or above it. The excessive energy accumulation specifically in adipocytes accounts increment in the progression of lipolysis phenomenon, as per its consequence, leukocytes infiltration proceeds cytokines secretion, macrophages produces adipocytes inflammation, leading to a state of pro-inflammation, dysfunction of endothelium, and insulin resistance. Therefore, chances of augmentation of several chronic disorders take place including renal dysfunctions and type 2 diabetes [2].

The frequency of disease prevalence has been doubled in the world population since up to 13% among whom 15% of women and 11% of men comprise the total blood population. The enormous expansion in body fat has serious constrains of serious metabolic syndromes and disorders [3]. Risk factors associated with obesity are predominantly, individual's behaviors, physical activity, and diet play a considerable role in alleviating obesity risk. More than 135 million people in India were influenced by obesity. The rate of prevalence depends on age, geographical environment, gender, socioeconomic status, and other factors. As per ICMR – INDIA epidemiological report of the year 2015, there is variation in the prevalence rate of obesity that is 16.9–36.3%, and prevalence rate of central obesity is 11.8–31.3% [4]. In addition, socioeconomic, environmental, and sociocultural also contribute to the risk factor of the disease. The environment of family and lifestyle patterns can be also influencing risk factors of obesity, especially during a young age [5]. The first and foremost treatment for obese patients is the alteration in lifestyle along with a restricted diet [6]. Those patients who cannot follow a restricted diet and lifestyle are kept on pharmacotherapy [7]. Obedience to a strict diet is quite poor and the synthetic medications have many side effects. Hence, there is an urge to introduce herbal medications in treatment therapy because of their safer therapeutic property and better patient adherence [8,9]. Herbal products have benefits over conventional drugs like these can be included in the diet. Extracts of various plants are effective as antioxidants, anti-inflammatory, antihyperglycemic, and effective against obesity [10-15]. As per jillions of studies, it is reported that plenty of natural herbs encompassing alkaloids, tannins, steroidal saponins, flavonoids, and glycosides as their active chemical constituents, have therapeutic potential to treat obesity. Several phenolic compounds have been found as a stimulating agent at the molecular level against obesity and metabolic disorders related to it [16,17]. Glycoside derived from the specific herb has a fruitful role in lowering down obesity in high fat-induced rats [18]. Furthermore, herbal drugs specifying saponin as active chemical constituents have shown a potent effect in weight loss [19]. In present, natural products and their therapeutic effects are being spotlighted by researchers to minimize the obesity effect along with slight or negligible toxicity [20]. This review accentuates on current research activities performed on herbal drugs in context to obesity. The study comprises the mechanism of obesity, factors responsible for obesity, and summaries of different researcher's activities done using various herbs against obesity along with their mechanisms.

MECHANISM OF OBESITY

Obesity is identified by the disproportionate white adipose tissue (WAT) enlargement [21], due to the multiplication of adipocyte number which is called hyperplasia or because of increment of adipocyte size, called as hypertrophy [22]. Adipocyte is characterized for extra storage of surplus energy which is stored in the form of triglycerides (TGs) and is released in the form of free fatty acids (FFA) during lack of energy [23]. Hypertrophy of adipocyte is liked with oxidative stress, endoplasmic reticulum stress, fibrosis, hypoxia, adipocyte dysfunction, and insulin resistance [24]. In addition, hypertrophy in the case of adipose tissue causes cell death which results in infiltration mechanisms in which
lipoprotein lipase (LPL) activity tends to diminish once WAT fails to result in very-low-density lipoproteins (VLDL) secretion. Adipocyte fatty acids are consolidated with TGs, all these processes eventually rich caloric diet cause synthesis of TGs and lipogenesis, further released accumulation and lipid toxicity in liver and skeletal muscle. Intake of fatty acids into the blood circulation and accumulation of TG is involved in the development of fat bulk, eventually, and cause obesity. BAT functions such as esterification, uptake, and further circulation of great vessels [36]. Specifically, in the case of some type of obesity mainly occur on perirenal and interscapular and also along the regions (BAT), is tiny and their prominent role is thermogenesis. BAT’s deposits are involved in the development process through adipocytes [33]. As per epidemiological reports, more frequent intake of carbohydrates and highly saturated fats leads to deposition of the intra-abdominal mass of fat, followed by variation in adipocytokine release pattern as well as altered lipid metabolism homeostasis [34,35]. Adipose tissue is mainly classified into two types: WAT is found in subcutaneous and visceral adipose tissues are commonly known fatty cells. These WATs are involved in the development of fat bulk, eventually, and cause obesity. The other type of adipose tissue is known as brown adipose tissue (BAT), is tiny and their prominent role is thermogenesis. BAT’s deposits mainly occur on perirenal and interscapular and also along the regions of great vessels [36]. Specifically, in the case of some type of obesity BAT functions such as esterification, uptake, and further circulation of fatty acids into the blood circulation and accumulation of TG is responsible for white adipocyte metabolism function for adaptation of energy as per animal requirements. BAT also avoids unwanted lipid accumulation and lipid toxicity in liver and skeletal muscle. Intake of rich caloric diet cause synthesis of FGs and lipogenesis, further released fatty acids are consolidated with TGs, all these processes eventually result in very-low-density lipoproteins (VLDL) secretion. Adipocyte lipoprotein lipase (LPL) activity tends to diminish once WAT fails to store TG because of its bulk quantity, through the hydrolysis process of TG which is carried by chylomicrons through the intestine. After a certain period, cause an increment in TGs levels into blood circulation. Likewise, adipocytes hypertrophy progression indicates inflammation, hypoxia, and macrophages infiltration promotes the generation of different mediators which are pro-inflammatory such as interleukin 6, tumor necrosis factor-alpha, plasminogen inhibitor 1, monocyte chemoattractant protein 1, and C-reactive protein [37]. Transcription factor, peroxisome proliferator-activated receptor gamma, has a major role in proliferation and differentiation of adipocytes, resulting in enlargement and multiplication of tiny adipocytes in response to balance energy along with better insulin sensitivity [38,39]. Insulin resistance in WAT and abdominal obesity facilitates FFAs generation in blood circulation as well as lipolysis. In addition, because of which remnant chylomicrons concentration in the blood increases as a result of diminished LPL in WAT and liver. The secretion of VLDLs from the liver elevates TGs. Increase the flow of FFAs in the portal system, apolipoprotein –B-100 generation increase, reduction of high-density lipoprotein (HDL), and production of low-density lipoprotein particles enhances [40,41]. All these processes are interlinked and associate with obesity. These metabolic disorders are directly or indirectly linked with abdominal obesity (Fig.1).

The antiobesity activity of flavonoids
Flavonoids are defined as familiar polyphenolic compounds, isolated from various plant sources. Flavonoids are characterized as photosynthesis active agents or pigments [42,43]. These compounds have high therapeutic value as well as a range of medicinal characteristics [46]. Structurally, the compound consists of two benzene ring linearly joined by carbon chain and with carbon skeleton of 15 carbons (C6-C3-C6). Based on substitution at the carbon ring, flavonoids are classified into different classes [47,48]. Further flavonoids are characterized into various subgroups, majorly into six subgroups which include flavonoids along with myricetin, quercetin, and kaempferol, isoflavonoids along with glycitein, daidzein, genistein, and flavanones along with luteolin and apigenin and anthocyanins including delphinidin, petunidin, peonidin, malvidin, pelargonidin, and...
flavonoids 3-ol along with quer cetin. According to numerous studies, it has been indicated that flavonoids exhibit better therapeutic potential in various diseases [49,50]. Flavonoids tend to improve obesity and are quite helpful in the management of weight [51-53]. The numbers of researches have been done which proves the antiobesity activity of flavonoids [56]. Some of which are summarized in Table 1.

The antiobesity activity of saponins
Saponins are naturally occurring compounds formed through conjugation of isoprenoid aglycone and sugar moieties. The term saponin describes its characteristics to acquire foam like soap because of its high foaming ability when dissolved in aqueous solutions. Due to the amphiphilic property of saponins foam formation takes place, as there is a linkage between side chains of hydrophilic saccharides and lipophilic sapogenins [60]. Saponins are separated most widely from plants belonging to the Magnoliophyta division, including monocotyledons and dicotyledons, although, dicotyledons cover a wide range of plants that produce saponins in comparison to monocotyledons [61]. Saponin containing herbs is being frequently utilized by the cosmetics and food industry because of its foaming-forming property and its chemical characteristics [62,63]. Many medicinal plants such as Glycyrrhiza glabra have major chemical constituents as saponins when extracted out [64]. Similarly, the extract of Panax ginseng contains saponins in major amount and is pharmacologically beneficial [65]. Saponins exhibits anti-inflammatory property [66], antiviral property [67], antitumor property [68], antifungal property [69], and antioxidant activity [70]. Few of them are summarized in Table 2.

The antiobesity activity of tannins
According to the definition, tannins are defined as the collection of secondary metabolites derived from plants that can convert the skin of animals into the leather. These compounds are phenolic which are water-soluble having molar mass in the range of 300–3000. These compounds are capable to precipitate proteins, gelatins, and alkaloids. However, currently, more compounds have been recognized that of 2000 Da, whose structures are similar [76]. Tannins are classified into two major categories based on hydrolysis into hydrolyzable tannins and nonhydrolyzable or condensed tannins. The hydrolyzable tannins contain different kinds of polyesters. Polyesters of hexahydroxydiphenic acids and gallic acid, the nonhydrolyzable tannins are whereas contain polymers and oligomers. Oligomers are polymers consist of nuclei of flavan-3-ol. Further tannins are classified based on structures into condensation, including monomers, dimers, trimers, and higher oligomers [77]. There are different sources of tannins. Tannins are found in different plants and their parts in high

| Scientist name | Flavonoids name | Sources of flavonoids | Study models animal/ cell culture | Observation for antiobesity activity | Molecular mechanism of action |
|----------------|----------------|-----------------------|-------------------------------|------------------------------------|-----------------------------|
| Isabelle Demonty et al. (2002) [54] | Genistein | Soy containing food | Animal model (Sprague Dawley rats) | Reduction in TGs; Reduction in adipocyte multiplication | Increased GLUT4, Decreased NF-κB; Decreased TNF-α; Increased AMPK; Increased ACC |
| Jin-Tack Hwang et al. (2005) [55] | Genistein | Soy containing food | Cell culture (3T3-L1 preadipocytes) and (3 week old Male C57BL/6 Mice) | Decreased total cholesterol, increased Glycogen and insulin secretion | Increased mRNa expression for UCP3, CPT1, ACC and PPARY genes |
| Myung Sunny Kim et al. (2012) [57] | Tangeretin | Mandarin orange | Animal model (KKAY mice) | Reduced adipocyte multiplication; decreased pancreatic lipase activity | PPAR-y downregulation |
| Nobuto Ikarashi et al. (2009) [58] | Flavon-3-ols, (isetinol and robinetinidol) | Bark of black wattle tree (Acacia mearnsii) | Animal model (Male Wistar Rats) | Decreased adipocyte multiplication; decreased pancreatic lipase activity | |
| Ali Imran et al. (2018) [59] | Thea flavins; Thearubigins | Black tea leaves (Salicornia europaea) | Animal model (Male Wistar Rats) | Reduced pancreatic lipase activity | |

GLUT 4: Glucose transporter type 4, NF-κB: Nuclear factor kappa-light-chain-enhancer of activated B cells, TNF –α: Tumor necrosis factor, TGFβ1: Transforming growth factor beta 1, AMPK:5 adenosine monophosphate activated protein kinase, ACC: Acetyl-CoA carboxylase, UPC3: Uncoupling protein 3, mRNA: Messenger ribonucleic acid, PPARα: Peroxisome proliferator activated receptor gamma. TG: Triglyceride

| Scientist name | Saponins name | Sources of saponins | Study models animal/ cell culture | Observation for antiobesity activity | Molecular mechanism of action |
|----------------|---------------|---------------------|-------------------------------|------------------------------------|-----------------------------|
| Cha hui Apphia Eu et al. (2010) [71] | Glycyrrhizin Glycyrrhiza glabra | Animal model (Sprague Dawley Rats) | Elevated insulin sensitivity; Improved HDL; Upregulation of LPL; decreased lipid deposition | apo- CIII down regulation; decreased TNF-α; activation of PPARα | |
| P.Thiyagarajan et al. (2011) [72] | Glabardin, Isoliquiritigenin, Glycyrrhizin Glycyrrhiza glabra | Cell culture ([774A.1Marine macrophages cell line [TTB-67]) | Anti-inflammatory activity | Inhibition of NO; IL-6; IL-1 | |
| Jin Kyung Kim et al. (2006) [73] | Glycyrrhizin Glycyrrhiza inflata | Cell culture (LPS induced Mouse cell culture RAW264.7) | Anti-inflammatory activity | Decreased TNF-α; Decreased IL-6; Increased IL-10 | |
| Lin Kun Han et al. (2002) [74] | Crude saponin Platycodi radix | Animal model (Male Wistar Rats) | Inhibition of pancreatic lipase activity; reduced in body weight; reduction in triglycerides; reduction in total cholesterol | Decreased TGs level | |
| Lu Guo et al. (2015) [75] | Saponin extract Phomognatha graeffii | Animal model (C57/BL6 Mice) | Reduces adipogenic activity | ABCA1 upregulation; stimulation of PPARs; upregulation of LXR-β | |

apo- CIII: Apolipoprotein C III, LXRs- R: Liver X receptor beta, NO: Nitric oxide, TNF –α: tumor necrosis factor; PPARα: Peroxisome proliferator activated receptor gamma, PPARα: Peroxisome proliferator activated receptor alpha, IL-6: Interleukin 6, ABCA1: ATP-binding cassette transporter ABCA1, IL-10: Interleukins 10, LXR-β – Liver X receptor beta. TGs: Triglyceride, TNF: Tumor necrosis factor, HDL: High-density lipoprotein
concentrations. It can be obtained from seed, bark, wood, leaves, fruit, and plant galls [78]. Tannins can also be isolated from the stem area, from growth areas of plants such as xylem and secondary phloem and between the layer of epidermis and cortex. Some plants tend to be known for very frequently produce tannins and are considered as its sickness. Tannins released from plants protect them from harm from insects and infections from microbes and animals. The condensed form of tannins reserved in tannosomes that are surrounded within the tonoplast, a kind of chlorophyllous organelle which only on cell breakdown or cell death takes its action, it does not take any action in plant metabolism activity [79]. Tannins contain different kind of chemical constituents which includes castalagin, chebulinic acid, pedunculagin [80], Telima grandidii II, Potentillium, Agrimonin, Gemin A, Oenothein B, epigallocatechin gallate, Acutisinin A, Camellianinn A, Guajavin B, Proanthocyanind A1, Proanthocyanidin A2, and Proanthocyanidine C1 [81]. Tannins are highly biologically active. According to epidemiological records, tannins show many therapeutic effects in various diseases [82]. Tannins are absorbable as they acquire structures of low molecular weight and antimicrobial, and radical scavenging. Tannins are also known as highly absorbable as they acquire structures of low molecular weight and show pharmacological effects in various diseases [82]. Tannins are known for its number of in vitro activities such as antimicrobial and antioxidant activity. Tannins tend to inhibit the peroxidation of lipids are well known for their free-radical scavenging activity which is majorly dependent on the degree of polymerization and its structure [83-85]. The free-radical scavenging activity is highly beneficial for weight loss. Therefore, tannins can be used for antiobesity activity. It is summarized in Table 3.

### The antiobesity activity of alkaloids

Alkaloids are found through plant tissues in the form of water-soluble salt these organic acids such as tartaric, citric, malic, acetic, and oxalic acids, some esters such as atropine, aconitine, cocaine, and scopolamine. These are combined with sugars or tannins instead bases which are in the free form [90-92]. Alkaloids are isolated in the form of amorphous, non-odorous, nonvolatile, and crystalline compounds from matrices of plants. Those alkaloids which have low molecular weight are found in liquid form, for instance, pilocarpine and arecoline [93]. Alkaloids are pharmacologically very active and are used as antispasmodic, anesthetics, narcotics, hallucinogenic, used in ophthalmic preparations, anti-inflammatory, antiviral, expectorant, cardiotonic, diuretic, analgesic, antiglucosidase, antihypertensive, and hyperglycemia [94]. Alkaloids are also helpful in weight reduction which has been proved by different studies, summarized in Table 4.

### The antiobesity activity of resins

Resins are by-products that are metabolically derived from the tissues of plants. Resins consist of combinations of various chemical entities such as terpenoids fatty acids and secondary phenolic constituents. Resins can be obtained from the plants through an incision or can be

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### Table 3: Representing the antiobesity effect of tannins

| Scientist name             | Tannins name | Source of tannins | Study model | Observation | Molecular mechanism of action |
|----------------------------|--------------|-------------------|-------------|-------------|------------------------------|
| Jinning Liu et al. (2018)  | Epigallocatechin gallate | Green tea | Cell culture (C. elegans) | Reduction in fat accumulation; Inhibition of adipogenesis; reduction in fat content | Decreased atg1-1 expression |
| L-K Han et al. (1998)      | (7)-epicatechin, (7)-epigallocatechin gallate | Thea sinensis L. | Animal model (ICR female rats) | Reduction in body weight; Reduction in fat accumulation; Reduction in TGs | Activation of adenyl cyclase cyclic AMP (AMP) phosphodiesterase cycle increased HSL mRNA expression |
| Zhen-Hui Cao et al. (2011) | Catechins | Pu-erh tea | Animal model (Male Sprague Dawley rats) | Increased LPL; Decreased Hepatic lipase; Decreased fat accumulation; Decreased body weight | |
| T Murase et al. (2002)     | Catechins Caffeine | Coffee beans | Animal model C57BL/6 mice | Reduction in fat accumulation of liver; reduction of body weight; Reduction in hepatic triglycerides | SREBP-1 regulation lowered down; Acetyl CoA Carboxylase regulation lowered down |

atg1-1: Adipose triglyceride lipase, HSL: Hormone sensitive lipase, SREBP-1 – Sterol regulatory element – binding protein, TGs: Triglyceride, LPL: Lipoprotein lipase

### Table 4: Representing the antiobesity effect of alkaloids

| Scientist name             | Alkaloid name | Source of alkaloids | Study model | Observation | Mechanism of action |
|----------------------------|---------------|---------------------|-------------|-------------|---------------------|
| Kyung Jin Kim et al. (2011) | Piperine Pippertonine dehydropipernonine | Piper retrofractum Vahl | Animal model (C57BL/6 mice); Cell culture (3T3-L1 adipocytes and L6 myocytes) | Animal model (C57BL/6 mice); Cell culture (3T3-L1 adipocytes and L6 myocytes) | Activation of AMP signaling: Altered lipid metabolism; Activation of PPAR5 |
| Hyounjeong Choi et al. (2009) | Citric acid Pectin esterase | Cucurbita moschata | Animal model (Male C57BL/6 Mice) | Reduction in TG accumulation; loss in body weight; Loss in fat accumulation | Inhibit adipocyte differentiation; control PPARs, and increase FA-oxidation |
| Gyo-Nam Kim et al. (2016)  | Citric acid Dehydrocypripedium | Diospyros kaki | Animal model (Male ICR mice) | Body weight reduction; reduction in triglyceride level; reduction in fat accumulation Decreased adipocyte differentiation; decreased fat accumulation; decreased triglycerides level | Inhibition of pancreatic lipase by free radical scavenging Diminished expression levels of the H-6 and TNF-α gene |
| S. Haaz et al. (2005)      | Caffeine | Camellia sinensis | Animal model (Sprague-Dawley (SD) male rats) | | |

AMP: Adenosine monophosphate, PPAR5: Peroxisome proliferator activated receptor delta, PPARα: Peroxisome proliferator activated receptor alpha, FA: Fatty acid, IL-6: Interleukins 6, TNF – α: Tumor necrosis factor, TGs: Triglycerides
naturally exuded out by the plants surface, sometimes infections also cause resins to exude out of the plant surface and hence are also termed as internal resins [99,100]. Resins are also obtained from insects, for an instance Laccifer laca, an insect species produces resins which are known as lac resin [101]. There are classified into different types such as lacquer resins, oleoresins, varnishes, balsams, and miscellaneous resins. The mono and sesquiterpenes are volatile whereas resins belonging to angiosperms are nonvolatile [102]. Resins are potentially naturally exuded out by the plants surface, sometimes infections also cause resins to exude out of the plant surface and hence are also termed as internal resins [99,100]. Resins are also obtained from insects, for an instance Laccifer laca, an insect species produces resins which are known as lac resin [101]. There are classified into different types such as lacquer resins, oleoresins, varnishes, balsams, and miscellaneous resins. The mono and sesquiterpenes are volatile whereas resins belonging to angiosperms are nonvolatile [102]. Resins are potentially

RESULTS
Jillions of studies have confirmed the therapeutic effect of herbal drugs in the management of various illnesses and disorders. More than 2000 herbs are known and verified for its pharmacological activities. Herbal drugs have the potential to treat obesity through different mechanisms including lipid peroxidation, free-radical scavenging activity, and inhibition of fat accumulation. Based on our interpretations, we have concluded that the herbal drugs constituting active constituents such as tannins, alkaloids, resins, saponins, and flavonoids are effective in lowering the blood TGs level, lipid accumulation in the liver, fat accumulation, adipocyte differentiation, and ultimately decrease body weight with almost negligible toxicity.

CONCLUSION
In this review, we have discussed the different mechanisms of action of multiple herbs in obesity treatment. Herbal drugs have potential to treat obesity through different mechanisms including lipid peroxidation, free-radical scavenging activity, and inhibition of fat accumulation. On the basis of our interpretations, we have concluded that the herbal drugs constituting active constituents as tannins, alkaloids, resins, saponins, and flavonoids are effective in lowering the blood TGs level, lipid accumulation in the liver, fat accumulation, adipocyte differentiation, and ultimately decrease body weight with almost negligible toxicity.

AUTHOR’S CONTRIBUTIONS
Literature search, manuscript framing, and preparation have been done by Madhvi Chaubey. Reviewed and editing have been done by Dr. Ankita Wal. The concept has been presented by Dr. Pranay Wal.

CONFLICTS OF INTEREST
The authors have declared no conflicts of interest.

FUNDING SOURCE
Nil.

REFERENCES
1. Mesenes MM, Flores ME. Flavonoids: A Promising Therapy for Obesity Due to the High-fat Diet. London, United Kingdom: IntechOpen; 2019.
2. Bollapragada MK, Shantaram M, Kumar R. Obesity: Development, epidemiology, factors affecting, quantity, health hazards, management and natural treatment-a review. Int J Pharm Pharm Sci 2017;9:12-26.
3. Yoon YS, Kwon AR, Lee YK, Oh SW. Circulating adipokines and risk of obesity related cancers: A systematic review and meta-analysis. Obes Res Clin Pract 2019;13:329-39.
4. Ahirwar R, Mondal PR. Prevalence of obesity in India: A systematic review. Diabetes Metab Syndr 2019;13:318-21.
5. Bjelonic J, Velicki R, Popovic M, Bjelica A, Jevtic M. Prevalence and some risk factors of childhood obesity. Nutrition 2017;19:138-45.
6. Lagerros YT, Rossner S. Obesity management: What brings success? Adv Nutr 2016;7:77-88.
7. Patel DK, Stanford FC. Safety and tolerability of new-generation anti-obesity medications: A narrative review. Postgrad Med 2018;130:173-82.
8. Wharton S. Current perspectives on long-term obesity pharmacotherapy. Can J Diabetes 2016;40:184-91.
9. Oo SS, Rao M, Zin T. Prevalence and factors associated with obesity among adult at the Kampung Kolam, East coast Malaysian peninsula-a cross sectional study. Int J Pharm Pharm Sci 2017;9:273-28.
10. Chellan N, Joubert E, Strijdom H, Roux C, Louw J, Muller CJ. Aqueous extract of fermented honeybush (Cyclopia maculata) attenuates STZ-induced diabetes and β-cell cytotoxicity. Planta Med 2014;80:622-9.
11. Schulze AE, Beer D, Mazibuko SE, Muller CJ, Roux C, Willenburg EL, et al. Assessing similarity analysis of chromatographic fingerprints of Cyclopia subternata extracts as potential screening tool for in vitro
Characterization of plant-derived saponin natural products to clinical use. A water-soluble extract of rhizome on the development of in vivo evaluation. BMC Complement Alternat Med 2014;14:86.

Cao ZN, Gu DH, Lin QY, Xu ZQ, Huang QC, Rap H, et al. Antioxidant activities of saponins extracted from radix trichosanthis: An in vivo and in vitro evaluation. BMC Complement Alternat Med 2014;14:86.

Chen Y, Miao Y, Huang L, Li J, Haiyan S, Zhao Y, et al. Antioxidant activities of saponins extracted from radix trichosanthis: An in vivo and in vitro evaluation. Asian J Pharm Clin Res, Vol 13, Issue 9, 2020, 13-19.

Kar A. Pharmacognosy and Pharmacobiotechnology. 2nd ed. New Delhi: New Age International Ltd.; 2003.

Swendens AB, Verpoorte R. Chromatography of Alkaloids. Part A: Thin-layer Chromatography. Vol. 23. Amsterdam, Oxford, New York: Elsevier Science Publishing Company; 1983.

Aniszewski T. Alkaloids Secrets of Life: Alkaloid Chemistry, Biological Significance, Applications and Ecological Role. 1st ed. Netherlands: Elsevier; 2007.

International Programme on Chemical Safety, WHO. Pyrrolizidine Alkaloids. Environmental Health Criteria 80. Geneva International Programme on Chemical Safety, WHO. Available from: http://www.inchem.org/documents/ehc/ehc/ehc080.htm.

Kim KJ, Lee MS, Jo K, Hwang JK. Piperidine alkaloids from Piper retrofractum Vahl. Protect against high-fat diet-induced obesity by regulating lipid metabolism and activating AMP-activated protein kinase. Biochem Biophys Res Commun 2011;411:219-25.

Choi H, Eo H, Park K, Jin M, Park EJ, Kim SH, et al. A water-soluble extract from Cucurbita moschata shows antinflammatory effects by controlling lipid metabolism in a high-fat diet-induced obesity mouse model. Biochem Biophys Res Commun 2007;359:419-25.

Kim GN, Shin MR, Shin SH, Lee AR, Lee JY, Seo BI, et al. Study of antiobesity effect through inhibition of pancreatic lipase activity of Diospyros kaki fruit and Citrus unshiu Peel. Bio Med Res Int 2016;17:123042.

Haaz S, Fontaine KR, Cutter G, Lindmi N, Chaney SP, Allison DB. Citrus aurantium and synephrine alkaloids in the treatment of overweight and obesity: An update. Obes Rev 2006;7:79-88.

Xu Y, Zhang M, Wu T, Li C, Zhang J, Zhou C. The anti-obesity effect of green tea polysaccharides polyphenols and caffeine in rats fed with a high-fat diet. Food Funct 2015;6:297-304.

Barnett JR, Langenheim JH. Plant resins: Chemistry, evolution, ecology, and ethnobotany. Ann Bot 2004;93:784-5.

Perveen A, Jahan N, Abdul W, Tanwir AM. Methods of processing of Lac (Laccifer laca Kert) described in Unani system of medicine. Res J Pharm Sci 2013;2:5-7.

Bohmann J, Keeling CL. Terpenoid biomaterials. Plant J 2008;54:656-69.

Mehrenda F, Bishl S. Ferula asafoetida. Traditional uses and pharmaceutical activity. Pharmacogn Rev 2012;6:141-6.

Carvalho KM, Filho JD, de Melo TS, Araújo AJ, Quez S, et al. The resin from protium heptaphyllum prevents high-fat diet-induced obesity in mice: Scientific evidence and potential mechanisms. Evid Based Complement Alternat Med 2015;2015:106157.

Azzizian H, Rezvani E, Esmaeiledaj M, Majid S, Sadoughi BS. Anti-obesity, fat lowering and liver steatosis protective effects of ferula asafoetida gum in Type 2 diabetic rats: Possible involvement of leptin. Iran J Diabetes Obes 2012;4:120-5.

Yadav KD, Chandrakar AK. New world syndrome (obesity) gone by. Int J Ther Radiat Oncol Biol Phys 1984;10:403-6.

Nannini S, Sreemantula S, Roufogalis BD. Protective effects of ethanol extract of Zingiber officinale thizime on the development of metabolic syndrome in high-fat diet-fed rats. Basic Clin Pharmacol Toxicol 2012;100:40-6.

Kim JH, Kim OK, Yoon HG, Park J, You Y. Anti-obesity effect of extract from fermented Curcuma longa L. through regulation of adipogenesis and lipolysis pathway in high-fat diet-induced obese rats. Food Nutr Res 2016;60:34028.

Elulla MS, Patimah I, Khara‘ai H, Rahmat A, Abood Y. Obesity and inflammation: The linking mechanism and the complications. Arch Med Sci 2017;13:851-63.

Danesh J, Kaptoge S, Mann AG, Sarwar N, Wood A, Angleman SB, et al. Long-term interleukin-6 levels and subsequent risk of coronary heart disease: Two new prospective studies and a systematic review. PLoS Med 2008;5:78.

Hansson GK. Inflammation, atherosclerosis, and coronary artery disease. N Engl J Med 2005;352:1685-95.

Sarvottam K, Yadav RK. Adiponectin, interleukin-6, and endothelin-1 correlate with modifiable cardio metabolic risk factors in overweight/obese men. J Altern Complement Med 2014;20:419-20.

Chen SJ, Yen CH, Huang YC, Lee BJ, Hsia S, Lin PT. Relationships between inflammation, adiponectin, and oxidative stress in metabolic syndrome. PLoS One 2012;7:e45656.

Arison O, Aral M, Sasmaz S, Ciragil P. Serum levels of TNF-alpha, IFN-gamma, IL-6, IL-8, IL-12, IL-17, and IL-18 in patients with active psoriasis and correlation with disease severity. Mediators Inflamm 2005;2005:5723-9.

Trayhurn P, Wood I. Adipokines: Inflammation and the pleiotropic role of white adipose tissue. Br J Nutr 2004;92:347-55.