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INTEGRATION OF HERBAL MEDICINES WITH CURRENT NANOTECHNOLOGY; A NEW ERA IN OBESITY MANAGEMENT IN FUTURE

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ABSTRACT: Obesity and overweight is excessive or abnormal accumulation of fat in body that presents a risk to health. Overweight and obesity have reached epidemic proportions, with over four million individuals dying every year as a result of their condition. Different approaches comprising biological sources, different drug therapy, have been used in obesity treatment; though, these unoriginal selections linger unproductive and carry risks of adverse drug reaction. Hence, treatment with high efficacy and specificity is the need of the hour. Novel drug delivery system use herbal medicines and chemical entities to develop healing efficacy, target oriented through herbal approach for equilibrium, controlled release of antiobesity agents. In this review, we provide insights into current treatments for obesity with a focus on recent developments of herbal polymeric carriers for improved antiobesity drug delivery.

INTRODUCTION: Obesity is a complex, chronic disease caused due to excess accumulation of adipose tissues in the body. Obesity is communal health problem evaluated in terms of fat deposition. It is the ratio between height and body mass, uneven fat distribution in human body that results in impact on health of the normal person along with financial economic burden. Obesity is confined based on 0BMI range, an individual with BMI 40 kg/m^2 is severe and the one ranging in between 40–44.9 kg/$m^2$is morbid [1]. Excess fat deposition is associated with Cardiovascular, Diabetes Mellitus, Breast cancer, Asthma, Arthritis etc. BMI affects in woman's pregnancy, chance of miscarriage, fetal abnormalities, increased risk of caesarean and delivery complications.

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Prevalence of obesity is rising globally and is considered as a life-threatening health issue. The WHO, also depicted raise in epidemiological obesity rates in US 14.5% - 30.9% [2]. In vice versa death risk is lower at a BMI having range at of 20–25 kg/m^2. Obesity is fifth leading cause of death worldwide [3]. The other parameters that indicate obesity besides raise in BP are increase in cholesterol, Triglycerides level [4]. Sedentary behavior plays an important part in obesity management; according to some estimates, 30 percent of the world's population neglect to do enough exercise [4-9]. Conventionally obesity was treated with synthetic medications, which resulted in ADRs such as dry mouth, restlessness, and insomnia.

Most antiobesity medications in the Sympathomimetic category include withdrawal effects such as increased heart rate and blood pressure. Rimonabant, a cannabinoid-1 receptor antagonist, and Fenfluramine anti-obesity treatments such as sympathomimetic amines have been pulled from the market. Pancreatic lipase is a key enzyme in the absorption of fats into monoglycerides and free fatty acids and is secreted by the pancreas. The fat deposition in adipose tissue is changed when this enzyme is blocked. Due to their site specificity, binding sites, and improved specificity for drug targeting properties, various nanoparticles have been designed for obesity management use. The drug can be shielded from premature release and degradation by the herbal carrier [8, 9, 10].

Management of Obesity: Obesity is a public health problem that develops as a result of a lack of balance in nutrition, eating habits, daily routine, treatment side effects and management strategies. The importance of successful interventions cannot be overstated. Traditional therapies include a well-balanced diet, regular exercise, medication such as natural or synthetic remedies and surgical treatment such as baroctomy. When dealing with obesity, the patient should follow a balanced diet plan, make lifestyle changes, and prevent gaining energy from junk food. Beverage consumption, particularly alcohol and soft drinks, should also be avoided [11]. Orlistat (Xenical), Liraglutide (Saxenda), Naltrexone (Contrave), Phentermine (Adipex-P), and Phentermine (Qsymia) are synthetic medications used to prevent fat deposition in pharmacotherapeutics and obesity management. However, commonly prescribed medications are ineffective in the treatment of obesity, and they come at an exorbitant price, and with a slew of negative side effects such as mental disorders and increased risk of heart disease [12]. Supplementary studies on obesity and its cofactors such as diabetes, blood pressure, and soon have being carried out. Moving away from traditional anti-obesity medications such as herbs, medicinal plants have active constituents such as flavonoids, polyphenols, and alkaloids constituents in their management to reduce significant ADRs when compared to currently available manufactured drugs.

Conventional Obesity Treatments: Diet treatments, which include a decrease in energy intake and increase in energy expenditure to reduce obesity, have been a major focus of this research over the past decade.

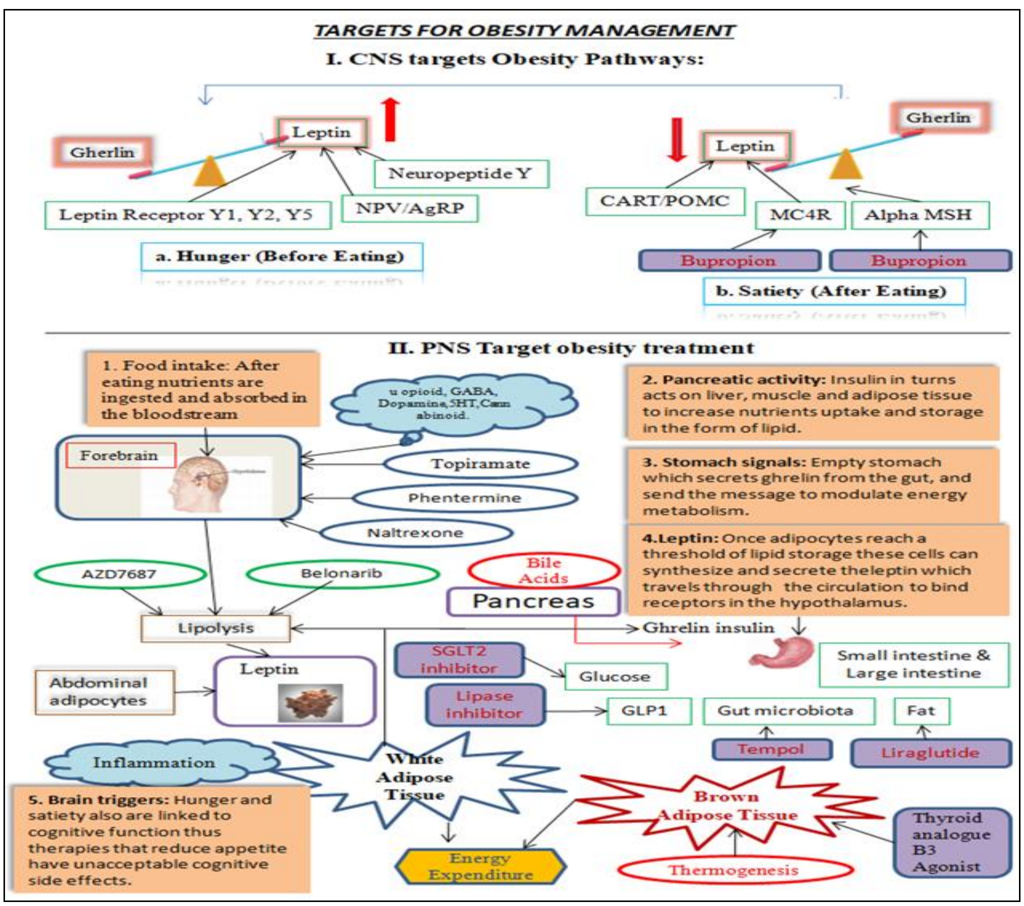


FIG. 1: OVERVIEW OF CONVENTIONAL TREATMENT APPROACHES FOR OBESITY MANAGEMENT

In today's world, investigators, experts, dieticians, doctors, and surgeons place a premium on study into the most effective weight reduction diets, such as the low-fat diet, reasonable fat diet, low carbohydrate diet, high protein diet, or extremely low-calorie diets [13]. Obesity treatment relies heavily on patient compliance when it comes to food. Following that, the primary goal of obesity therapy is to provide the proper food in order to enhance the compliance level of patients with higher BMI levels, both women and men. One of the most important aspects of obesity management is to eat healthier foods and engage in regular physical activity. This reduces the risk of long-term weight gain [14, 15].

Pharmacotherapy for Obesity: The BMI range and severity of obesity or type of obesity were used to determine which drugs were administered as an additive therapy. The BMI range is 30 Kg^2 to 27 Kg^2. Obese people who are overweight are advised to reduce their food intake and increase their daily activity. Obesity-causing medications; the list of medicines that raise BMI is mentioned in the table, that includes few drug which are used for antiobesity treatment [16]. **Table 1** USFDA approved drugs such as Belviq (Lorcaserine), Aminorex, PPA are based on the mechanism of preventive hunger through reducing the level of neurotransmitters like 5HT, norepinephrine, dopaminergic drugs, withdrawn from market due to contrary effects psychiatric illnesses MI. **Table 2** Weight control drugs like orlistat, an inhibitor of gastric, pancreatic lipase which impede the nutritional fat absorption [31]. In light of herbal medicine's widespread acceptance for obesity therapy, owing mostly to lower ADR, an increase in public demand for a herbal carrier strategy to obesity treatment, as described in **Table 3** [17, 18].

TABLE 1: COMMONLY USED MEDICATIONS FOR THE TREATMENT OF OBESITY WITH THEIR DOSES AND MAJOR SIDE EFFECTS

S. no.	Name	Dose	Side effects
1	Phentermine	3.75/23 mg,15/92 mg once daily	Dizziness, Parasthesia, Rise in blood pressure
2	Lorcaserin	10 mg twice daily	Headache, Nausea, Vomiting
3	Naltrexone	32 mg/360 mg 2 tablets, Four times daily	Nausea, Vomiting, Headache,
4	Liraglutide	3.0 mg injection once daily	Nausea, Vomiting, Pancreatitis
5	Bupropion	32 mg/360 mg 2 tablets	Vomiting, Headache, Nausea, Dizziness, Rise in blood pressure

TABLE 2: DRUG CLASSES ASSOCIATED WITH WEIGHT GAIN/DRUG-INDUCED OBESITY, THEIR DOSES AND SIDE EFFECTS

S. no.	Medicines induce Obesity	Dose	Side effects
1	Antipsychotics e.g. Clozapine, Olanzapine	25 mg - 50 mg/day, Higher dose: 900 mg/day	Nausea, vomiting,
2	Antidepressants e.g. Tricyclic antidepressant	75 - 100 mg/day, more than 100 mg/day	Dry mouth, Blurred vision, Dizziness or light-headedness, Drowsiness, Restlessness
3	Antimanics e.g. Lithium	600 mg oral 2 - 3 times/day, 900 mg oral 2 times/day, 600 mg oral 2 times/day	Confusion, Loss of memory, fainting, fast or irregular heartbeat or pulse
4	Anticonvulsants e.g. Valproate, Gabapentin	10-15mg/ kg/day oral route, Doses more than 250 mg/day, 5 - 10 mg/kg/week	Bleeding gums, Swelling of the arms, hands, feet, Cough, confusion
5	Antimigraine and Antihistaminergic drugs e.g. Cyproheptadine, flunarizine, Pizotifen	4 mg - 20 mg/day in children	Drowsiness tired, Sleep problems, spinning sensation
6	Antidiabetic agent's e.g. Glitazones, insulin	15 mg/ day, 45 mg oral/day, 45 mg oral/day.	Allergic reaction, Difficult breathing, symptoms of liver damage
7	Glucocorticoids e.g. Dexamethasone	5 - 60 mg orally/day	Swelling, Increase bodyweight, feeling Shortness of breath, Depression
8	Beta adrenergic receptor blocker e.g. Propranolol, Atenolol.	0.6 mg/kg orally 2 times/ day	Depression, Confusion, Liver problems
9	Sex hormones e.g. Estrogen, Tamoxifen	3 mg three times per day for adults, 30 – 20 mg injected into	Fever, Skin inflammation, Pain in joints and itching

10	Others e.g. Anti-neoplastic agents.	a muscle every 4 weeks as per need. 5mg/ml in injectable solution form, 20 mg powder for the injection	Nausea, Vomiting, Arrhythmias, Alopecia

TABLE 3: ANTI-OBESITY AGENTS UNDER PHASE II AND PHASE III CLINICAL TRIALS

S. no.	Medicines in phase II trials	Medicines in phase III trials
1	Dopaminergic inhibitore.g. Bupropion	Adrenergic agonist e.g. Mazindol
2	CCK A antagonist e.g. Linitript	SSRT inhibitor e.g. Sertraline
3	Pegylated leptin	TRH analogue e.g. Posatirelin
4	DPP IV inhibitors	Cannabinoid antagonists
5	Human growth hormone e.g.AOD9604	Lipase inhibitor, ATL-962
6	Phytostanol	Lipase inhibitor

Advance Clinical Treatment Aspects: Despite progress over the last two decades, traditional obesity therapy approaches are frequently insufficient for protecting ME and avoiding life-threatening ADRs. Surgical techniques include GIT bypass, gastrectomy, adaptive gastric band, biliopancreatic diversion, and duodenal switch [19]. Surgical procedures are simple to do for patients with weight gain who are not responding to drug therapy and a diet regimen has been shown to be useful in the treatment of obesity [20].

Confines over Traditional Antiobesity Treatment: Obesity treatment options are limited due to adverse drug reactions (ADR). When consumers choose for a conservative treatment, they are usually disappointed. Despite the diet therapy, the most significant drawback of the obese patient's is sporadic adherence to the diet, which results in erratic results, implying dissatisfaction with the therapy. Hypertension, dyslipidemia increased risk of mental ADRs including Depression, Anxiety, Stroke, and nonfatal myocardial infraction are all risk factors associated with obesity treatment. The most common adverse reaction to the medications sibutramine and orlistat is an increase in heart rate and blood pressure. These ADRs of conventional obesity management play an important role in changing social views to natural remedies for obesity management [21, 22].

Herbal Nanotechnology for Obesity Treatment: Herbal nanotechnology has had an impact on the development of innovative NDDS. Sizes of vesicles range from 10 to 100 nm. The novels are concerned with increasing drug bioavailability in order to increase drug interest. This nanocarrier plays a critical role in nanotherapeutics, which are derived from herbs such as apigenin, revesetrol, piperine, and capsaicin. At the nanoscale level, the surface area of the nanocarrier increases, allowing for the loading of nanoparticles at therapeutic and diagnostic levels for the treatment of obesity.

This herbal nanotechnology based on a new method has explored to increase bioavailability result in improved cell uptake, controlled release, improved solubility, therapeutic drug target, reduced dose, enhancement in pharmacological action compared to the free herbal drugs. Nano therapy which helps in treatment of Cancer, Dibetes, Obesity, Viral infection, long term hormonal therapy means in case assisted reproductive procedures. Henceforth integration of herbal medicines with current nanotechnology opens a new era in obesity therapeutics in upcoming future [70, 71, 73, 74].

Nanocarrier for the Targeted Drug Delivery System: Obesity has been treated with herbal nanocarriers such as Reseversetrol, Capsicin, and hydrocitric acid. These medications have been combined in obesity control using various nanocarriers such as liposomes, micelles, polymeric nanoparticles, gold, silver, PEG, Dendrimers, and SLN integrated biomolecules at specified sites **Table 4, 5** and **6** [75, 76, 79, 80, 100].

TABLE 4: NANOCARRIERS EMPLOYED IN DRUG DELIVERY SYSTEMS FOR OBESITY MANAGEMENT

S. no.	Carrier matrix (Nanocarrier)	Experimental model	Reference
1	PLGA	Mice fed HFD, Normal diet	90,98
2	Methylcellulose-gold nanoparticle	3T3-L1 cells.	91,98

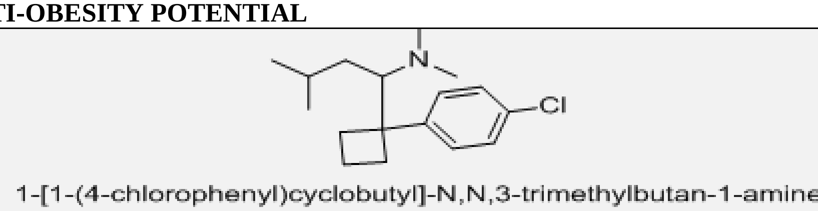
3	Hydrocitric acid	HFD induced obese mice	92,98
4	PCL	Obese rats induced by hypothalamic lesion using monosodium L-glutamate	93,98
5	Chitosan	HFD-induced obese rats	94,98
6	Cerium oxide	Lean rats	95,98
7	Gold	Mice fed HFD or normal diet	96,98
8	Linseed oil	HFD-induced obese mice	97,98

TABLE 5: MEDICINAL PLANTS REPORTED TO POSSESS ANTI-OBESITY POTENTIAL

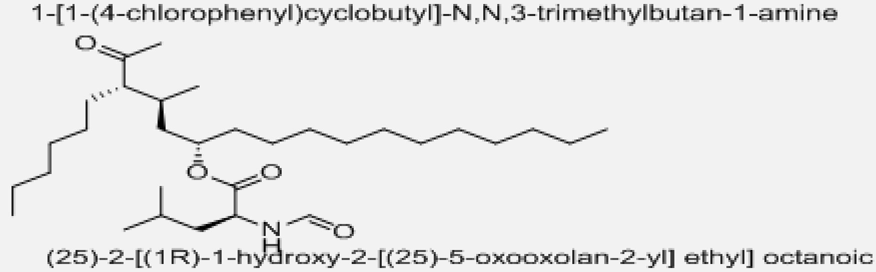
S. no.	Plant name	Family	Parts used	Reference
1	*Achyranthes aspera* Linn	Amaranthaceae	Seed	29
2	*Acorus calamus* Linn	Araceae	Roots and leaves	30
3	*Achyranthesbidentata* Blume	Amaranthaceae	Root	31
4	*Actinidia polygama* Max	Actinidiaceae	Fruits	32
5	*Ade nophora triphylla* Hara	Campanulaceae	Root	33
6	*Aegle marmelos* Linn	Rutaceae	Leaves	34
7	*Allium cepa* Linn	Amaryllidaceae	Peel	35
8	*Allium fistulosum* Linn	Liliaceae	Root	36
9	*Allium nigrum* Linn	Amaryllidaceae	Bulb	37
10	*Allium sativum* Linn	Amaryllidaceae	Stem, Bulb and Root	38
11	*Alpinia galanga* Linn	Zingiberaceae	Rhizome	39
12	*Alpinia officinarum* Hance	Root		40
13	*Angelica gigas* Naka	Apiaceae	Roots	41
14	*Argyreia nervosa* Bojer	Convolvulaceae	Root	42
15	*Artemisia iwayomogi*	Compositae	Whole Plant	43
16	*Atractylodes lancea*	Compositae	Rhizome	44
17	*Aster pseudoglehni* Lim	Asteraceae	Leaves	45
18	*Bauhinia variegate* Linn	Leguminosae	Stem, root Barks	46
19	*Bergenia crassifolia* (L.) Fritsch	Saxifragaceae	Leaf	47
20	*Boehmeria nivea* (L.) Gaudich	Urticaceae	Leaf	48
21	*Bombax ceiba* L.	Malvaceae	Stem bark	49
22	*Anredera cordifolia*	Basellaceae	Leaves	50
23	*Brassica rapa* L	Brassicaceae	Root	51
24	*Buddleja officinalis*	Scrophulariaceae	Whole Plant	52
25	*Bursera grandiflora*	Burseraceae	Roots	53

TABLE 6: CHEMICAL STRUCTURES OF SELECTED SYNTHETIC ANTI-OBESITY DRUGS AND BIOACTIVE PHYTOCONSTITUENTS WITH ANTI-OBESITY POTENTIAL

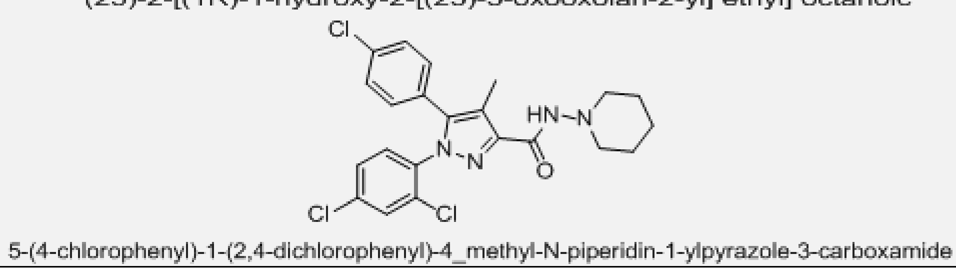
Sibutramine

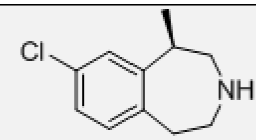
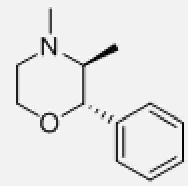
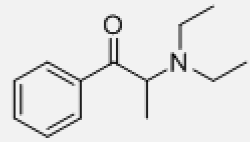
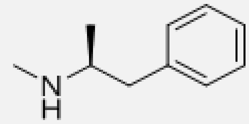
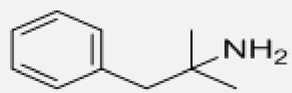
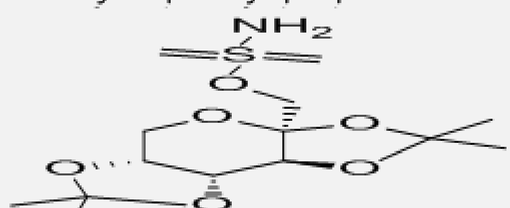
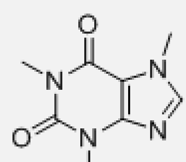
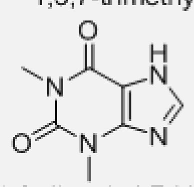
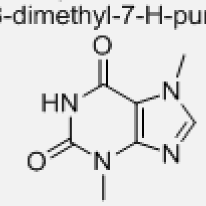


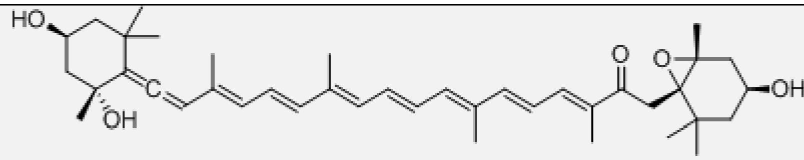
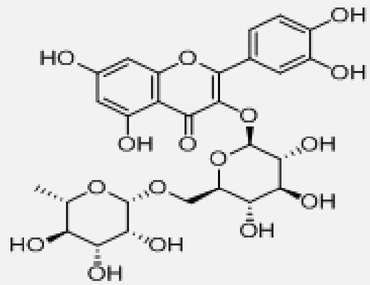
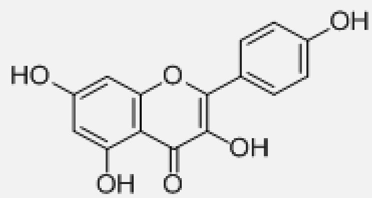
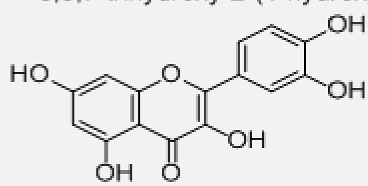
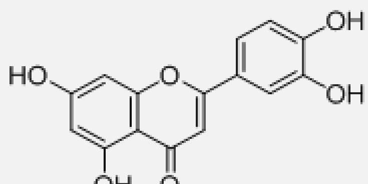
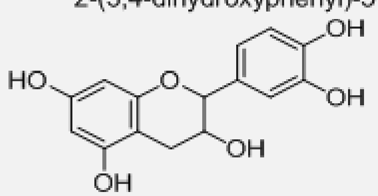
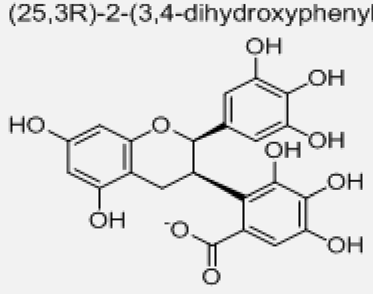
Orlistat

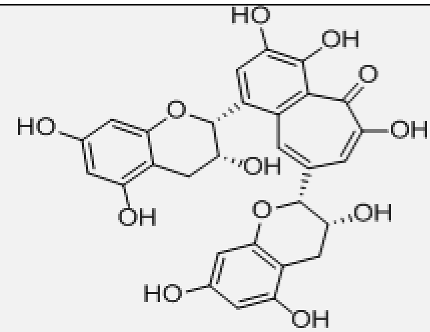
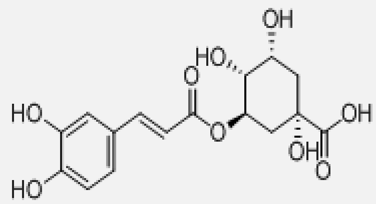
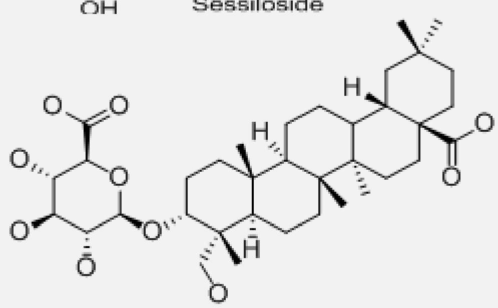
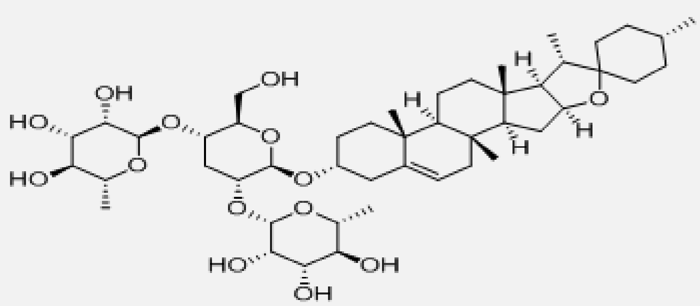


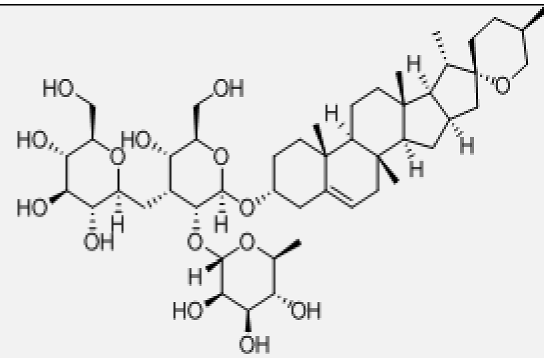
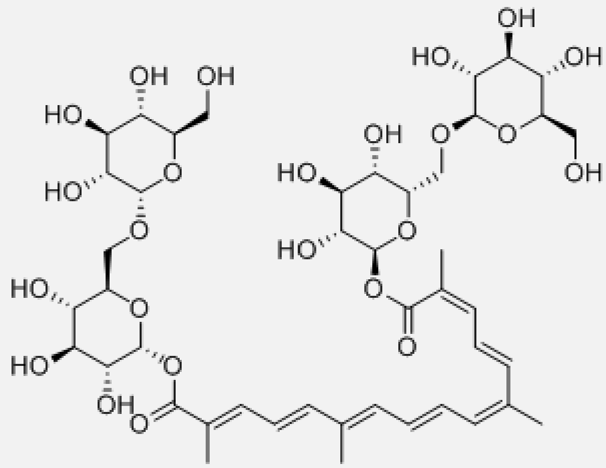
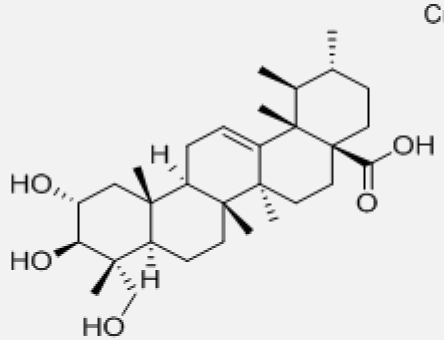
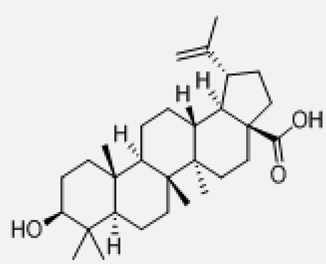
Rimonabant

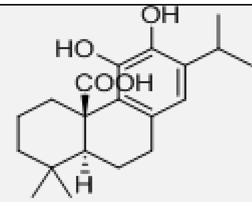
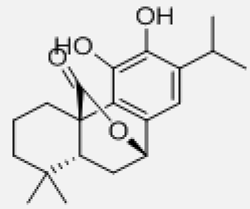
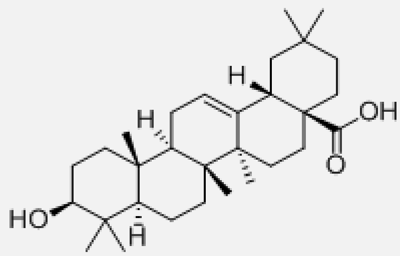
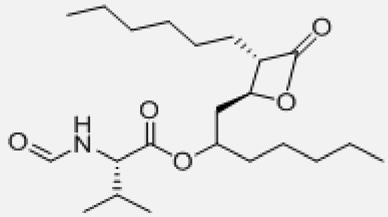
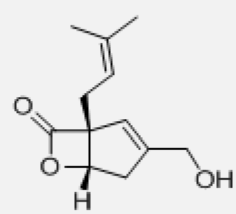
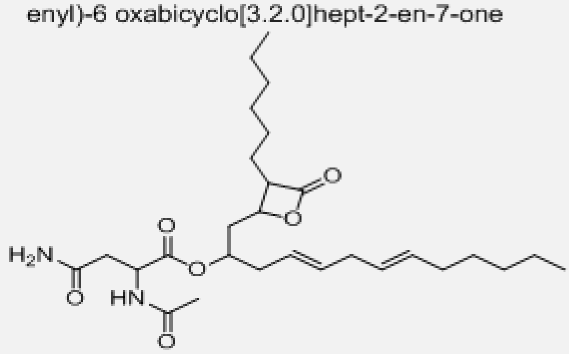


Lorcaserine	 (5R)-7-chloro-5-methyl-2,3,4,5-tetrahydro-1H-3-benzazepine
Phendimetrazine	 (2S,3S)-3,4-dimethyl-2-phenylmorpholine
Diethylpropion	 2-(diethylamino)-1-phenylpropane-1-one
Methamphetamine	 (2S)-N-methyl-1-phenylpropane-2-amine
Phentermine	 2-methyl-1-phenyl-propan-2-amine
Topiramate	 [(1R,2S,6S,9R)-4,4,11,11-tetramethyl-3,5,7,10,12-pentaoxatricyclododecan-6 yl] methylsulphamate
Caffeine	 1,3,7-trimethylpurine-2,6-dione
Theophylline	 1,3-dimethyl-7-H-purine-2,6-dione
Theobromine	 3,7-dimethylpurine-2,6-dione

Fucoxanthinol	 (3E,5E,7E,9E,11E,13E,15E)-18-[(2R,4S)-2,4-dihydroxy-2,6,6-trimethylcyclohexylidene]-1-[(1S,4S,6R)-4-hydroxy-2,2,6-trimethyl-7-oxabicyclo[4.1.0]heptan-1-yl]3,7,12,16-tetramethyloctadeca-3,5,7,9,11,13,15,17-octaen-2-one
Rutin	 2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2S,3R,4S,5S,6R)-3,4,5-trihydroxy-6-[[(2S,3R,4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl]oxymethyl]oxan-2-yl]oxychromen-4-one
Kaempferol	 3,5,7-trihydroxy-2-(4-hydroxyphenyl)chromen-4-one
Quercetin	 2-(3,4-dihydroxyphenyl)-3,5,7-trihydroxychromen-4-one
Luteolin	 2-(3,4-dihydroxyphenyl)-5,7-dihydroxychromen-4-one
Catechin	 (25,3R)-2-(3,4-dihydroxyphenyl)-3,4-dihydro-2/chromene-3,5,7
(-)-epigallocatechin	 [(2R,3R)-5,7-dihydroxy-2-(3,4,5-trihydroxyphenyl)-3,4-dihydro-2H-chromen-3-yl]3,4,5-trihydroxybenzoate

Theaflavin	 3,4,5-trihydroxy-1,8-bis(2R,3R)-3,5,7-trihydroxy-3,4-dihydro-2H-1-benzopyran-2-yl]-6-H-benzo[7]annulen-6-one
Chlorogenic acid	 (1S,3R,4R,5R)-3-([(2E)-3-(3,4-dihydroxyphenyl)prop-2-enoyl]oxy)-1,4,5-trihydroxycyclohexane-1-carboxylic acid
Sessiloside	
Copteroside B	 (2S,3S,4S,5R,6R)-6-[[(3S,4R,4aR,6aR,6bS,8aS,12aS,14aR,14bR)-8aepigallocatechin DidesgalloylDioscinAsiatic acidcid,Carnosol-4-(hydroxymethyl)-4,6a,6b,11,11,14b-hexamethyl 1,2,3,4a,5,6,7,8,9,10,12,12a,14,14a-tetradecahydropicen-3-yl)oxy] 3,4,5-trihydroxyoxane-2-carboxylic acid
Dioscin	 (2S,3R,4R,5R,6S)-2-[(2R,3S,4S, 5R,6R)-4-hydroxy-2-(hydroxymethyl)-6 -[(15,25,45,5'R,6R,7S,8R,95,12S,13R,16S)-5,7,9,13 tetramethylspiro[5-oxapentacyclo[10.8.0.02,9.04,8.013,18]icos-18 ene-6,2-oxanel-16-ylloxy-5-[(2S,3R,4R,5R,6S)-3,4,5-trihydroxy-6 methyloxan-2-ylloxyoxan-3-ylloxy-6-methyloxane-3,4,5-triol

Gracillin	 (25,3R,4R,5R,6S)-2-[(2R,3R,4S, 5R,6R)-5-hydroxy-6-(hydroxymethyl)-2 -[(1S,2S,4S,5'R,6R,7S,8R,9,12S,13R,16S)-5,7,9,13 tetramethylspiro[5-oxapentacyclo[10.8.0.02,9.04,8.013,18]icos-18 ene-6,2'-oxane]-16-yl)oxy-4-[(2S,3R,4S, 5S,6R)-3,4,5-trihydroxy-6 (hydroxymethyl)oxan-2-yl]oxyoxan-3-yl]oxy-6-methyloxane-3,4,5 triol
Crocin	 Crocin
Asiatic acid	 (15,2R,4a5,6aR,6aS,6bR,8aR,9R,10R,11R,12aR,14b5)-10,11hexamethyl,68,7,8,8a,10,11,12,13,14b-tetradecahydro-1H-picene-4a carboxylic acid
Betulinic acid	 (1R,3aS,5aR,5bR,7 aR,9,11aR,11bR,13aR,13bR)-9-hydroxy 5a5b,8,8,11a-pentamethyl-1-prop-1-en-2-yl,7a,9,10,11,11b,12,13,13a,13b hexadecahydrocyclopenta[a]chrysene-3a-carboxylic acid

Carnosic acid	 (4aR,10aS)-5,6-Dihydroxy-1,1-dimethyl-7-(propan-2-yl)-1,3,4,9,10,10a4a(2H)-carboxylic acid
Carnosol	 (1R,8S,10S)-3,4-dihydroxy-11,11-dimethyl-5-propan-2-yl-162,4,6-trien-15-one
Oleanolic acid	 (4aS,6aR,6aS,6bR,8aR,10S,12aR,14bS)-10-hydroxy 2,2,6a,66,9,9,12a-heptamethyl-1,3,4,5,6,6a,7,8,8a,10,11,12,13,146 -tetradecahydropicene-4a-carboxylic acid
Valilactone	 [(2S)-1-|(2S,3S)-3-hexyl-4-oxooxetan-2-yl]heptan-2-yl] (2S)-2-formamido-3-methylbutanoate
Vibralactone	 (1R,5S)-3-(hydroxymethyl)-1-(3-methylbut-2-enyl)-6 oxabicyclo[3.2.0]hept-2-en-7-one
Esterastin	 1-(3-hexyl-4-oxooxetan-2-yl)trideca-4,7-dien-2-yl 2-acetamido-4-amino-4-oxobutanoate

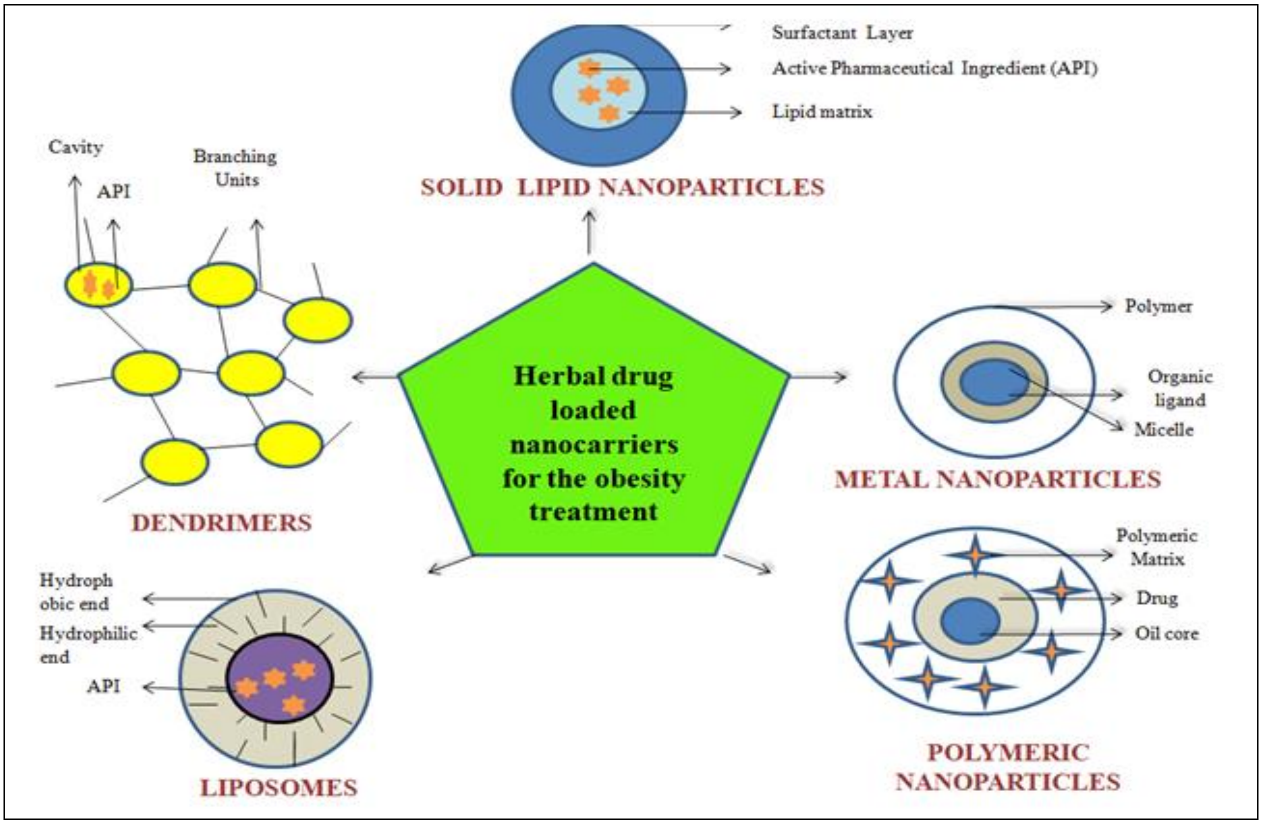


FIG. 2: SCHEMATIC REPRESENTATION OF HERBAL NANOTECHNOLOGY-BASED DRUG DELIVERY SYSTEMS FOR OBESITY MANAGEMENT

Liposomes: A concentric membrane lipid layer with a hydrophilic head on one end and a hydrophobic tail on the other end compensates nanoparticles. In the water phase, HN is integrated into lipids. Combining herbal carriers such as apigenin, reservetrol, and HA with liposomes as carriers for herbal medicine enhances the active components' stability, acceptability, and toxicity [81, 82]. Dr. Prof. Alec D. Bangham, a British haematologist, created the word liposome. Liposomes are spherical in shape and contain a double layer of water on the interior or outside. Because of their limited solubility in the aqueous phase, lipophilic and hydrophilic medicines are locked inside the double layer. Furthermore, due to RES, the edges of this two-layer DDS were swiftly eliminated from the body. The opsonin proteins, which act as a receptor on membranes with a diameter of 50–200 nm, are ejected from the bloodstream into the spaces between irregular cells in the tissue. Nanoparticles are nano-sized particles created by combining PEG molecules. PEG, PLGA, and PCL are carriers that aid in the efficient uptake of herbal drugs in the treatment of obesity [77, 78, 89].

Micelles: This technique entraps herbal drug micelles and is spherical nanosized in nature, with a hydrophobic drug at the core and a hydrophobic zone linked to the surrounding solvent [85, 86]. If you're looking for a unique way to express yourself Polymer micelles, which are widely used for hydrophobic drugs, were developed to increase RES, permeability, retention time, and to entrap various types of remedies in the inner core. PEG-2500 and PCL -1200 were used to create multifunctional block copolymer micelles. Micelles were absorbed and delivered to the nuclei of EGFR-positive BC cells in a substantial way. DDS appears to be a good treatment option for BC [89].

Solid Lipid Nanoparticles (SLN): SLN is a lipid monolayer that is nontoxic and stable and it has a hard lipid core that is employed in the DDS. It's simple to scale up production with particle sizes ranging from 50 to 1000 nm. SLN combines the herbs' low-water-soluble elements to improve absorption, stability, and reduce negative effects at the targeted site, as well as provide a longer-lasting benefit in the treatment of obesity [83, 84].

In the adriamycin-resistant HBC MCF-7 cell line, doxorubicin loaded polymeric micelles showed improved loading, prolonged release, and substantial accelerated uptake [89].

Dendrimers: This is a branched, core macromolecule with a branching structure that enables for conjugation at a specific point and is used to treat obesity. These are highly branched molecules with a well-defined core, ranging in size from 1 to 15 nm. It is divided into three sections: core, branches, and surface. Dendrimers are an ideal carrier for drug delivery because of their monodispersity, water solubility, encapsulation capabilities, and huge number of functional groups. In comparison to liposomes and micelles, dendrimer-drug conjugates are more stable, easy to synthesise, and sterilize because to their unimolecular structure. Dendrimers are distinguished from other drug delivery carriers such as micelles, liposomes, and emulsion droplets by their capacity to attach cell-specific targeting groups, solubility modifiers, and imaging tags to a dendritic surface in a well-controlled manner [89].

Metal Nanoparticles (MN- Gold, Copper): Metals like iron oxide and gold, which have benign, non-toxic qualities, are being investigated for their drug loading capability in this delivery method, which is used to treat obesity [87, 88].

Pb nanoparticles in the size range of 1 nm to 150 nm have exhibited single chemical and physical capabilities for transporting and unloading active components. Tamoxifen-polyethylene glycol-thiol gold nanoparticles conjugates were designed to selectively target the hormonal therapy for many types of reproductive diseases. Tamoxifen-polyethylene glycol- thiol GNconjugates developed to selectively target, GNused to target the hormonal therapy for different kind of reproductive disease.

Carbon Nanotubes (CN): These are graphitic carbon CN with exceptional properties that have developed as a new approach for transporting medicinal compounds. The CN site is involved in the transport of peptides, proteins, and AGCT. Simply solitary walled carbon nanotubes were used for site-specific drug administration because to cell membranes, which had decreased toxicity and immunogenicity [89].

CONCLUSION: In antiobesity management, various medicinal plants and their bioactive components differs, nanotherapeutics can help to see the potential of those bioactive substances as anti-obesity, anti-cancer, and hormonal therapy for overcoming drug side effects. Straight pharmacological therapy appears to improve the active components' therapeutic utility. The main drawback is treatment failure, which is largely due to the behavior of today's generation newborns, i.e., adolescents and adults who are predisposed to consume fats and sugar-containing foods in their daily lives [99].

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