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# Significance of Plant Secondary Metabolites in Adiposity Control

**Dr. Kul Bhaskar**
Department of Botany, Government Degree College Sukrauli, Kushinagar
kulgovt@gmail.com

**Abstract:** *The Phytochemicals especially secondary metabolites (chemical compounds found in plants), are responsible for biological activities. More than thousand phytochemicals have been identified and are present in whole grains, fruits, vegetables, nuts and herbs. Phytochemicals are basically secondary metabolites. Many naturally occurring secondary metabolites or phytochemicals (alkaloids, flavonoids, glycosides, tannins, terpenoids, polyphenols, carboxylic acid etc.) are found in various plants and possess anti-obesity properties through diverse mechanisms of action.*

**Keywords:** *Phytochemicals*

## I. INTRODUCTION

### Saponins

Plants have high concentration of bioorganic chemicals called 'saponins'. They are naturally occurring glycosides having soap-like property as they produce foam when shaken in an aqueous solution. They are classified as steroid glycosides and triterpene glycosides. In terms of structure, saponins are made up of a lipophilic triterpene molecule coupled with one or more water-loving glycoside sugar residues. Chemically, they have a minimum of one C-O sugar bond, or glycosidic linkage, at position C-3, connecting an aglycone to a sugar chain. They have various therapeutic properties: anti-inflammatory, antiviral, anticancer, antifungal, immunomodulatory, and antioxidant. The anti-obesity effects of several active constituents, including ginsenoside and diosgenin, and their mechanisms are given in Table 1. The dietary saponins, also known as bio-detergents reduces lipid synthesis, preventing intestinal lipid absorption, suppressing adipogenesis encouraging the elimination of triglycerides and bile acids in faeces. Dietary saponins suppresses appetite, prevent formation of fatty liver, protect epithelial vasculature, regulates body weight, and act as antagonists to suppress appetite and in-vitro lipid synthesis.

**Table-1**

| Phyto chemicals | Active constituents | Mechanism of action |
|---|---|---|
| **Saponins** | Diosgenin | It inhibits lipogenesis by reducing the expression of two genes (FASN, and SREBP-1c). |
| | Ginsenoside | It combats obesity by browning the white adipose tissue. |

### Flavonoids

Flavonoids are biologically active substances with variety of biological functions and are abundant in plants kingdom. These are potent inhibitors of obesity and associated metabolic problems. In its structure, it has a pyrone ring joined to a benzene ring, where a phenyl ring is substituted at position 2 or 3. Flavonoids are categorized as flavonols, isoflavones, flavones, anthocyanidins, flavanols, flavanones and chalcones. Their mechanism of action is by alteration of proteins, genes and transcriptional factors involved in promoting fatty acid B-oxidation, lowering lipogenesis, raising lipolysis, burning energy and break down and metabolize carbohydrates. Furthermore, oxidative stress is suppressed, and inflammatory reactions are mitigated. Several active constituents (apigenin, genistein, quercetin, myricetin, kaempferol, daidzein, and naringenin) contribute to anti-obesity effects and their mechanisms are described (Table 2).

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Table-2

| Phyto chemicals | Active constituents | Mechanism of action |
|---|---|---|
| Flavonoids | Apigenin | Apigenin inhibits the porcine pancreatic lipase enzyme. Its binding may affect the typical spatial shape of the pancreatic lipase active pocket. Docking tests revealed that apigenin shows its antiobesity activity by binding to 6 hub target proteins (ESR1, PPARA, MAPK14, MMP9, NR3C1, and IGF1). |
| | Genistein | It shows its action by promoting lipolysis, stimulating fatty acid oxidation, reducing adipose tissue formation, enhancing differentiation of fat cells, and provoking adipocyte apoptosis. It also upregulates genes such as PPARϒ, Cebpα, and Cebpβ. |
| | Kaempferol | It has the ability to stimulate thermogenesis and impede adipogenesis through the control of C/EBPα, PPARγ, and SREBP-1c expression. These three are recognized as the primary regulators of adipocyte development. |
| | Myricetin | It inhibits the human pancreatic lipase enzyme by binding to its allosteric site. |
| | Diadzein | 65 It inhibits lipid formation and adipogenesis by controlling C/EBP, SREBP-1c, FAS, and ACC. |
| | Naringenin | It suppresses the accumulation of fats by stimulating AMPK. |

**Terpenoids**

Terpenoids ("isoprenoids") are the biggest groups of natural compounds and are composed of isoprene units containing five carbons. Based on the number of isoprene units present, they are categorized as monoterpenoids, hemiterpenoids, sesquiterpenes, diterpenes, triterpenes, tetraterpenes, and polyterpenes. Several active constituents (betulinic acid, ursolic acid, and oleanolic acid) demonstrate anti-obesity effects their mechanisms detailed in Table No. 3. To treat metabolic disorders like diabetes and obesity, AMPK (Activated Protein Kinase) is a perfect therapeutic target. The terpenoids found in dietary or herbal plants activates AMPK, which acts as a "fuel sensor" to regulate energy homeostasis. Eating daily these terpenoids may manage obesity and other metabolic disorders associated with obesity. PPAR (Peroxisome Proliferator Activated Receptors) plays a significant role in the metabolism of lipids, which is a biomarker of obesity. They are involved in the formation of adipose tissue and adipogenesis, especially PPAR-α and PPAR-γ. Through these receptors, terpenoids affects the obesity and associated metabolic disorders. Besides, terpenoids have antiviral, antimalarial, anti-cancer, anti-inflammatory and antibacterial properties. They also have hypoglycemic properties, enhance transdermal absorption and prevent and cure cardiovascular illnesses. Furthermore, terpenoids have many uses [immunoregulation, neuroprotection, insect resistance, antioxidation, and antiaging].

Table-3

| Phyto chemicals | Active constituents | Mechanism of action |
|---|---|---|
| | Betulinic acid | It reduces the deposition of fats, decreases the enzymes associated with lipogenesis (desaturases), and alters important transcription factors (hlh-11 and nhr-49) as well as microRNAs (miR-786, miR-60, let-7, and lin-4) related to lipid metabolism. |
| | Ursolic acid | It shows its action by altering the metabolism of amino acids and the gut microbiome. By changing the JNK signaling |

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|---|---|---|
| **Terpenoids** | | pathway and insulin, it also demonstrates its anti-obesity properties. |
| | Oleanolic acid | It induces lipolysis via PKA pathway, stimulates heme oxygenase-1 expression, and decreases the oxidative stress inside the cells. |

**Alkaloids**

These are indigenous bioactive compounds, whose structures include one or more nitrogen atoms. Their pharmacological properties are: impact human health, including anti-oxidant, anti-tumor, anti-hypertensive, anti-microbial, anti-inflammatory and anti-diabetic. They show their anti-obesity activity by regulating lipid metabolism and they basically target AMPK (Activated Protein Kinase). The availability of lipids like fatty acids is reduced because it inhibits anabolic metabolism and increases lipid catabolic metabolism. Their active constituents (piperine, nuciferine, trigonelline, and capsaicin) with anti-obesity effects and are mechanisms described (Table 4).

**Table-4**

| Phyto chemicals | Active constituents | Mechanism of action |
|---|---|---|
| Alkaloids | Nuciferine | Activates brown adipose tissue and increases thermogenesis. |
| | Piperine | Impedes the absorption of intestinal fatty acids by downregulating genes linked to the uptake of fatty acids. It improves gut barrier function and aids in the reduction of obesity-related chronic inflammation. |
| | Trigonelline | By increasing the expression of genes specific to beige (Tmem26, Tbx1, Cited1, Cd137) along with brown-fat signature proteins and genes, it causes 3T3-L1 white adipocytes to brown. It also enhances white adipocyte lipid metabolism by promoting fatty acid oxidation and lipolysis while reducing lipogenesis and adipogenesis. |
| | Capsaicin | It shows its action by changing the gut microbiome, inhibiting low-grade chronic inflammation, modifying the gut-brain axis to modulate hormones that control appetite and fullness, and controlling obesity by regulating energy metabolism. |

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