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Research Article

Bioactive Compounds in Green Tea: Understanding Their Role and Limitations in Weight Management

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ABSTRACT
This review examines the relationship between green tea consumption and its potential effects on weight loss. Green tea, rich in bioactive compounds such as catechins, polyphenols, flavonoids, and caffeine, has garnered significant attention as a potential nutraceutical for weight management. The review explores the mechanisms by which these compounds influence metabolism, fat oxidation, and appetite control. Several studies involving both animal models and human subjects are analyzed to provide a balanced overview of the current body of evidence. While green tea's effectiveness in promoting weight loss varies among individuals, findings suggest an approximate 40% success rate in humans. It is important to note that green tea alone may not lead to complete weight reduction, and the inclusion of regular physical exercise is recommended to enhance its fat-reducing benefits. This review concludes that green tea a valuable addition to weight management strategies, particularly when combined with a balanced diet and exercise regimen. However, further research is warranted to elucidate the optimal dosages, durations, and potential side effects associated with its consumption for weight loss purposes

Key Words: Green Tea, Polyphenols, Weight Management, Metabolism

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1. INTRODUCTION

In 2737 BCE, the Chinese emperor Shen, unfortunately, detected tea in boiling water. A leaf from a wild tea plant leaves fall into his vessel, then he consumed that drink and felt excited .so that he examines that the tea plant contains medicative properties[1]. Later the tea plant was reported taxonomically in 1753 by carl Linnaeus in species plantarum. He proposed the tea plant Thea and later confined the species into tea (*Thea viridis*)[2].As reported by fermenting process tea is split into such categories that are, Black tea (fermented),Green tea (unfermented),Oolong tea (semifermented), and white tea (partially fermented)[3]. Early 19th-century taxonomists conceded that green tea from the Camellia sinensis species belonged to the order *Theaceae*. It is also called unorganized tea.The small variety known for green tea production is generally in eastern China, Taiwan, and Japan[3]. It is also cultivated in India's Darjeeling region to provide delicious tea. Green tea is more frequently taken from a small variety than the

broad leaf variety because of its taste[4].Nowadays, there are several varieties differentiated by their range of cultivation and processing methods they are kukicha, matcha, sencha, genmaicha, biluochun, etc[5]. The pharmaceutical and nutraceutical uses are to improve insulin sensitivity(Type -II Diabetes)[6], cancer prevention[7] (endometrial cancer)[8], cardiovascular disease[9], liver disease, antioxidant properties[3], leukoplakia[4], autoimmune diseases, and anti-obesity[3].

2. Lipid metaboloism

The food we ingest it goes through the oral route. Then it forms a bolus and directs through the esophagus by peristalsis movement. Next, it enters through the stomach which contains chief cells and parietal cells. Chief cells-secretes pepsin. Parietal cells-secretes HCl. Their metabolism of protein, carbohydrates, and fats. There are two ways of fat metabolism namely endogenous and exogenous pathway

2.1.1 Exogenous pathway

They are mainly used in the translocation of cholesterol and triglycerides. Which are actively absorbed from the ileum of the small intestine. Which gets transmitted to blood through the lymph through chylomicrons.Later, they are uptake by muscles and adipose tissues. Triglycerides are transmitted and consumed by lipoprotein lipase by activating apo c11 through Hydrolysis.Later, some are taken by tissues and metabolized it into fatty acids and glycerol.Then chylomicrons are formed from hdl. Chylomicrons contain cholesteryl esters transferred to the liver through endocytosis. Later, the cholesterol is synthesized and again oxidized to bile acids and enters the endogenous pathway[11]

2.1.2 Endogenous pathway

This pathway synthesized cholesterol and triglycerides released. It is discharged by theliver as VLDL to muscles and Adipose tissues. Triglycerides are hydrolyzed by fatty acids and glycerol. The cholesterol goes to the liver as LDL,then they are secreted as VLDL.Which gets converted to LDL by lipoprotein lipase enzyme.The cholesterol goes to the plasma membrane and turnsinto HDL through metabolism,the remaining cholesteryl esters in the liver are transported in form of LDL.Later, the tissues of the liver take LDL by endocytosis through LDL receptors by previewing APO B-100. LIPO PROTEIN TRANSPORT: Lipoproteins are transporter proteins for lipids and cholesterol.

Their composition includes Hydrophobic lipids(triglycerides, cholesteryl esters), Hydrophilic lipids in the outer core (coat of phospholipid, free cholesterol), and Apoproteins are present in the outer core of lipoprotein lipase. They consist of two kinds of proteins namely apo A and apo B that are mainly used in the metabolism of lipids by attaching to specific receptors at selective targets such as the liver,blood, or other tissue[12].

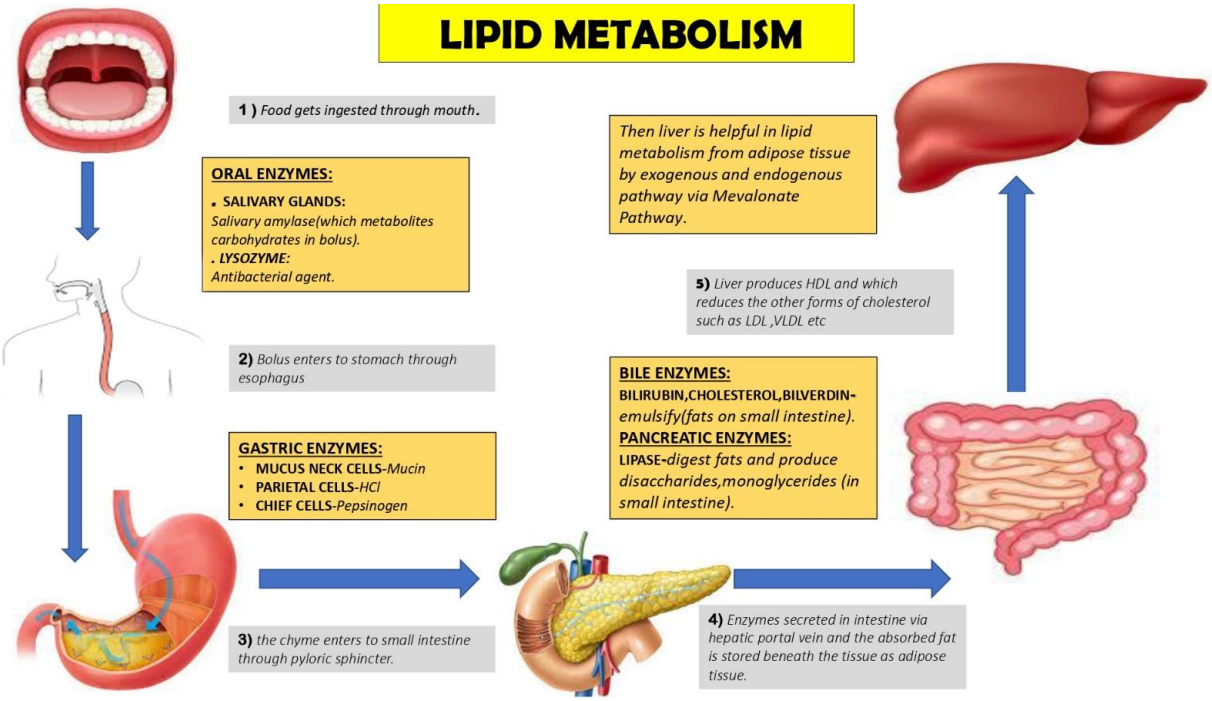


Fig 1: Process of Lipid Metabolism

3. Role of Green tea in weight loss

3.1 Chemical constituents of green tea

The chemical composition of green tea differs with genetic strain, climatic conditions, soil properties, plucking season, leaf position, and processing storage[13].

3.1.1 Catechins

This compound more excessively present in non-fermented tea such as green tea helps in a large extent of cell metabolism and gives a strong antioxidant effect on the body it comprises about 30% of the dry weight of the leaf[1].

It mainly contains four varieties of catechins they are catechins epicatechins(EC), epigallocatechin(EGC), epicatechin gallate(ECG), and epigallocatechin gallate(EGCG)[14].

3.1.2 Mechanism of action of catechins in

Catechins bind with lipid metabolism by acting on NF-kb receptor, thus, it stimulates fat oxidation, and it also inhibits the COMT(catechol-O-methyltransferase), which metabolizes the catecholamine neurotransmitter.Nor-epinephrine and Adenylyl cyclase increase and the glucose uptake decreases mediated by the glucose transporter then the hormone-sensitive lipase (HSL) adipose triglyceride lipase release for the stimulation-free fatty acid leads to lipid breakdown and the fat oxidation occurs[15].

In animal testing, The action of catechins on energy expenditure and fat oxidation decreasesthe absorption of dietary fat at the time of weight loss. It inhibits the enzymes such as pancreatic and gastric lipase the emulsification of fat[16]. Hsu et al experimented on humans, which shows the increasing removal of lipids in the feces. So,the catechins increase the stored fat oxidation on fat metabolismand dietary fat absorption decreases[17].

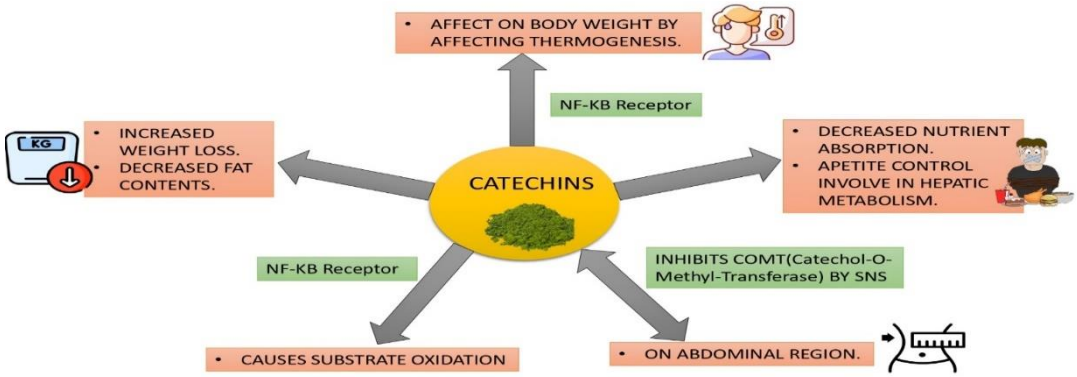


Fig 2: Mechanism of action of catechins

4. Role of Green tea flavonoids

Flavonoids are composed of theaflavins, thearubigins that exhibit antioxidant properties duringthe enzymatic oxidation of leaves. During this process, flavonoids are get converted into catechins thus they became highly water soluble, then they produce a reddish brown colored tea which gives an astringence[19].According to this thorough review, green tea flavonoids—in particular, catechins—support weight management through a variety of processes. Their varied physiological impacts and intricate structural characteristics result in modest but noteworthy metabolic advantages. While recognizing these chemicals' limits in weight control applications, knowledge of their biological mechanisms and structure-activity connections offers insight into their their therapeutic potential. The complex web of flavonoid-mediated effects emphasizes how crucial it is to view these substances as a component of a comprehensive weight-management strategy rather than as stand-alone medicinal treatments. Despite having limited individual mechanisms of action, their combined effects promote overall metabolic health.

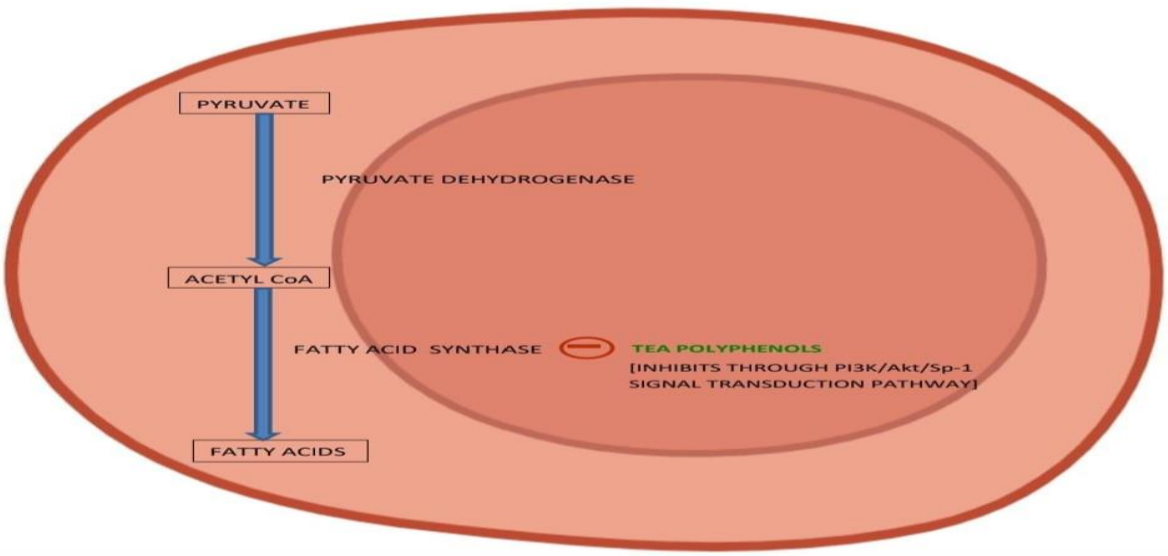


Fig 3 : Mechanism of action of flavonoids in human cell

By this mechanism20 fatty acid synthase are inhibited by a green tea polyphenols such as theaflavins and thearubigins. and blocks the activation of signal transduction pathway pi3k/akt (phophoinositide -3-kinase- protein kinase)which to regulate a normal cellular processes in cell growth, proliferation,metabolism, motility, survival, apoptosis. This leads to decrease in DNA binding capacity of nuclear transcription factor sp-1 (specificity protein) thus reduction gives a down regulation of fatty acid synthase gene ,lipid formation and growth of tissues[21].

After intake of food , glucose should metabolized into pyruvate and acetyl coA by the enzyme of glucose -6-phosphate in cytosol. Then the monomolecules are gets digested in bile and excreted. some molecules metabolized again that are the formation of lipids stored in adipose tissue and liver these stored lipids should be inhibited by the green tea polyphenols and cholesterol reduction[23].

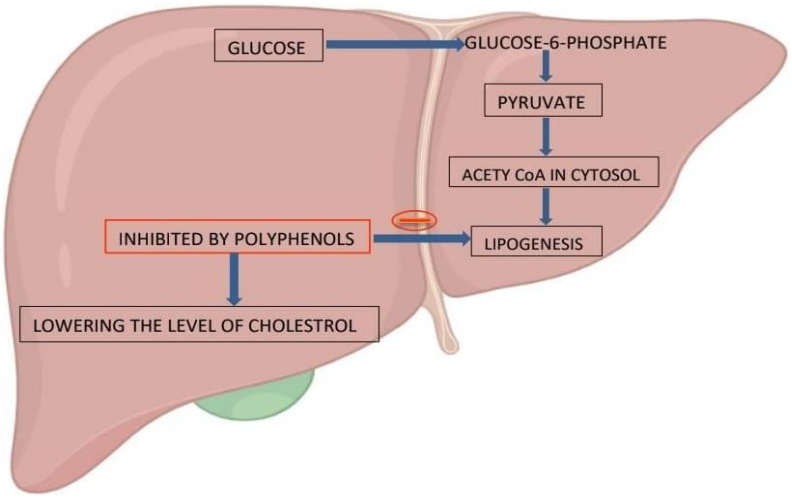


Fig 4:Action of cholesterol in liver cell and Role of Polyphenols

5. Role of Caffeine

Caffeine is a trimethyl derivative of purine 2,6-diol present in tea leaves, it acts as a CNS stimulant and increases energy metabolism. After consumption caffeine antagonizes the adenosine which decreases a norepinephrine concentration and binds to the phosphodiesterase enzyme it catalyzes the hydrolysis of Camp (cyclic adenosine monophosphate) and protein kinase which leads to an increase in the sympathetic nervous system activity. With an uncoupling of protein and brown adipose tissue get increased also energy intake is decreased, by this process fat absorption leads to a decrease[24].

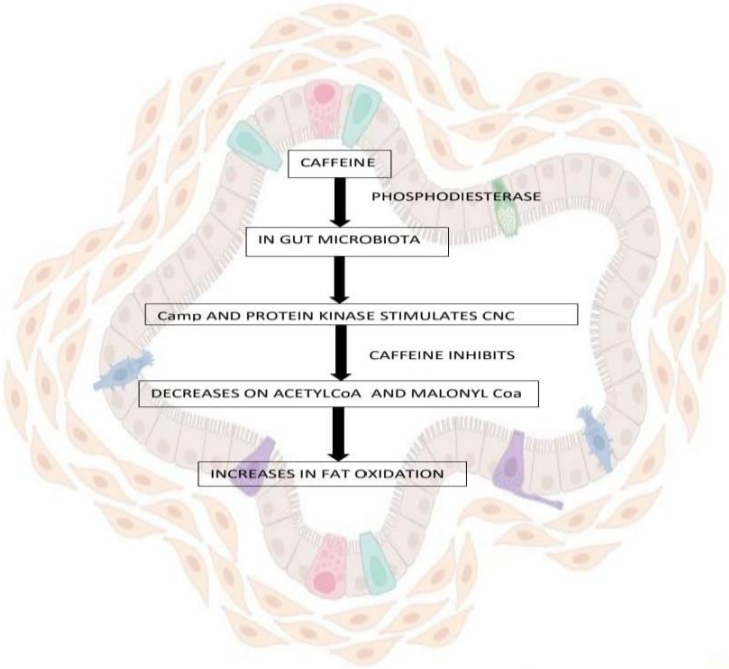


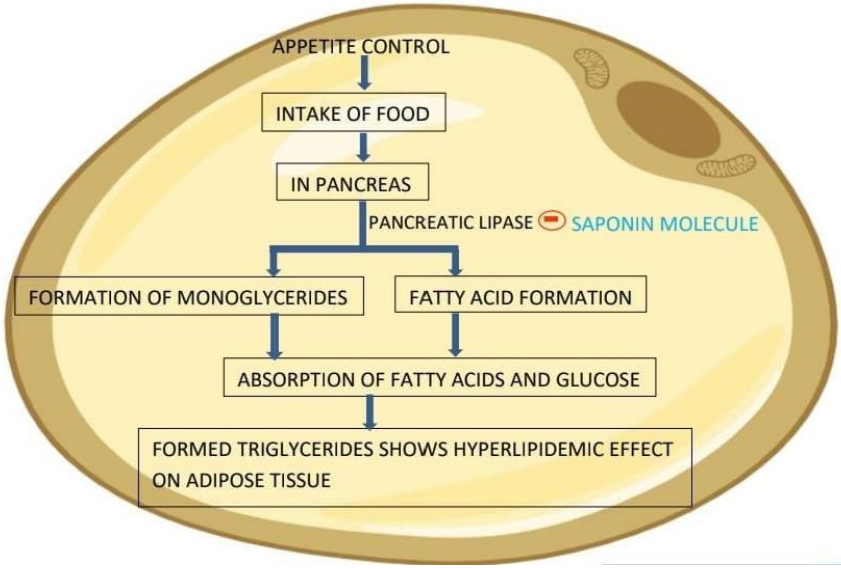
Fig 5 : Mechanism of action of Caffine in adipose tissue

6. Saponins

Saponins have the medicinal property of lowering serum

cholesterol. It has been found effective against atherosclerosis by altering molecular and cellular mechanisms and decrease in the production of H202 causes inhibition of phosphor-ERK1/2ANDPKC-alpha by angiotensin-II[26]. Saponins are phytoconstituents containing glycosides, majorly produced by plants which consist of sugar moiety bonded with an aglycone(a steroid). It contains more pharmacological actions mainly anti-inflammatory, hypocholesterolemia, and hypoglycemic effects. From this, we come to know that the treatment of obesity is by in vitro and in vivo activity of phytochemicals such as saponins. The saponin-rich extract theoretically inhibits pancreatic lipase and appetite .however, no such clinical trials do not have any evidence to support the application of saponins in the treatment of obesity. future clinical trials must evaluate the effects of saponins observed in vitro and in vivo[27].

Fig 6: mechanism of action of saponins 21 in fat cell



Obesity is the major risk factor for cardiovascular diseases, (LDL increases HDL decreases). In Asian countries, body mass indexes above 25 kg\m will be considered overweight are obese[28]. Particularly green tea is significant with kaempferol glycosides. The Chinese database where used to find randomized control trials on the effect of green tea on lipid metabolism[29]. For this finding, the Jadad scale was used to determine the quality[30]. This data suggests that there is a decreasing plasma LDL level and hypocaloric effect[23]. Earlier studies showed that epigallocatechin gallate was an important hypolipidemic component in green tea its mechanism may decrease the adsorption of lipids and reduce the effect of inflammation[32]

7. GABA

The GABA content is about 34-42 in tea. In earlier years the reports from several laboratories say that GABA (gamma amino butyric acid) helps in balance of food intake[33]. Study from an initial period of 10 days animals are divided to several groups and with proper diet. In the preliminary study, the slender and heavy mice were stuffed 8% casein with 4.5% GABA for 70 days of the analysis. In the following experiment slender and heavy mice were stuffed of less than 4.5% of GABA continued until lost their 25% of initial weight. Finally at day 103, fed with GABA continues for the next 21 days. The studies suggested that slender mice stuffed with GABA show a loss in body weight with a low content of GABA 4.5%. Effects of 2-2.5% GABA were less effective with no depression than 0.5-1.5% of GABA. GABA in green tea (10%) shows tea contains more than the normal concentration of 0.1-1% so, it doesn't cause a severe impact on obesity.

8. Role of Green Tea Minerals in metabolism

8.1 Calcium:

calcium metabolism becomes important in morbidly obese. Includes of the population of 213 successive patients (176 Females,37 Males) for treatment of morbidity obesity of average age of 21-68 years and average BMI (of 35-42).

Hyperparathyroidism is high in morbidly obese at increased levels of positive with an increase in BMI, with a normal concentration of calcium. since 25-OHD is inversely related to Parathyroid hormone levels.in other words, the 25-OH D is sequestered in fat and consequently has fall in bioavailability.it is not clear that calcium metabolism prevents increased body mass. further studies are needed to investigate the calcium relation in obesity[35].

8.1.2 Pottasium

Theassociations between potassium and obesity syndrome, identified the 8 relevant studies by meta-analysis and nonlinear dose response. The meta-analysis (from table 1) indicates potassium intake to be having more sensitivity towards the index of obesity, mainly volunteers with the highest potassium uptake show lower odds of metabolic syndrome compared to the

lower amount of potassium(CI:0.5-1). Adequate daily potassium intake can reduce the risk of obesity and MetS (Metabolic Syndrome)[36].

9. CONCLUSION

Green tea is considered as an important nutraceutical for improving metabolism. The presence of catechins, polyphenols, flavonoids, and caffeine indicates its role in the weight reduction mechanism. It has shown approximately 40% effectiveness in humans, and it has not led to complete weight reduction. regular physical exercise can complement its fat-reduction effects. Research suggests that while green tea's chemical constituents support weight management through multiple mechanisms, they produce modest effects rather than dramatic weight reduction. The compounds work best as part of a comprehensive approach to weight management that includes proper diet and regular physical activity. Green tea's role in weight management should be viewed as supportive rather than primary, with its chemical constituents offering metabolic advantages that can enhance, but not replace, traditional weight management strategies. The complex interaction of its various compounds contributes to health benefits beyond weight management, making it a valuable addition to a healthy lifestyle regardless of weight loss goals.

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