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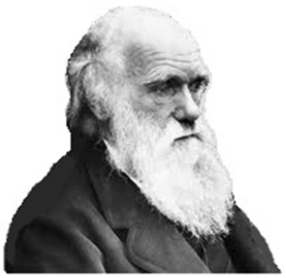

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A Review on the Role of Selected Functional Foods in Obesity Management

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ABSTRACT

Obesity is a foremost but preventable cause of deaths globally. It is a significant risk factor for the development of cardiovascular diseases, particularly heart failure, and diabetes. Natural products such as some foods, fruits, medicinal plants have been known to be functional in the management of Obesity. This article is aimed at reviewing the weight loss and anti-obesity potentials of Ginger (*Zingiber officinale*), Avocado (*Persea americana*) and Green Tea (*Epigallocatechin gallate*, EGCG). Google Scholar, PubMed, NCBI and Elsevier databases were searched from 2004 to 2020 using specific keywords. Searching was restricted to English language. Seventeen articles (Eleven human studies and six animal studies) were included in this review. Majority of the research papers that were considered in this review supported the weight loss and anti-obesity potentials of these natural products in obese human and animal subjects by lowering most of the clinical markers of obesity. Some of the anti-obesity mechanisms proposed by the authors include suppression of lipogenesis, inhibition of ghrelin secretion, e.t.c. This article also established the need for future trials.

***Keywords*:** Obesity, body weight, weight loss, natural products, appetite, Ginger, *Zingiber officinale*, Avocado, *Persea Americana*, Green Tea, *Epigallocatechin gallate*

1. INTRODUCTION

Obesity

Obesity is a metabolic disorder resulting from the anomalous or excessive buildup of fat in the body having negative effects on health. Obesity is evaluated with respect to body mass

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index (BMI) and weight of the body. BMI is simply a mode of measurement using weight and height. It is mostly used for weight classification. It is defined as weight of the person in kilograms (kg) divided by the person's height's square (m^2). It is measured in (kg/m^2).

The World Health Organization (WHO) standard definition is that a BMI greater than or equal to 25 can be classified as overweight while a BMI greater than or equal to 30 can be classified as obesity. [21]

Table 1. WHO classification of Obesity

BMI	CLASSIFICATION
Less than 18.5	Underweight
18.5-24.9	Normal weight
25.0-29.9	Overweight
30.0-34.9	Class I obesity
35.0-39.9	Class II obesity
Greater than or equal to 40	Class III obesity

According to the National Heart, Lung and Blood Institute (NHLBI) of the United States in 2013, Obesity can be caused by the following; lack of energy balance, physical inactivity**,** environmental factors, genetic factors and family history, hormonal imbalance, chemotherapies (e.g. corticosteroids, antidepressants and antischizophrenic drugs), smoking and emotional factors. Other causes of obesity are age, lack of sleep, pregnancy.[15]

The World health organization (WHO) hypothesized that obesity can result in development cardiovascular diseases, musculoskeletal conditions particularly osteoarthritis, diabetes, and cancers such as endometrial, breast and colon cancers. Childhood obesity is linked to a greater possibility of untimely death, adulthood disability, difficulty in breathing, increased risk of fractures, hypertension, cardiovascular diseases, resistance to insulin and psychological effects.[21]

The complex development of obesity indicates the need for different management strategies to counteract this problem. Diet-based therapies are among the most frequently used complementary strategy for weight loss.[3]

In the market today, there are varieties of natural products that include medicinal plants, either as pure compounds or as extracts, fruits, foods and their derivatives which are used as alternative treatment for obesity.[10] In this study, we will review the weight loss and anti-obesity potentials of Ginger (*Zingiber officinale*), Avocado (*Persea americana*) and Green Tea (*Epigallocatechin gallate*, EGCG).

2. MATERIALS AND METHODS

Search for Articles

Google Scholar, PubMed, NCBI and Elsevier databases were searched from 2004 to August 2020 using specific key terms. The key terms that we used to search were "Natural products" or "Functional foods" and "weight loss" or "anti-obesity" or "body weight" or "appetite." The search was restricted to articles written in English language. Significant human and animal studies were included in this review. We also checked the references of the articles to find possible new studies carried out in this regard.

Articles Selection

A total of Forty five papers (Twenty four animal and twenty one human studies) were initially selected. Seventeen papers (Six animals and eleven human studies) were eventually considered suitable to be included in the study based on relevance to the study and also the fact that these plants were used without combining with any other plant in order to ascertain its efficacy. Review papers were also excluded from the list of articles selected. The plants reviewed include; Ginger (*Zingiber officinale*), Avocado (*Persea americana*) and Green Tea (*Epigallocatechin gallate*, EGCG).

3. RESULTS

The results of the literature search for human and animal studies are presented in Tables 2 and 3 respectively.

Table 2. Results of Human Studies Reviewed.

AUTHOR	YEAR	SUBJECTS	INTERVENTION	RESULTS
Attari et al	2016	Human	Ginger Powder	Reduction in BMI, HOMA-IR and QUICKI levels, *R*eductions in serum leptin, resistin and glucose compared to placebo.
Mansour et al	2012	Human	Ginger beverage drink	Lower hunger level, Lower potential food intake greater satiety levels, Increased thermogenesis
Park et al	2020	Human	Steamed Ginger Ethanolic Extract	Reduced Body mass index, body weight and body fat levels.

Gayar et al	2019	Human	Ginger powder	Reduced BMI, fasting blood sugar (FBS), 2 hour postprandial glucose levels, Total cholesterol (TC), Triglycerides (TG), LDL-C, Fasting insulin levels, Increased HDL-C levels.
Wang et al	2015	Human	Avocado	Lowered LDL-C, LDL-P, and non-HDL-C levels.
Wien et al	2013	Human	Avocado	Increased satiety levels and decreased appetite levels. Higher insulin levels.
Fulgoni et al	2013	Human	Avocado	Significantly reduced body weight, BMI, waist circumference. Higher HDL-C.
Henning et al	2019	Human	Avocado	Significant weight loss, Decrease in BMI, visceral adipose tissue and total body fat, Significant decrease in serum triglycerides
Chen et al	2016	Human	Green tea extract	Significant weight loss and decreased BMI. Reduction in waist circumference. Decreased total cholesterol and LDL plasma levels. Significantly lower ghrelin levels and elevated adiponectin levels
Auvichayapat et al	2018	Human	Green tea	Reduction in body weight. Increased energy expenditure.
Basu et al	2010	Human	Green tea and green tea extracts	Reduction in Body weight and BMI. Reduction in lipid peroxidation

Table 3. Results of Animal Studies Reviewed.

AUTHOR	YEAR	SUBJECTS	INTERVENTION	RESULTS
Elrokh et al	2010	Rats	Aqueous Ginger	Significant decrease in all lipid profile parameters. Improved risk ratio
Misawa et al	2014	Rats	Ginger extracts	Weight reduction, Inhibition of fat accumulation, HOMA-R, plasma insulin and leptin and total cholesterol were significantly lower, Significantly smaller adipocytes, Expressions of adipogenic genes like UCP1, PGC-1α were higher while that of UCP2 was lower.
Brai et al	2007	Rats	Avocado leaf extracts	Reduction in body weight gain, Decrease in mean liver weight
Padmanabhan and Arumugam	2014	Rats	Hydro-alcoholic extract of *Persea Americana* (HAEPA)	Reduced BMI, total fat pad mass and adiposity index, Levels of reduced glutathione, adiponectin, mRNA expression of adiponectin. Significant increase in PPAR-γ and protein expression of PPAR-γ.
Klaus et al	2005	Mice	Epigallocatechin Gallate (EGCG)	Attenuation of body fat accumulation. Faeces energy content was slightly increased. Leptin and SCD1 gene expression in white fat was reduced. Gene expression of SCD1, ME, and GK was reduced and that of UCP2 increased.

Raederstoff et al	2003	Rats	EGCG	TC and plasma LDL levels were significantly reduced. Rate of cholesterol absorption was also reduced significantly in the treatment group compared to the control group.

4. DISCUSSION

Ginger (*Zingiber officinale*)

In this review, six studies (n=6) reported the weight loss and anti-obesity potentials of Ginger and its derivatives. Attari *et al,* [7] reported that consumption of 2g of Ginger powder daily drastically reduced the BMI and other parameters such homeostatic model assessment of insulin resistance (HOMA-IR) and quantitative insulin sensitivity check index (QUICKI) levels of the obese subjects compared to the placebo group who received 2g of corn starch tablets daily for 12 weeks. There were also significant decreases in blood levels of leptin, resistin and glucose levels in the two groups, particularly in ginger group. However, there were no significant differences between both groups. It was concluded that administration of ginger powder has a slight favorable effect on loss of weight loss and other metabolic parameters.

The study carried out by Mansour *et al,* [13] evaluated the effects of hot ginger beverage drink on appetite, satisfaction and energy expenditure in overweight men. Ginger had a substantial effect of ginger on energy required for digestion of food. Visual Analog Scales (VAS) measurements indicated reduced appetite levels, lower possible food intake and greater satiety levels with ginger consumption in comparison with the control groups. No significant effect was recorded on energy expenditure, glucose levels, insulin, lipid profiles and inflammatory biomarkers. The results also revealed improved thermogenesis and reduced appetite levels after intake of the ginger beverage. This suggests a potential function of ginger in management and loss of weight. This article also suggested the need for supplementary studies to confirm these findings.

Elrokh *et al,* [8] described the effects of aqueous ginger infusion in reduction of cholesterol in hypercholesterolemic rats. The rats were fed on a diet high in cholesterol. The rats were then divided into five groups. One was a control group that wasn't given any treatment. Three of the groups were given aqueous ginger infusion in different doses (100, 200 and 400 mg/kg) orally. The fifth group was treated with atorvastatin (0.18 mg/kg) as a reference drug. Blood was collected from all the groups of rats and they measured the lipid profile parameters such as Total cholesterol (TC), Low density lipoprotein-cholesterol (LDL-C), Triglycerides (TG) and High density lipoprotein-cholesterol (HDL-C) and risk ratio parameters (TC/HDL-C). Results showed that ginger intervention significantly reduced all the lipid profile parameters and improved the risk ratio parameters.

Misawa *et al,* [12] explained in their study that ginger extract increased energy expenditure and attenuated induction of obesity in mice through diet. It also resulted in weight reduction. HOMA-R, plasma insulin and leptin and total cholesterol were also discovered to be

significantly lower in the intervention group compared to controls. Significantly reduced number of adipocytes and expressions of adipogenic genes like Uncoupling protein 1(UCP1), Peroxisome proliferated-activated receptor gamma coactivator 1-alpha (PGC-1α) were higher while that of Uncoupling protein 2 (UCP2) was lower.

Park *et al*, [17] demonstrated the effect of steamed ginger extract (SGE) on loss of weight and fats. Eighty healthy obese subjects participated in the study and were assigned to the treatment and placebo groups. After 12 weeks of administration of the extracts, it was observed that the body mass index, body weight and body fat levels were significantly decreased in the intervention group compared to the placebo group. This indicated that Ginger is an effective agent in obesity management. Therefore, Ginger supplementation in combination with a modified lifestyle can be effective in the management of body weight and modulating body fat.

Avocado (*Persea americana)*

Avocados have been known to help in weight loss, thus having anti-obesity potentials. Researchers have carried out different clinical trials to prove this and also describe possible mechanisms in which avocado reduces body weight and body fat. In this review, six studies (n=6) also reported the anti-obesity mechanisms of avocado. Wang *et al*, [19] carried out a study with 45 overweight or obese patients. In this experiment, one avocado was administered along with a moderate fat diet (34%fat) daily for a period of 5 weeks. Results that inclusion of avocado lowered low density lipoprotein-cholesterol (LDL-C), low density lipoprotein-particle number (LDL-P), and non- high density lipoproteins-cholesterol (non- HDL-C) levels. This research suggested that avocados have beneficial effects on the cardio-metabolic risk factors.

Wien *et al*, [20] also carried out a randomized study with 26 healthy overweight adults. They were fed with a standard breakfast and subsequently, lunch. The subjects consisted of a group being fed with avocado included in their diet while another group consumed food free of avocado and were used as controls. Appetite sensations were measured with the aid of a visual analog scale (VAS) prior to lunch then at specific intervals more than 5 hours after consumption of the test diet. Levels of glucose and insulin in the blood were also measured prior to lunch and at intervals over 3 hours after consumption of the test diet. There were notable variances in satiety as well as appetite levels of the subjects. Those that had avocado included in their diets had increased satiety levels and decreased appetite levels compared to the controls. The avocado added groups also had higher insulin levels. This study showed that Avocado helps in modulating obesity and weight gain by increasing satiety levels and decreasing the level of appetite.

Fulgoni *et al*, [9] reported on the National Health and Nutrition Examination Survey (NHANES) between 2001 and 2008. The NHANES interviewers collected data on Avocado intake and nutrition based on a dietary recall of 24 hours. Physiological data was also collected. 17,567 subjects participated in this survey. It was discovered that Avocado consumers had markedly higher fruits and vegetables intake, total fat, diet quality, dietary fiber, mono and polyunsaturated fats, magnesium, vitamins K and E and potassium and they had lower added sugars intakes. Avocado consumers had lesser body weight, BMI, and waist circumference and higher high density lipoprotein-cholesterol (HDL-C) levels. This survey elucidated that consumption of Avocado is associated with better overall quality of diet, intake of nutrients, and the risk of developing metabolic disorders is quite reduced.

Hennin *et al*, [18] explained the effect of daily avocado consumption on body composition, weight loss, satiety, inflammation biomarkers and the composition of gut microbiota. 51 healthy

men and women who were overweight or obese were assigned into two groups. One group (n=24) consumed a reduced calorie diet with one hass avocado daily while the other group (n=27) consumed a reduced calorie diet alone which served as the control group. This study was carried out for 12 weeks. Significant reduction in weight, BMI, total body fat and visceral adipose tissues were observed in both groups. There was also significant decrease in serum glucose in both groups. Serum triglyceride was significantly reduced in the avocado group compared to the controls. The serum hepatic growth factor (SGF) and a relative proportion of the bacteria phyla (firmicutes and bacteroidetes) were altered significantly in the intervention group compared with the controls. There was a decreasing trend in the serum inflammatory factors IL-1β and C-reactive protein.

Brai *et al*, [4] described the effect of aqueous and methanolic *P. americana* leaf extract on weight of the body and levels of liver lipids in male albino rats. The rats consumed a high fat diet to provoke hyperlipidemia and they were treated with the leaf extracts of avocado for a period of 8 weeks. Results showed that addition of body weight was minimal in the rats treated with the extracts compared to the hyperlipidaemic controls (14% and 25% respectively). The methanolic extract triggered an 8% reduction in the mean weight of the liver compared to the hyperlipidaemic control rats. It can therefore be said that avocado leaf extracts increase lipid catabolism bioaccumulation rate in adipose tissue which leads to weight reduction but does not affects the levels of liver lipds in rats.

Another research carried out by Padmanabhan and Arumugam, [16] demonstrated the influence of hydro-alcoholic fruit extract of *P. americana* (HAEPA) on the plasma lipid levels and other parameters in rats that consumed a high-fat diet (HFD). A group of rats consumed a high fat diet for 14 weeks and were orally treated with HAEPA started from the third week. The result of the experiment showed that the total fat, body mass index (BMI) and adiposity index were markedly reduced in the animals that were co-administered with HAEPA rats than in high fat diet-fed rats acting as controls. Lipid peroxides levels and low density lipoproteins (LDL) were elevated in controls compared to the treatment group. The mRNA expression of adiponectin, Glutathione, adiponectin, PPAR-γ levels and protein expression of peroxisome proliferator activator receptor gamma (PPAR-γ) were significantly reduced in treatment group compared to the control group. The histological assessment of organs like heart, liver and adipose tissue also indicated the hypolipidemic effect of the extract.

Green Tea Extract (*Epigallocatechin gallate*, EGCG)

Epigallocatechin gallate (EGCG) is a unique compound from plants known to have possible beneficial health effects. It has been discovered to reduce inflammation, promote loss of weight, and prevents brain and heart disease. It is predominantly found in Green Tea, Tea, Nuts and Fruits such as cranberries, strawberries, cherries, peas, etc. Five studies (n=5) reported that green tea and its bioactive compounds have anti-obesity potentials. Chen *et al*, [5] studied demonstrated the therapeutic effect of Green Tea extract in 115 obese women. The women were grouped randomly into green tea extract (given in high dose) and a placebo group. The treatment was done for 12 weeks. Results showed significant loss of weight and decreased BMI in the subjects. The waist circumference was reduced as well in the intervention group. Total cholesterol and plasma Low density lipoproteins (LDL) levels were also decreased in the treatment group. The results also indicated significant decrease in the ghrelin levels and increase in adiponectin levels in the treatment group in comparison with the placebo group. The

mechanism of anti-obesity of high-dose of green tea extract might partially be linked to inhibition of ghrelin secretion, resulting in increased adiponectin levels.

Auvichayapat *et al*, [2] also studied the effect of green tea in weight reduction in some Thai obese subjects. The study involved 60 subjects that were confirmed to be obese. All the subjects were fed with Thai diet for a period of 12weeks. The diet contained 65% carbohydrates, 20% fat and 15% protein. The body mass index, weight, resting energy expenditure, body composition, and oxidation of substrate were measured at baseline, and at weeks 4, 8 and 12 of the study. Leptin levels and urine vanillylmandelic acid (VMA) were also assessed at the start of the study and at week 12. Comparing both groups, differences in weight loss were detected at the different weeks of the study. There were substantial variations in loss of weight at the 8th and 12th weeks of the study. At week 8, the variance in resting energy expenditure was 183.38kJ/day and there was no significant difference in satiety, physical activity or intake of food. Urine VMA was considerably different in the 12th week of the experiment. It was concluded that green tea facilitates weight loss in obese patients by increasing expenditure of energy and oxidation of fat.

Klaus *et al*, [11] demonstrated the anti-obesity potentials of epigallocatechin gallate (EGCG), which is a bioactive compound in green tea in obese male mice. Induction of obesity was done by feeding the male mice with a diet high in fat. Purified EGCG from green tea was introduced in their diet. Body make up, intake and digestibility of food were recorded for 4 weeks. Body temperature, activity, and energy expenditure were also assessed. The results of the study showed that supplementation of EGCG to the diet resulted in attenuation of accumulation of fat in the body. Food intake was unaffected but the energy content of their faeces was slightly increased by EGCG. This indicates a decrease in digestibility of food .Expression of Leptin and Stearoyl-CoA desaturase-1 (SCD1) gene in white fat was decreased nevertheless, expression of SCD1 and UCP1 in brown fat was unchanged. Expression of SCD1, (Malic enzyme) ME, and Glycerol kinase (GK) genes were reduced and expression of UCP2 was increased in the liver. Respiratory quotient at night was reduced supporting reduced lipogenesis and increased oxidation of fat. It was concluded that dietary EGCG halted accumulation of body fat in the mice. EGCG seemingly enhanced oxidation of fat; however its fat-reducing effect could be totally described by its effect in reduction of food digestibility.

Raederstoff *et al*, [6] also demonstrated the effect of EGCG on plasma cholesterol reduction in blood and absorption of cholesterol. The wistar rats were fed with a diet high in cholesterol and fat. They were assigned in groups and were treated with EGCG in doses while those that were untreated served as controls. After 4 weeks of treatment, total cholesterol and low density lipoproteins in the plasma were significantly reduced. In-vitro studies carried out in this research using biliary micelle model showed that EGCG affects lipid metabolism by interfering with the solubilization of cholesterol of the digestive tract.

Basu *et al*, [1] carried out a study to assess the effects of green tea beverage and extracts on body weight, glucose and lipid profiles and oxidative stress biomarkers in obese people. Thirty five obese people participated in the study. They were assigned into control groups (4 cups of water per day) or treatment groups (4 cups of green tea per day or 2 capsules of green tea extract and 4 cups of water per day). This was done repeatedly for a period of 8 weeks. Results showed that the green tea beverage and extracts resulted in significant reduction in body weight and body mass index compared to the controls. A decreasing trend was also observed in low density lipoprotein-cholesterol and low density lipoprotein in treatment group versus controls. The beverage also significantly reduced malondialdehyde (MDA) and hydroxynonenals (HNE). It

was concluded that green tea beverage and extracts lowered body weight and body mass index which are the major markers for obesity. Green tea also lowered lipid peroxidation which is indicative of its role in oxidative stress.

5. CONCLUSION

Obesity is a serious global health challenge. There are several treatment options which include surgery and drugs. However, there are side effects associated with these options therefore making modification of lifestyle the best treatment option. Furthermore, natural substitutes may help in ameliorating this health problem. As it has been summarized in this paper, several foods, fruits and vegetables and their derivatives possess anti- obesity potentials which have not been properly studied, and others are not even supported.

More studies are needed in the area of natural anti-obesity therapeutics. This calls for more research with properly designed clinical trials which focuses on both safety and effectiveness of some of the known natural products.

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