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Effect of Watermelon Rind Powder on Gut Microbiome and Weight Loss in Obese Rats

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Abstract

The purpose of this research was to examine the impact of watermelon rind powder on the blood lipid profile of male albino rats (Sprague-Dawley strain), weighing about 200–250 g) were separated randomly into two main groups as follows: The first main group -ve control = 6 rats) was given a basic diet. The second main group (24 rats) was fed a high-fat diet (10% sheep fat) for one month to induce obesity and hypercholesterolemia. Six rats were separated and fed on a high fat diet only as a control (positive group + ve), then the remaining 18 rats were separated into 3 subgroups (6 rats per group). These subgroups 1, 2, and 3 were fed on a basal diet mixed with watermelon rind powder at 5%, 10%, and 15%, respectively. All rats were killed after 8 weeks of experimentation in order to get their blood. LDL, HDL, VLDL, TG, ALT, AST, TC, and HB were determined. Results: Hypercholesterolemia rats fed on a basal diet mixed with watermelon rind powder showed significantly ($P<0.05$) decreasing liver function enzymes, VLDL, LDL, TC, TG, and VLDL, with significantly ($P<0.05$) increasing hemoglobin and HDL levels when contrasted with the control groups. Conclusion: Feeding on a basal diet mixed with watermelon rind powder could be utilized as a suitable therapy for obese cases and may lead to microbial diversity.

Keywords: *Obese rats, obesity, watermelon rind powder, Microbiome.*

1. Introduction

The body of a human contains a diverse range of microbes, including bacteria, fungi, and protozoa, which contribute to the microbial population in the intestines of humans and animals. Research suggests a close relationship between gut bacteria and public health, specifically in relation to obesity. Obesity and metabolic disorders associated with obesity are characterized by changes in the structure and function of the gut microbiota. Mechanistic studies have shown that the gut microbiota can influence both aspects of the energy balance equation: by affecting the utilization of energy from the diet and by influencing the genes in the host that regulate energy expenditure and storage.

Moreover, the composition of the gut microbiota is flexible and can be influenced by various dietary components. This discovery raises the possibility that modifying the gut flora could potentially aid in weight loss or prevention of obesity. Targeting the microbiota is emerging as a promising approach for obesity prevention and treatment, considering the global concern surrounding obesity. In response to socio-demographic changes, researchers have gathered new ethnobotanical information on the anti-obesity effects of plants, including Citrullus lanatus, which has been identified as one of the plant species used empirically for treating obesity.

Watermelon, a widely grown plant in different parts of the world, such as India, Africa, Asia, the United States, and Egypt, offers various medicinal uses from its fruit pulp, juice, rind, seeds, and leaves. It contains natural antioxidants like lycopene, ascorbic acid, and citrulline. Citrulline, found in high amounts in watermelon, interacts with another acid to produce arginine, which plays a role in the

urea cycle, responsible for eliminating ammonia from the body. Watermelon also contains other beneficial compounds such as amino acids, chlorophyll, phenolic compounds, and flavonoids, which have been associated with benefits like protection against angina, chronic illnesses, cardiovascular disorders, oxidative stress, cancer, and immune system stimulation.

The watermelon rind, often consumed in China as a vegetable, is rich in water and solid matter. It is low in calories and rich in vitamins A, C, potassium, B6, zinc, and citrulline. Studies have shown that watermelon rind extracts, due to the presence of flavonoids and phenolic compounds, have hypoglycemic effects, potentially reducing blood glucose levels. Additionally, watermelon's high water and fiber content, along with the gut microbiota, promote a healthy gut by aiding digestion, reducing constipation, and supporting regular bowel movements.

Recent research has also suggested that citrulline, an amino acid found in watermelon rind, may possess appetite-suppressant properties. The combination of water and fiber in watermelon contributes to a healthy gut environment. These factors play a role in reducing constipation, promoting bowel regularity, and supporting proper digestion.

Aim of study: this study aimed to estimate the

1. Impact of watermelon rind powder on obesity.
2. Impact of watermelon rind powder on blood lipids.
3. Impact of watermelon rind powder on gut microbiota.

2. Materials And Methods

Animals for the experiments came from the Agricultural Research Center in Dokki, which is located in Giza, Egypt. The nutritional needs outlined by AIN (1993) were taken into consideration while developing the standard diet and it was designed to make use of high-quality foods.

According to Moss (1982), the high fat diet (HFD) was prepared from fine ingredients per 100g according to the following composition: fat 30% (tallow 15% + corn oil 15%), casein 12%, salts mixture 4%, vitamins mixture 1%, fiber 5%, methionine 0.3, choline chloride 0.2%, and bile acid 0.2%.

Materials: The Al Gomhoriya Company for Med. Preparations, Chemicals, and Medical Equipment in Cairo, Egypt was used to get casein, vitamins, minerals, cellulose, choline chloride, sodium selenite, and zinc carbonate. A watermelon, scientifically known as Citrullus lanatus, was obtained from the Agricultural Research Center in its fresh case. The Gama Trade Company for Chemicals in Cairo, Egypt was contacted in order to make the purchase of blood analysis kits.

Method:

Preparation of watermelon rind

After the watermelon fruits had been thoroughly cleaned and rinsed with running water to get rid of any dust that may have been present, the rind was removed from the freshly washed samples, sliced into tiny slices, distributed in trays to dry, and baked in an air oven at a temperature of fifty degrees Celsius for twenty-four hours. Once the rind had been dried, it was then processed in a grinder mill to make rind flour, which was then kept in an airtight container until it was needed (Amr,2017).

Biological Study: -

Owing to the fact that the metabolism of obese rats is quite similar to that of humans. In the study of atherosclerosis, the use of Albian rats was suggested by Bravo et al., (1994). At the biological studies Lap of the Agricultural research center in Dokki, Giza, Egypt, thirty adult male rats were housed in cages that were well-aerated and kept in hygienic circumstances. During the adaption process, the rats were fed a basal diet for one week. The foundational diet was constructed using the guidelines provided by Reeves et al. (1993). Food and water were weighed once a week, and the rats were examined each day. (6 rats) were maintained on a standard diet (serving as the control group negative, ve). 24 Rats were fed on a high-fat diet for one month before the start of the experiment to reach the desired weight **Chien et al., (2016)**, then separated into two main groups as follows: -

The first group (6 rats): were fed on high - fat diet (10% sheep fat) as a control positive group +ve.
The second group (18 rats): were separated into 3 sub-groups, each subgroup consists of (6 rats) as following: -
Subgroup (1): were fed on basal diet mixed with watermelon rind powder 5 %.
Subgroup (2): were fed on basal diet mixed with watermelon rind powder 10 %.
Subgroup (3): were fed on basal diet mixed with watermelon rind powder 15%

At the conclusion of the experiment, which lasted for eight weeks, all of the rats were required to abstain from food for one full day prior to their sacrifice, after which blood samples were taken from each rat and centrifuged to extract serum. The amount of food consumed as well as the body weight were recorded twice each week. A calculation was made of the food efficiency ratio.

Chemical analysis:
After the completion of the experiment serum were analyzed at the Agricultural Research Institute to determine the following parameters:

- Hemoglobin.
- Aspartate aminotransferase (AST) concentration.
- Alanin aminotransferase (ALT) concentration.
- Triglycerides (TG).
- Total cholesterol (TC).
- low density lipoprotein (LDL).
- High density lipoprotein (HDL).

Microbiome analysis:
Collection and processing of samples of the microbiome: Samples of gastrointestinal content and feces were inoculated in peptone water and incubated at 37 ° C for 24 hours. The samples were cultured onto a different set of specialized culture media to identify the bacteria **Chow *et al.*;2006 & Islam *et al*.;2014).**

Statistical Analysis: -
SPSS statistical software (version 13 SPSS Inc., Chicago. USA) was used to do the analysis on the findings that were collected. The findings were summarized using the mean value. As stated by, significance was determined by utilizing a one-way analysis of variance (often known as "ANOVA") **Armitage & Berry, (1987)**. The significance of the differences between the means was investigated using the least significant difference test (LSD) at a significance level of ($p< 0.05$).

Biological indices calculation:
Every day of the trial period, the subjects' diets and weekly body weights were recorded. According to **Chapman et al., (1959),** the following formulae were used to determine the body weight increase percentage and the feed efficiency ratio: Lean Body Mass (LBM) = Final Weight (g) - Starting Weight (g) 100/Starting Weight (g). FER = weight growth (in grams)/feed consumed (in grams). Evaluation of Serum Biochemistry: **Allain (1974), Lopez (1977), and Fossati and Prencipe (1982)** were used to calculate total cholesterol (TC), triglycerides (TG), and high-density lipoprotein (HDL). Lipoproteins of low and extremely low density were measured using a protocol based on that developed by **Lee and Nieman (1996).** LDL = Total Cholesterol – [(VLDL- C) + (HDL- C)]. VLDL = Triglycrides /5. The atherogenic index (AI) was determined using the formula proposed by Nakabayashi et al., (1995). AI = LDL+VLDL / HDL; AI is a measure of atherogenicity. **Young (2001)** was used to measure glucose levels in the serum. The concentration of (AI) was estimated according to **Kikachi et al., (1998).**

Sample collection
Over the course of the 8-week investigation, participants' total body weight was tracked. Animals were starved overnight before being put to sleep (under ether) at the conclusion of the feeding period. Serum was extracted from around 2 ml of blood using the retro orbital technique and then centrifuged into sterile, dry plastic tubes. Serum and plasma were separated using heparized micro tubes. Serum was extracted from centrifuged blood samples and frozen at -20 degrees Celsius. This analysis cannot be completed until. The serum was tested for a number of different lipids and

cholesterol levels as well as triglycerides, HDL-c, LDL-c, risk rate, and liver function enzymes (GOT, GPT). Moreover, liver, heart, kidney and stomach were excised, rinsed, blotted, weighed and kept in formalin solution (10%) and collected stool samples to take a swab for examinations carried out.

3. Results and Discussion

Table (1): Effect of Watermelon Rind Powder on Body weight gain%, feed efficiency ratio**.**

Variables Groups	BWG%	FER	FI (g/d)
Basal diet (negative control)	**-4.56±1.8 bc**	**-0.23±0.09bc**	**17.00**
High-fat diet (positive control)	**6.9±0.5a**	**0.35±0.02a**	**15.00**
diet +5%W.M.	**-4.05±1.29bc**	**-0.2±0.06b**	**17.00**
diet +10%W.M.	**-6.2±1.91c**	**-0.31±0.1c**	**20.00**
diet +15%W.M.	**-5.1±0.46bc**	**-0.25±0.02bc**	**18.00**

Exhibit the mean values of body weight gain (BWG), food intake (FI), and feed utilization (Fer) in obese mice fed a diet containing varying amounts of watermelon rind powder. The findings showed that the BWG and Fer of the positive control group were higher than those of the negative control and obese groups treated with watermelon rind powder at varying concentrations ($P \leq 0.05$). The findings corroborated those of **Mohammed,** (2016) and Hosny, (2017), who had previously determined that BWG and Fer mice consume a diet much higher in fat than that of the control group (-).

Mice fed a baseline meal with varying concentrations of watermelon rind powder lost weight and had lower Fer and BWG compared to the control group. There was no difference in Fi between the watermelon rind powder and the negative control group, which was fed the same amount of watermelon rind powder as the slow mice on a basal diet (5%). There was a correlation between our findings and those of Ware and others, (2015), who found that watermelon consumption lowered the probability of being overweight or underweight.

Also, show Aderiye et al. (2020) that watermelon can be effective for weight loss. Moreover, Manivannan et al. (2020) that eating watermelon food has been used to treat obesity and manage weight. In the same table,

The top FI in the obese mice that feed on the basal diet with a watermelon powder is 10 % this is due to according to Hashim (1997), the influence of B-carotene on food intake may be ascribed to a decrease in the palatability of the diet. This could explain why animals given watermelon mixes consumed significantly less food per day than control (-ve) rats it is also Saikia et al. (2016) who previously isolated and analyzed fiber from watermelon rind. They discovered that 100g of dried rind samples contain 47.5g of fiber, of which 32.5g are insoluble and 15g are soluble. They found that the fiber created from the rind of the watermelon had a greater water holding capacity (WHC), oil holding capacity (OHC), and swelling capacity than the control, which was made from cellulose.

Similar to low OHC, high OHC will lead to decreased absorption and higher excretion According to Saikia et al. (2016), increased WHC will decrease food transit in the gut, resulting in a rise in satiety & an assistance in regard to fecal bulk. Similar to high OHC, high-fat excretion and decreased absorption in the intestine may help lower serum cholesterol & prevent the buildup of cholesterol in the liver and arteries.

Table (2): Effect of Watermelon Rind Powder on Microbiome in obese rats.

Bacterial / Groups	**LACTOBCUILLUS SP. Cfu/ml**	**BIFIDOBACTERIUM SP. Cfu/ml**	**LACTOBCUILLUS SP. (cfu/ml) stool**	**BIFIDOBACTERIUM SP.Cfu/ml**
Basal diet (-)	7.50*10^6	8.40*10^6	7.60*10^6	8,57*10^6
High-fat diet (+)	8.20*10^6	9.13*10^6	8.57*10^6	7.25*10^6
Diet+5%W.M.	9.96*10^6	8.26*10^6	7.50*10^6	8.29*10^6
Diet+10%W.M.	7.30*10^6	8.35*10^6	7.40*10^6	8.50*10^6

The findings revealed that the value of the bacterial count for Bifidobacterium SP. in the group that fed on a basal diet with a mean value of 8,57*10^6 cfu/ml was greater than the value of the bacterial count for Bifidobacterium SP. in the group that fed on a high-fat diet with a mean value of 7.25*10^6 cfu/ml. This is due to the bacteria associated with a lean status report (Schwartz A. et al (2010), Kalliomaki M, et al (2008), Collado MC, (2008), Santacruz A, (2010) and Balamurugan R, (2010) in addition to According to five investigations.

Obese people had less Bifidobacterium species present at the genus level in their feces bacterium was shown to be more prevalent in controls with normal weight in a study by Kalliomaki et al. (2008). but the results revealed that the value of the bacterial count for LACTOBCUILLUS SP. in the group that fed on a high-fat diet with the mean value of 8.57*10^6 cfu /ml was greater than the value of the bacterial count for LACTOBCUILLUS SP. in the group that fed on a basal diet with a mean value of 7.60*10^6 cfu/ml. This is because an increase in some types of bacteria has been associated with both human and animal obesity (Armougom F, et al (2009) and Million, M, et al. (2012).

The findings showed that the value of the bacterial count for BIFIDOBACTERIUM SP. in the groups that fed on a basal diet with watermelon rind powder 5 %, 10%, and 15% had a mean value of 8.29*10^6 CFU/ml, 8.50*10^6 cfu/ml and 8.32*10^6 cfu/ml were the closest result to the group fed on a basal diet compared to positive control was a mean value of 7.25*10^6 cfu/ml. This data lends credence to the idea that the microbiome is impacted by dietary fat intake. We speculate that WR and skin contain bioactive fiber as well as other phytochemicals that have advantageous effects on metabolism. In 2020, Becraft, A., et al. As a result, altering the gut microbiota through dietary changes may affect how nutrients are absorbed, how pathogens multiply, and how metabolism functions. There is an increasing body of research suggesting that the microbiota found in the gut may play a significant part in the development of metabolic disorders and obesity. In addition to that, it is well knowledge that one's diet may change the make-up of the microbes that live in one's gut. Intestinal bacteria are fed complex plant polysaccharides that are not digestible by mammalian digestive enzymes when diets are high in fiber. These polysaccharides come from plants. These prebiotic fibers go through the ileum and enter the colon in their intact state. In the colon, the intestinal microbiota releases the glycoside hydrolases essential to break down large polysaccharides into monosaccharide units. According to Leturque and Brot-Laroche et al. (2013) and Slavin (2013), various microorganisms in the gut ferment these monosaccharides in order to produce CO2, H2, and short-chain fatty acids (SCFAs) such as acetic acid, propionic acid, and butyric acid, which are subsequently absorbed in the colon. Butyrate is the preferred source of energy for colonocytes, as stated by Rossi et al. (2005). It also contributes between 60 and 70 percent of the energy that colonocytes require, in addition to fostering the expansion and multiplication of colorectal mucosal cells. SCFAs that aren't put to use are flushed out into the bloodstream, where they might make their way to the liver and be used for metabolic processes there. Propionate, on the other hand, is absorbed by the liver and put to use in lipogenesis, gluconeogenesis, and protein synthesis (Kallus and Brandt, 2012). Acetate, on the other hand, is eliminated from the body after passing via the liver and serving as a substrate for cholesterol formation in peripheral tissues.

Table (3): Effect of Watermelon Rind Powder on hemoglobin in obese rats.

Variables / **Groups**	**H. b g/dl**
Basal diet (negative control)	12.7±0.23a
High-fat diet (positive control)	11.2±0.81a
diet+5%W.M.	12.47±0.28a
diet+10%W.M.	12±0.32a
ditet+15%W.M.	12.37±0.18a

It has been suggested that iron plays an important role in the pathogenesis of atherosclerosis, primarily by acting as a catalyst for the atherogenic modification of low-density lipoprotein (LDL). **You SA and Wang., (2005) and Yuan XM and Li W.; (2003**)

Fig (1): Effect of Watermelon Rind Powder on hemoglobin in obese rats.

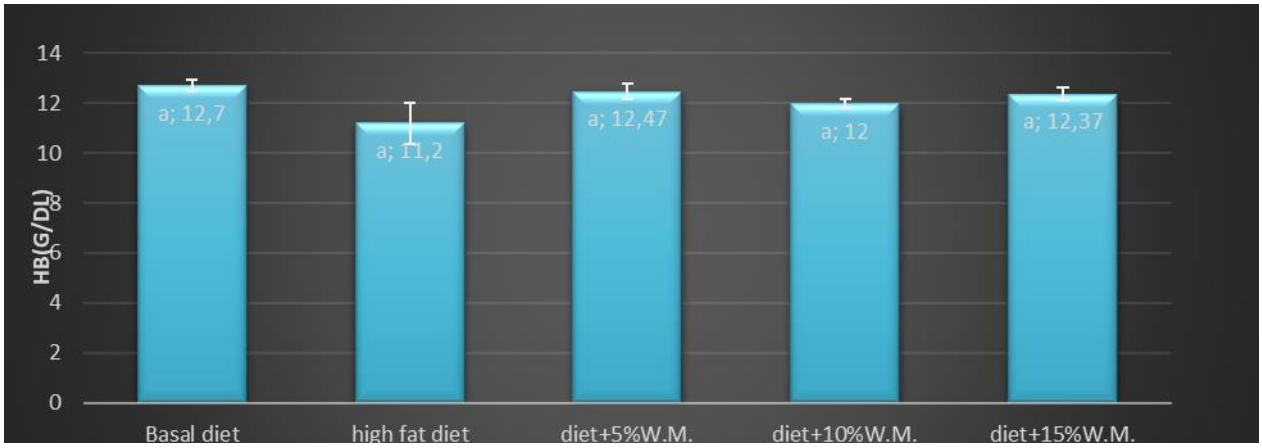

Table (3) and figure (1) showed that the hemoglobin concentration of obese rats fed on different levels of watermelon rind powder which represented 12.47±0.28g/dl, 12±0.32g/dl, and 12.37±0.18g/dl respectively which there was result nonsignificant contrasted with a negative control group which represented 12.7±0.23g/dl but The concentration of hemoglobin value increased ($p \leq 0.05$) in the obesity groups that were fed on basal diet with watermelon rind powder 5%,10%, and 15% levels of intake which represented 12.47±0.28g/dl, 12±0.32g/dl, and 12.37±0.18g/dl respectively. compared with the positive control which meant 11.2±0.81g/dl The findings line up with those of Kahlon et al., (1997) who stated that Hb may be caused by poor unilization of iron and metabolic defects that occur by feeding the animals diets containing cholesterol which affect the unilization of iron in comparison to basal diet. All watermelon rind powder treatments (Table 2) raised Hb level compared to control (+) group.Additionally, in hypercholesterolemic rats, this may possibly be a result of oxidants' effects on cell damage. Feri et al. (1989) , Sies and Stahl, Gey.,(1995) and Bieri et al. (1976) reports on the peroxidation damage to the membrane of red blood cells.

Table (4): Effect of Watermelon Rind Powder on Serum Lipid Profile in obese rats.

Parameters / Groups	CHLO (mg/dl)	T.G(mg/dl)	HDL (mg/dl)	LDL (mg/dl)	LDL-c(mg/dl)	VLDL (mg/dl)	AI
Basal diet (-)	68.17±0.78^{b}	58.2±2.3^{b}	43.57±0.61^{c}	56.27±1.15^{b}	12.96±1.45 b	11.64±0.46	0.57±0.04 b
High-fat diet (+)	88.77±3.47^{a}	67.3±0.81^{a}	37.97±0.69^{d}	62.1±1.66^{a}	37.34±3.15a	13.46±0.16	1.34±0.07 a
Diet+5%W.M.	66.4±1.1b^{c}	52.6±1.12^{c}	49.13±0.69a	53.43±0.9b^{c}	11.21±0.54 b c	10.52±0.22	0.49±0.02 b
Diet+10%W.M.	60.23±1.65^{c}	40.27±1.84^{e}	44.67±1.43bc	47.83±0.8^{d}	3.05±2.1 ^{d}	8.05±0.37	0.23±0.05 c
Diet+15%W.M.	63.33±2.24b^{c}	46.63±1.25^{d}	47.1±1.32a^{b}	52±0.97^{c}	6.91±0.93 ^{d} c	9.33±0.25	0.34±0.01 c

Control (-) = Normal rats fed basal diet. HDL = High-Density Lipoprotein Cholesterol. VLDL =Very Low-Density Lipoprotein Cholesterol. TC =Total Cholesterol. (AI)= Atherogenic Index TG =Triglycerides

Table (4) illustrate the impact of the basal diet with watermelon rind powder on serum lipid profile in obese rats. findings shown that serum CHLO, T.G, LDL, LDL-c,VLDL, and AI concentration were significantly increased as a result of hypercholesterolemic induction with the mean values of 88.77±3.47mg/dl, 67.3±0.81mg/dl, 62.1±1.66 mg/dl mg/dl,37.34±3.15 mg/dl , 1.34±0.07mg/dl, and 13.46±0.16 respectively contrasted with the normal control group fed basal diet 68.17±0.78mg/dl,58.2±2.3mg/dl, 12.96±1.45mg/dl , 0.57±0.04mgdl, and 11.64±0.46 mg/dl respectively.

While serum HDL concentrations were reduced as a result of hypercholesterolemic induction the mean value of 37.97±0.69 mg/dl contrasted with the normal control group 43.57±0.61 mg/dl The levels of HDL significantly increased ($p \leq 0.05$) when adding watermelon rind powder for groups fed on basal diet with 5,10 and 15% levels of intake contrasted with the positive control group. These values were 44.67±1.43 mg/dl, 49.13±0.69 mg/dl, and 7.1±1.32 mg/dl, respectively. The highest improvement for HDL was detected in the group that fed on 10% of watermelon rind powder , while the group that consumed 5% watermelon rind powder had the lowest mean value when compared to the group that did not consume the powder (the negative control group).

While the levels of CHOL, LDL, TC, AI , LDL-C , and VLDL significantly reduced ($p \leq 0.05$) when obesity groups fed on basal diets with watermelon rind powder at 5,10 and 15% levels of intake contrasted with the positive control group with the mean values of 66.4±1.1 mg/dl,60.23±1.65 mg/dl and 63. 33±2.24 mg/dl , respectively for CHOL , 53.43±0.9 mg/dl , 47.83±0.8 mg/dl and 52±0.97 mg/dl , respectively for LDL , 52.6±1.12 mg/dl , 40.27±1.84mmg/dl and 46.63±1.25 mg/dl, respectively for TG , 0.49±0.02 , 0.23±0.05 and 0.34±0.01 , respectively for AI , 11.21±0.54 mg/dl , 3.05±2 mg/dl and 6.91±0.93 mg/dl, respectively for LDL-c.

The most pronounced improvement in LDL, TG, AI, LDL-C, HDL, and GHOL concentrations was detected in the groups of obesity rats fed the basal diet with 10% watermelon rind powder, followed by group 15 and then 5% compared with the basal diet control group. Also, it was detected that there were no significant variances in serum for level CHOL for this group contrasted with the negative control group. but in the result of other the values LDL, TG, LDL-c, HDL, VLDL, and AI were observed were significant differences in the groups of obesity rats fed the basal diet with 5,10, 15% watermelon rind powder contrasted with the basal diet control group concentration findings displayed that the best improvement was detected in the group of obese rats fed the diet with 10% watermelon rind powder contrasted with the normal control group. The greatest development in lipid profile was observed in the group fed on 10%watermelon rind powder.

A disorder known as blood cholesterol is one in which the amount of fats in the blood, particularly cholesterol and low-density lipoplastics (LDL), leads to an increased risk of developing atherosclerosis. The watermelon rind crust cortex has a high antioxidant activity, which is responsible for its benefits when consumed. Cauza et al., (2004). This transformation to l-citrulline and therefore dietary l-arginine is partly metabolized by the enzyme arginase in the gastrointestinal tract and the liver to l-carnitine and urea, which results in lower plasma l-arginine concentrations than dietary l-citrulline that bypasses intestinal and first-pass liver processes. The watermelon rind powder contains citrulline. (Citrulus Lantus) has been used to treat a broad variety of ailments, such as cardiovascular problems and illnesses connected to aging, and research has shown that increasing an individual's consumption of l-citrulline significantly improves the adult's cardiovascular health results. Moinard, Nicolis, and Neveux (2008) and Figueroa, Wong, and Jaime, (2017). , the watermelon rind powder riched with carotenoids, vitamin K and Mg, p, zn,fe citrulline, carotenoids and flavonoids and fat and cholesterol free, therefore taken into account as low caloric fruit Leskovar et al., 2004; Bruton et al., (2009). Additionally, according to the findings, the peel is where the fruit's antioxidant activity is strongest, the highest antimicrobial effect, and has the highest content of the total phenol that has been observed that there is a strong connection between the contents of the total phenol and biological activity and thus watermelon rind powder protected body from oxide lipids oxidation, while Collins et al., (2007)

4. Conclusion

The significance of the study's findings lend credence to the utilization of watermelon by-products as a means of warding off the beginning of metabolic syndrome. The results of this research suggest that the high citrulline content of watermelon, putative anti-inflammatory compounds, and the high fiber content of watermelon rind and skin may all play a role in the possible mechanisms of action that are impacted by these factors. It would be prudent to conduct more in-depth research into these potential modes of action. Future study that examines the citrulline content of the diets and endogenous NO production in the mice may help explain whether or not this mechanism contributed to the observed improvement in glucose metabolism, lipid profile, and content of different types of microbiomes, as well as obesity, when watermelon powder rind was consumed.

For human consumption, watermelons are an exceptionally rich source of a variety of vitally needed nutritional components. In addition to this, it possesses a variety of medicinally valuable components, making it a more potent tool for the administration of healthcare. It is advised that watermelon rinds be utilized for the treatment of obesity and overweight individuals, as well as for the improvement of the blood lipids profile and glucose. The best results were shown in the group that was fed the basic diet mixed with watermelon rind powder at a concentration of 10%; this concentration is the best, according to the preceding results that are mentioned in "the results and discussion.".

Watermelon rind powder could be utilized as a suitable fortification therapy for hypercholesterolemia cases.

Recommendations:

1. Hypercholesterolemia cases should be aware of the health Benefits of watermelon rind.
2. Increasing the dietary consumption of watermelon rind powder has beneficial effects in lowering lipid profile.
3. Watermelon rind powder could be used as a suitable supplementation for reducing body weight. Further studies are required focusing on the anti-obese.
4. Effect of this powder for a longer duration.
5. More research on the relationship between watermelon rind powder and microbiome in humans must be done.
6. Watermelon rind powder could be used as a suitable supplementation for reducing the count of bacteria (microbiome).

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