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Hypocholesterolemic and Anti-Obesity Effects of Radish Sprouts (*Raphanus sativus*) in Adult Females

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RED radish sprouts (RRS) (*Raphanus sativus)* are rich sources of health-promoting phytochemicals more than in its seeds.The present study aimed to evaluate the protection efficiency of red radish sprouts as hypocholesterolemic and antiobesity agents in adult females. Forty-five females with body mass index (BMI) >28 and aged between 25 and 40 years were randomly divided into three groups each one containing 15 females; RRS group and the controls. G1 (the first control) consumed their usual diet, while the second control group includes participants who were subjected to a low-calorie diet individually. The third group includes participants who were subjected to a low-calorie diet with RRS (100 g per day). Participants were initially submitted to anthropometric measurements (weight, body fat %, height, waist circumference, and mid-upper arm circumference), and blood samples for analysis of serum glucose, lipid profile (total cholesterol, HDL-c, LDL-c, and triglycerides) AST, ALTand TSH levels, total protein, and serum albumin. Then the groups started the intervention protocol lasting 8 weeks. After an 8-week follow-up period, the study results showed that the consumption of RRS significantly ($P \leq 0.05$) suppressed the elevations in body weight (~12 %), serum cholesterol (~27.5 % reduction), serum triglycerides (~33 % reduction), AST and ALT (~35 and 21 % reduction respectively) and glucose (~7 % reduction). This work reveals, for the first time, the hypolipidemic and antiobesity potential role of RRS in adult females.

Keywords: Red radish sprouts; Glucose; Obesity in females; Hypocholesterolemic.

Introduction

Obesity is the accumulation of abnormal or excessive fat that may interfere with the maintenance of an optimal state of health and associated with metabolic dysfunction and over nutrition. Increased body mass index and obesity are strongly amalgamated with changes in the physiological function of adipose tissue, leading to altered secretion of adipocytokines, inflammatory mediators release as well as chronic inflammation and insulin resistance (Ellulu et al., 2017 and Amin et al., 2019). Obesity in women is associated with changes in the reproductive cycle with a fertility reduction,an elevated the hazard of polycystic ovarian syndrome (PCOS), and irregular or no ovulation. Overweight in women with PCOS make them tend to insulin resistance and susceptible to developing diabetes, especially in later life (Sam, 2007). Moreover, the tendency to menstrual and ovarian disorders associated with obesity may promote a hazard of breast, ovarian, and endometrial cancer. It is currently obvious the occurrence of all gynecological cancersrises with increasing BMI (Bhaskaran et al., 2014). As well, maternal obesity in the pregnancy is also falling with risks to the mother and baby together. Unfavorable maternal outcomes related to obesity include a grown risk of unprompted miscarriage, gestational diabetes, hypertensive syndrome of pregnancy involving gestational proteinuric hypertension with multi-system effects (Guelinckx

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et al., 2008). Additionally, Kurachi, et al. (2005) reported that obesity also increased the chance of hyperlipidemia, cardiovascular diseases, corpus uteri cancer, and breast cancer in obese women after menopause (Kurachi, et al., 2005).

Plant products can not only increase glucose metabolism but also increase lipid metabolism, antioxidant status (Zhu et al., 2012). Red radish «*Raphanus sativus*" family "*Brassicaceae*" is a radical crop. It may be eaten raw, pickled, or cooked. (Otsuki et al., 2004 and Tamura et al., 2010). Red radish containsmany important vitamins and minerals (folic acid, anthocyanins, potassium (K), calcium (Ca), copper (Cu), iron (Fe), phosphorus (P), and zinc (Zn), anthocyanins, fiber, and antioxidants (Cheon and Kim, 2014 and Anna et al., 2016). These factors make it has advantages as improving id metabolism, avoiding cardiovascular diseases, dyslipidemic conditions, and hypoglycemic influences (Khedr and El Sheikh, 2016).Vivarelli et al. (2016) suggested that radish juice could be a good nutraceutical product with efficient antioxidant, hypolipidemic, and anti-obesity effects. All previous studies were performed on mice not human with radish seeds or juice, to better understanding and fill the gap in the knowledge regarding the effect of RRS on human, therefore conducted this trial to investigate the effect of RRS on anthropometric measurements, serum lipids, AST, ALT and TSH levels, serum glucose, total protein, and serum albumin in obese females. Additionally, we analysed the chemical composition as well as the contents of phenolic, flavonoids, alkaloids, and saponins of RR sprouts and seed.

Subjects, Materials, and Methods

Subjects

A total random sample of 45 obese adult females, their age ranged from 25 to 40 years, were selected. All subjects had a BMI of 28–40 kg m-2, do not have the habit of consuming food supplements containing active substances present in that food (dietary fiber), and do not use drugs or supplements aiming at weight loss. The experiment was preceded by a pilot study, females were undertaken for the assessment of anthropometric measurements, liver enzymes including (AST and ALT), total protein, serum albumin, triglycerides, TSH, total cholesterol (TC), LDL-C, HDL-C, and blood sugar. Analysis in advanceand next to the experiment was performed for all participants. The experimental period was continued for two months.

RRS Preparation

Red Radish Seeds was purchased from a private company of agricultural seeds, spices, and medicinal plants, in Cario, Egypt. The seeds were cleaned from all impurities and soaked for 16 h in water then the seeds were placed on a wet cotton tissue and covered the seeds by another wet tissue. The seeds were left to sprout in the dark at room temperature (25-30° C) and then sprouts were harvested after 3-4 days from seed sowing and applied for supplementation in the study.

Study design

The participants in this experiment were randomly categorized into three groups as follows: G1 (the first control) consumed their usual diet, while the second control group includes participants who were subjected to a low-calorie diet individually. The third group includes participants who were subjected to a low-calorie diet with RRS (100 g per day). A low-calorie diet was provided individually for each case. There were some reservations including low sugar, low salt, and low fats for participants in G2 and G3 (Table 1) till the end of the trail. After two months the participants were fasted all-night and all anthropometric and biochemical analyses were estimated again. Blood samples were collected and placed in a dry clean centrifuge tube, and then centrifuged (Multi Centrifuge OHAUS "Frontier™ 5706") for 10 mins at 3000 rounds per min to separate the serum. The serum was cautiouslymoved into a dry clean Wassermann tube by a Pasteur pipette and stored frozen till analysis.

Anthropometric measurements

Anthropometric measurements including weight, height, waist circumference and mid-upper arm circumference were carried out by standardized procedures at baseline and after 8 weeks. Weight was measured by using electric weight balance by standing posture of the subject. Body mass index was measured as weight in kilograms divided by the square of their height in meter. Weight was measured while participants were wearing light clothing without shoes by using the weighing scale. Height measurement was taken using a portable tape meter without shoes and recorded to the nearest 0.5 cm.Waist circumferences (WC) of the subjects was measured with an inelastic tape used at the narrowest point below the ribs, or halfway between the lowest ribs and the iliac crests. mid-upper arm circumference (MUAC) was measured at the midpoint between the acromion and olecranon processes on the shoulder blade and the ulna, respectively, of the arm. Body fat % was determined by using InBody (120, Medi Needs). Inbody is a bioelectrical impedance analysis (BIA) that depends on measuring the impedance of the body at each of 5 segments (right arm, left arm, trunk, right leg, and left leg) by applying micro-currents and then measure the voltage drop. After that, the body water, fat-free mass, body fat and other body components can be obtained.

Biochemical analysis of serum:

Glucose was analyzed in the serum as in the method of Trinder (1959). The TC was analyzed according to the method of Allain et al. (1974), while the TG was measured by the method described by (Trinder, 1969). The HDL-C was estimated as mentioned in Lopes - Virella et al. (1977), while serum LDL value was calculated by the equation of Friedwald et al. (1972):

LDL=TC-(HDL + TG/5)

AST and ALT were measured by the method of Reitman and Frankel (1957), the protein was estimated by Sonnenwirth and Jaret (1980), and albumin was analyzed by Drupt (1974) method.

Determination of radish sprouts composition

Moisture, crude fiber, ash, protein, and fat contents of RRS were determined according to the Association of Official Analytical Chemists, (AOAC, 2012) at Central lab. of Food Technology Research Institute Agric. Res. cent. Egypt. Total carbohydrate was calculated by difference using the following equation:

Total carbohydrate = 100- (%moisture + %fat+ %ash + %crude fibers + %protein)

Preparation of the alcoholic extract

About 5g of air-dried plant powder were refluxed with 2.5 L of 70% methyl alcohol for 6 hours, and then filtered. The residue powder was then washed several times with hot alcohol. The combined filtrates were concentrated under reduced pressure at 50 ºC and then used for the following tests: Tests for alkaloids, glycosides, cardiac glycosides, saponins, phenols, sterols, tannins, flavonoids, and diterpene.

Estimation of total flavonoid content (TFC)

Total flavonoid content (TFC) in the previous extract was colorimetrically estimated by aluminum chloride assay. A 0.5 ml aliquot of appropriately diluted sample was mixed with 2 ml of distilled water, then with 0.15 ml of a 5% $NaNO_2$ solution. After 6 min., 0.15 ml of a 10% $AlCl_3$ was added and left to stand for 6 min., then 2 ml of 4% NaOH was added to the mix. Immediately, water was added to complete the whole volume to 5 ml, carefully mixed, and left to stand for an additional 15 min. The absorbance of the mix was assessed at 510 nm against the prepared water blank. Rutin was utilized as a standard compound for the quantification of total flavonoid. The TFC was expressed as mg ruting^{-1} dry weight (mg rutin g^{-1} DW) by the calibration curve of rutin. All samples were measured in triplicates (Samatha et al., 2012 and Han and May, 2012).

y = 0.0012x + 0.0011

R2 = 0.9986

(y) was the absorbance and (x) was the µgrutin/mg of the extract

Analyzing the total phenolic

The total phenolic content (TPC) in the extracts of RR sprouts and seed was determined by the Folin–Ciocalteu reagent. Gallic acid was used as a standard and the total phenolic was expressed as µg/mg gallic acid equivalent to (GAE). The concentrations of 10, 20, 30, 40, and 50µg/ml of gallic acid were prepared in methanol. Concentration of 1mg/ml of plant extract was also prepared in methanol and 0.5 ml of each sample was introduced into the test and mixed with 2.5ml of a 10 fold dilute FolinCiocalteu reagent and 2ml 0f 7.5% sodium carbonate. The tubes were covered with parafilm and allowed to stand for 30 minutes at room temperature before the absorbance was read at 760nm spectrophotometrically (UV-Vis Shimadzu "UV-1601 PC"). All determination was performed in triplicate. The Folin Ciocalteu reagent is sensitive to reducing compounds including polyphenols. They produce a blue color upon reaction. This blue color was measured spectrophotometrically (Chun et al., 2013 and Maurya and Sing, 2010). Line of Regression from Gallic acid was used for the estimation of unknown phenol content. From the Standard curve of Gallic acid line of Regression was found to be

y = 0.0013x + 0.056

R2 = 0.9872

(y) was the absorbance and (x) was the µg GAE/mg of the extract

Measuring the total alkaloids using gravimetric method

Approximately two g of the RRS were extracted by 90 % ethanol till exhaustion (tested with Mayer's reagent). The alcoholic RRS extract was concentrated inreduced pressure untildrying at a temperature (not above40 °C), acidified with 3% HCl, and filtered. The filtrate was extracted by chloroform for removingthe acid alkaloid. The acidic aqueous layer was modified to alkaline media ($_pH$= 9) with ammonia and the free alkaloid base portion and extracted with chloroform until exhaustion and estimated by Mayer and Dragendorrf's reagents. The chloroform extract was filtered through anhydrous sodium sulfate and evaporated in reduced pressure until drying and weighed to estimate the percent as w/w (Woo et al., 1977).

Estimation of total saponins

Two g of RRS were sparsedin 20 ml of 20 % ethanol. The suspension was heated on a hot water bath (ZheHngji, H-W) for 4 hr with continued stirring at around 55°C. The mix was filtered and the remainder was re-extracted by another 200 ml of the same concentration of ethanol. The mixed extracts were heated on a water bath at about 90°C and reduced to 40 ml and transferred into a 250 ml separating funnel with adding 20 ml of diethyl ether and vigorously shaken. The aqueous layer was recovered whereas the ether layer was eliminated. The purity procedure was done one more time and 60 ml of n-butanol was added. The mixedn-butanol extract was double washed with 10 ml of 5 % aqueous sodium chloride. The rest of the solution was a water bath heated. The evaporated samples were oven-dried (performed in an electric thermal blast dryer, Type-101-3, Shanghai Ruda Experimental Apparatus Co., Ltd., China) to a constant weight. The saponins content was estimated in a percentage based on Obadoni and Ochuko (2001) and Okwu and Ukanwa (2007).

$$\text{Saponin \%} = \frac{\text{weight of saponin}}{\text{Weight of sample}} \times 100$$

Statistical analysis

Statistical analysis was carried out using the programme of Statistical Package for Social Sciences (SPSS), PC statistical software (Version 20; Untitled–SPSS Data Editor). The results were expressed as mean ± standard deviation (mean ± SD) and statistically analyzed using one-way analysis of variance (ANOVA) by the Duncan test. Also, a paired-samples T test was used to determine the statistical difference between the pre- and postmeans for each parameter in each group (Sendcor and Cochran, 1979). The statistical significance of difference was taken as $P \leq 0.05$.

Results and Discussion

Chemical composition of red radish sprouts

Data in Table 2 demonstratethe proximate chemical composition of RRS. It could be noticed that the crude protein and carbohydrate content in RRS recorded the highest percent. Data also showed a higher content of fibers in RRS indicating that the sprouts can be consumed as dietary fiber (DF) supplements where many researchers showed that germination can enhance protein and DF contents, decreasethe tannin and phytic acid contents, and increase the vitamins concentration, bioavailability of minerals, and trace elements (Ghavidel and Prakash (2007), Khattak et al. (2007), Kaushik et al. (2010) and Khandelwal et al.(2010). Moreover, Tork et al. (2019) stated that germination significantly increased the micronutrients and phytonutrient contents of radish seeds, hence verifying an obvious increase in the nutritive value of the sprouting seeds. This displays the potential result of sprouting on developing and enhancing the nutritional value as reported by Megat et al. (2016) in their study on legumes. They also revealed that total (soluble and insoluble) DF were significantly elevated in all germinated legume samples.

Total active materials of red radish sprout crude alcohol extract

The RRS contained the highest concentration of total phenolic, total flavonoid, and saponinthan the seeds ($P \leq 0.001$). On the other hand, the concentration of the total alkaloids was higher ($P \leq 0.001$) in radish seeds, while saponin was declined (to an undetected limit) in sprouts as shown in Table 3. Our obtained results accord with the results of Devaraj et al. (2011) who noticed that the ethanolic extract of radish leaves and its fractions showed the existence of carbohydrates, proteins, tannins, alkaloids, saponins, flavonoids, and glycosides in the phyto chemical assessment. As well, according to Mute et al. (2011), the aqueous extract of radish root found to contain triterpenes, flavonoids, alkaloids, saponins, and coumarin. Glucoraphasatin, a glucosinolate, was mainly observed in red radish roots and sprouts as reported by Montaut et al. (2010). Many authors also stated that RRS has a high concentration of the main glucosinolates (GLSs) (i.e. glucoraphasatin (4-methyl thio-3-butenyl) and glucoraphenin). Glucoraphenin is hydrolyzed to the isothiocyanates (ITCs) sulphoraphene (SFE), a bioactive compound that assists to decrease the oxidative stress of cell and provide santimutagenic activity antimany malignant cell types (Bhandari et al., 2015, Baenas et al., 2017 and Abellán et al., 2019).

TABLE 1. Composition of diet (1500 -1800 kcal) Low calorie food only

Days	Breakfast (from 7-9 am)	Between Breakfast and lunch	Lunch (2-3 pm)	Between lunch and dinner	Dinner
The first day	.cups of water before breakfast 2 - (A cup of lemon juice (with no sugar - (Boiled egg or fried without fat (FRY - Half a loaf of bread - - 1 service fruit and vegetable	100 g germinated red radish	.cups of water before lunch -2 -Green salad (green pepper-tomato-cucumber-spoon of vinegar). -Half a loaf of bread. -Grilled fish (1-2).	- Fruit apples or orange	.cups of water before dinner -2 -A cup of skimmed milk cup.- Fruits.
Second day	-.cups of water before breakfast 2 - - A cup of skimmed milk - Half a loaf of bread 3 tablespoons bean (with a little oil and lemon)- -Fruits and vegetables.	100 g RRS	.cups of water before lunch -2 -Green salad (green pepper-tomato-cucumber -1 tsp lemon). - A quarter of skinned chick. -5 tablespoons of spaghetti or rice.	-Green salad.	-2 cups of water before dinner. .A cup of green tea or ginger - -Fruits and vegetables.
Third day	.cups of water before breakfast -2 -Half a loaf of bread A piece of cottage cheese, -One tomato or any vegetable - Tea	100 g RRS	-2 cups of water before lunch. -Green salad (green pepper-tomato-cucumber-1 tsp lemon). -Red meat. -A small dish, stuffed (any type, number 5, the amount of rice and a few vegetables. without much fat).	-Fruit salad without sugar	.cups of water before dinner -2 - A cup of vegetable soup. - fruits.
The fourth day	-.cups of water before breakfast -2 Half loaf of bread or wheat toast slice- Grilled Eggplant with lemon, cumin, garlic, and pepper (half the- (fruit .Green peppers or vegetables - -Fruit and vegetable	100 g RRS	-2 cups of water before lunch. -Green salad (green pepper-tomato-cucumber-1 tsp lemon). -Sautéed vegetable dish (the-peas-zucchini-green beans-cauliflower-potato). -A piece of chicken breast. - A fat-free chicken soup.	A cup of tea or coffee.	.cups of water before dinner -2 -Fruits and vegetables.
Fifth day	.cups of water before breakfast 2 Half a loaf of bread Mashed potatoes (boiled potatoes with cumin and a pinch of salt- (and a pinch of skimmed milk Fruit vegetable one Fruits- -Tea or coffee after breakfast hours.	100g RRS	-2 cups of water before lunch. -Green Salad (green pepper-tomato-cucumber-1 tsp lemon). -Cup yellow lentils. -bran bread. -Fruits.	cup ginger and cin- 1 .namon or green tea	.cups of water before dinner -2 -A quarter of bread. -Cottage cheese (30g)
The sixth day	.cups of water before breakfast 2 Half a loaf of my apostasy Fruit vegetable one A single fruit .Piece of cottage cheese- .Only one Tamiya- .A glass of lemonade or orange juice-	100g RRS	-2 cups of water before lunch. -Green Salad (green pepper-tomato-cucumber-1 tsp lemon). -Vegetable soup (dish). -Chicken. -5 tablespoons rice.	Green Salad	.cups of water before dinner -2 -Green Salad.
Seventh-day	.cups of water before breakfast 2 -Half a loaf of bread Bean, tomato and pepper and lemon.- fruit- Cup of skimmed milk or orange juice or lemon water or tea with-- .out sugar after eating	100g RRS	-2 cups of water before lunch. -Green salad (green pepper-tomato-cucumber-1 tsp lemon). -bran bread. -Okra or corchorus spinach.	.Fruits-	.cups of water before dinner -2 -Green tea with mint and lemon (with no sugar). -Fruits (Kiwi or tangerine or orange).

TABLE 2. Chemical composition of red radish sprouts ($g100g^{-1}$) on the dry weight basis

Parameter	Amount ($g\ 100\ g^{-1}$)
Moisture Content	4.15
Crude Protein Content	31.30
Crude fat Content	1.08
Fiber Content	14.10
Ash Content	3.57
Carbohydrates	59.85

TABLE 3. Total phenolic, total flavonoid, total Saponins, and total alkaloids contents in red radish seeds and red radish sprouts.

Total active materials	Red Radish Seeds	Red Radish sprouts
Total flavonoids ($mggm^{-1}$rutin)	126±0.30	**209±0.10
(Total phenolic acids ($mggm^{-1}$ Gallic acid	185±0.30	**234±0.20
(%) Total Saponins	0.81±0.02	*ve-
(%) Total Alkaloids	1.2±0.04	**0.58±0.03

***-ve**: negative

** indicates values for sprouts and seed of radish were significantly different (t-test, P≤0.001).

The effect of red radish sprouts on the anthropometric measurements

The recorded Data in Table 4 displayed the effect of feeding on RRS on final body weight, body fat %, BMI, waist, and arm circulation. The data revealed a highly significant (p≤0.05) decrease in the weight, body fat, and BMI of participants after subjecting to a low-calorie diet with RRS for G3 and participants of G2 who subjected only to a low-calorie diet without RRS. The percentages of weight reduction, body fat, and BMI were (-8.73% and -12.16%), (-8.66% and-25.30%) and (-14.73% and -16.60%) for G2 and G3, respectively, compared to G1 (the control) who consumed their usual diet (-1.25%, -2.02% and -2.32%), respectively. As well, the data in Table 3 showed an insignificant difference in WC of participants in G3 than those in G1. An insignificant difference was noticed in the mid-upper arm circumference (MUAC) of the participants in G3 and G2. While a significant (p≤0.05) difference was noticed between participants after and before subjecting to the diet in G3 or only subjecting to the diet in G2 for waist and arm circumference.

The reduction in weight, body fat, and BMI observed in the participants in G2 was probably as a result of reducing calories in the usual diet (-500kcal). The results indicated a more effective decrease in weight, body fat, and BMI observed in participants in participants of G3 than those of G2.

These results are in agreement with Lee et al. (2018) who investigated the effect of anti-obesity by the Red Radish Coral Sprout Extract (RRSE) in a mouse model. Where the body weight gain of mice fed a high-fat diet with 0.1% RRSE was significantly decreased by about 60% than those fed on a high-fat diet alone after 8 weeks. Also, body fat of the high-fat diet with -RRSE-fed group was noticeably decreased by 38.3% than those fed on the high-fat diet. Also, Vivarelli et al. (2016) reported a strong ability of radish juice to counter the influence of a high-fat diet on body weight. Particularly, rats treated with 15 mgkg-1b.w. maintained an approximately constant body weight through the radish juice intervention period and reported a mean loss of -0.29 g contrary toa mean of 14.67 g gained by the high-fat diet control group (P<0.05).Furthermore,Lee et al. (2018) reported that the 75 mgkg-1b.w. treatment showed a significant (P<0.01) decrease in the body weight up to 5 g than the high-fat diet control group. Moreover, Kim et al. (2014) stated that using RRSE of over 200 μgml^{-1} could inhibit the expression of adipogenic transcription factors (PPARγ, C/EBPα, and SREBP-1) and proteins (adiponectine, perilipin, FAS, and FABP4) in 3T3-L1 preadipocytes.

TABLE 4. The effect of red radish sprouts on the anthropometric measurements

Groups / Parameters		Group 1	Group 2	Group 3
		Mean ± SD	Mean ± SD	Mean ± SD
Weight (kg)	Before	87.36±5.4	90.73±10.67	89.52±9.35
	After	86.27±3.81[a]	82.81±3.33[b]	78.63±5.10[c]
	% reduction	-1.25%	-8.73%	-12.16%
T. test		1.70	2.65	6.51
Sig.		0.110[NS]	0.019[*]	0.000[**]
Body fat%	Before	33.71±4.9	36.03±6.96	39.40±3.72
	After	33.03±4.56[a]	32.91±5.78[a]	29.43±3.16[b]
	% reduction	-2.02%	-8.66%	-25.30%
T. test		1.66	4.22	5.70
Sig.		0.119 [NS]	0.001[**]	0.000[**]
BMI ($kg\ m^{-2}$)	Before	33.13±2.4	34.89±5.45	33.50±2.96
	After	32.36±2.09[a]	29.75±1.87[b]	27.94±1.91[c]
	% reduction	-2.32%	-14.73%	-16.60%
T. test		2.30	3.35	5.45
Sig.		0.037[*]	0.005[**]	0.000[**]
WC (cm)	Before	91.46±6.98	88.40±9.00	95.43±8.20
	After	88.27±7.12[a]	83.10±5.41[a]	86.93±5.69[a]
	% reduction	-3.49%	-5.99%	-8.91%
T. test		2.11	1.01	3.11
Sig.		0.05 [*]	0.321	0.008[**]
(MUAC (cm	Before	35.60±2.29	36.26±5.02	35.53±4.05
	After	35.40±2.85[a]	34.00±4.19[ab]	31.60±3.68[b]
	% reduction	-0.56%	-6.23%	-11.06%
T. test		0.36	3.61	6.16
Sig.		0.72 [NS]	0.003[**]	0.000[**]

Means within the same rowwith different letters are significantly different ($P \leq 0.05$).
* $P \leq 0.05$, ** $P \leq 0.01$ NS = not significant

Data from this work suggested that a consumed diet with RRS showed an anti-obesity effect and this may be attributed tothe high content of fibers and its content of phenolic compounds. This is in accordance with previous findings by Bahreynian et al. (2018) who showed that DF intake may have a protective role against obesity, where higher fiber intake was related to lower anthropometric indices involving weight and waist circumference WC. Therefore, high fiber intake should be promoted for children and adolescents. Also, Ruheea and Suzuki (2018) stated that along with exercises and physical activity, a dietary regime of fiber-rich food could be a prime solution to overcoming obesity. During the past decades, researchers have investigated the role of DF to prevent obesity via innumerable experiments or observations. Epidemiological indications demonstrated that DF, in a soluble or insoluble form, assists in reducing weight among stover weight or obese adults. Additionally, Miketinas et al.(2019) stated that DF intake that is independent of macronutrient and caloric intake endorses weight loss and dietary involvement in overweighed or obese adults who consumed a calorie-restricted diet.

Furthermore, the high fibers content in RRS can help in reducing obesity by repressing appetite, where the reports support that DF not only provides low energy but also has significant roles in slowing down gastric emptying out, leading to a satisfaction feeling, reducing serum insulin excretion, and decreasing food intake. Moreover, fermentation of fibers creates short-chain fatty acids that modify intake patterns through releasing peptides and gut hormones such as cholecystokinin and glucagon such as peptide 1; hence lowering hunger and endorsing satiety (Anderson et al., 1994, Yao and Roberts, 2001 and Du et al., 2009). Also, Jovanovski et al. (2020) stated that the inclusion of viscid fibers as part of an ad libitum diet in adults, with a more obvious effect noticedon body weight in overweighted/ obese persons and those with diabetes and metabolic syndrome. Viscid fibers as a mono-therapy did not represent clinically significant weight loss, however, co-administration of viscid fiber with an energy-restricted diet may alternatively provide a more efficientapproach. Vivarelli et al. (2016) recently demonstrated that red radish sprouts, that contain high levels of isothiocyanates and anthocyanins that endorse the effect of anti-obesity, was effective in decreasing the body weight of high-fat diet-fed obese rats.

The effect of red radish sprouts on the serum levels of total cholesterol, triglycerides, LDL, and HDL in humans

Data in Table 5 declared that diet only or diet with RRS improved significantly the levels of serum lipid in the study participants (*P*<0.01). The TC, TG, and LDL significantly p<0.001) decreased from 225.73±18.00, 139.20±13.68, and 152.29±16.15 to 180.20±14.23, 109.33±9.98, and 107.07±13.60 (mgdl^{-1}) respectively in participants of G3 and G2in group 2. Meanwhile, the percentages reduction in TC, TG, and LDL were (-27.48%, -33.43% and -33.74%) respectively, for participants in group 3, compared to those in group 1 (-0.52%, 0.76% and -0.67%) respectively. Also,Table (4) shows a significant (*P*<0.01) increase in HDL of participants in group 2 and group 3 by 9.60% and 8.05%, respectively.

Similar results were reported by Taniguchi et al. (2006) who found that the rats were fed a diet comprising 0%, 2.5%, or 5% of Japanese radish sprout (JRS) ad libitum for 21 days. When comparing the corresponding control group, the JRS fed normal rats displayed decreased plasma levels of total TC, TG, phospholipids (PL). JRS also reduced the hepatic levels of TC, TG, and PL in the normal rats as well, the level of TG in the diabetic rats. Also, Aly et al. (2015) stated that the addition of Egyptian radish sprouts (ERS) or Egyptian clover sprouts (ECS), at 10% in diabetic rats diet (as a semi-modified diet), led to a significant decrease in blood glucose, TC, LDL-c, VLDL-c, and TG without significant difference in the HDL-c level. In addition, Aly et al. (2018) stated also decline in glucose level as a result of the addition of ERS and ECS to the rats' diet may be attributed to the regeneration of pancreas cells and potentiating of insulin excretion from surviving -cells. The rise in insulin excretion and following decline in blood glucose levels may result in inhibiting lipid peroxidation and control of lipolytic hormones. This finding suggested that ERS and ECS could efficiently prevent hypercholesterolemia as lipotropic factors.

Soliman (2019) revealed that the consumption of RRS was associated with a statistically significant reductionin TC, TG, and LDL after the daily consumption of RRS for 16 weeks in the intervention group. This might be because RRS is a good DF source, which has been indicated to be hypocholesterolemic, where observational reports have demonstrated that DF consumption is associated with a reduced risk of cardiovascular disease. Somepossible mechanisms have been proposed by previous studieswhere fiber can lower blood cholesterol. The physicochemical properties of DF modify metabolic pathways of lipoprotein and hepatic cholesterol metabolism, leading to a lower level of plasma LDL cholesterol (Fernandez, 2001). The fiber binds with bile acids or cholesterol in the formation of micelles (stickygel-like structure), which reduced the cholesterol content of hepatic cells. This causes the upregulation of the LDL receptors and extra increases clearance of LDL cholesterol from the blood circulation (Bowman and Russell, 2006, Whitney and Rolfes, 1999). Furthermore, this gel formation slows down gastric emptying, maintains satiety, and assists in reducing weight (Slavin et al., 1999). Wong et al. (2006) suggested other mechanisms including the suppression of hepatic fatty acid synthesis by fermentation products of the soluble fibers like short-chain fatty acids and resistant starch in the small intestine which cause the reduction of the plasma lipid levels.

Table 5. The effect of red radish sprouts on the serum levels of total cholesterol, triglycerides, LDL, and HDL in adult females

Groups / Parameters		Group 1	Group 2	Group 3
		Mean ± SD	**Mean ± SD**	**Mean ± SD**
T. Cholesterol (mg dl^{-1})	**Before**	254.80 ±28.6	225.73±18.00	247.20±23.5
	After	253.47±25.20^{a}	180.20±14.23^{b}	179.27±10.17^{b}
	% reduction	-0.52%	-20.17%	-27.48%
T. test		0.38	11.75	11.98
Sig.		0.708 ^{NS}	0.000**	0.000**
TG (mg dl^{-1})	**Before**	216.93±14.57	139.20±13.68	153.53±13.91
	After	218.57±16.10^{a}	109.33±9.98^{b}	102.20±12.76^{b}
	% reduction	0.76%	-21.45%	-33.43%
T. test		-0.30-	9.20	10.08
Sig.		.766^{NS}	0.000**	0.000**
LDL (mg dl^{-1})	**Before**	170.56±11.02	152.29±16.15	172.53±14.49
	After	169.41±10.09^{a}	107.07±13.60^{b}	114.31±10.92^{b}
	% reduction	-0.67%	-29.69%	-33.74%
T. test		0.35	7.75	11.01
Sig.		0.729 ^{NS}	.000**	.000**
HDL (mg dl^{-1})	**Before**	40.80±3.93	45.60±3.10	43.86±5.09
	After	39.80±4.86^{b}	49.27±2.71^{a}	48.07±4.04^{a}
	% reduction	-2.45%	8.05%	9.60%
T. test		1.19	-3.97-	-3.77-
Sig.		0.250 ^{NS}	.001**	.002**

The effect of red radish sprouts on liver enzymes, total protein, and albumin levels

The results of Table 6 show that there was a highly significant (p<0.001) reduction in liver enzyme; AST and ALT, of participants of G2 and participants of G3 compared with the control, however, there was an insignificant difference between participants in G2 and G3. The reduction percentages of those groups than control were (-32.98% and -34.65%) and (-21.12% and -21.44%) in AST and ALT respectively, while the reduction percentage in the control group was -9.77% and -5.64%, respectively. Also, an insignificant difference was recorded in serum T. protein and albumin of participants in G2 and G3.

This accorded with previous findings of Kalantari et al. (2009) who studied the protective effect of radish seed in liver toxicity motivatedby carbon tetrachloride in mice and observedthat crude extract of radish seed in a dose of 600 and 800 mgkg^{-1} may be sufficientto protect liver damage promptedby CCL4. In addition, Sadeek (2011) noticed that the pretreatment with radish juice significantly (*P*<0.05) restored the liver enzyme activities; AST, ALT, and ALP, to the normal level and counter CCl4- caused hepatotoxicity and oxidative stress in rats.

TABLE 6. The effect of red radish sprouts on liver enzymes, total protein, and albumin levels in adult females

Groups / Parameters		Group 1	Group 2	Group 3
		Mean ± SD	**Mean ± SD**	**Mean ± SD**
AST U L^{-1}	**Before**	31.33±3.6	38.60±3.7	38.67±3.64
	After	28.27±2.19^{a}	25.87±1.73^{b}	25.27±1.94^{b}
	% reduction	-9.77%	-32.98%	-34.65%
T. test		3.00	11.99	11.11
Sig.		.009**	.000**	.000**
ALT U L^{-1}	**Before**	31.93±4.27	32.20±4.53	32.93±3.95
	After	30.13±3.48^{a}	25.40±2.06^{b}	25.87±2.64^{b}
	% reduction	-5.64%	-21.12%	-21.44%
T. test		1.12	6.30	4.51
Sig.		.283^{NS}	.000**	.000**
T. pro-tein	**Before**	7.57±0.78	7.14±0.65	7.62±0.68
	After	7.53±0.54^{ab}	7.42±0.46^{b}	7.86±0.39^{a}
	% reduction	-0.53%	3.92%	3.15%
T. test		0.26	-1.61-	-3.55-
Sig.		0.801^{NS}	0.129^{NS}	0.003**
Albumin	**Before**	5.40±0.25	4.66±0.45	4.36±0.4
	After	5.09±0.26^{a}	4.73±0.39^{b}	4.81±0.43^{b}
	% reduction	-5.74%	1.50%	10.32%
T. test		-0.59-	-0.88-	0.91
Sig.		0.567^{NS}	.394^{NS}	0.379^{NS}

Means within the same rowwith different letters are significantly different (P≤0.05).

* P≤0.05, ** P ≤ 0.01 NS = not significant

The effect of red radish sprouts on the serum levels of glucose and thyroxin stimulating Hermon (TSH)

The data in Table 7 showed a significant ($p \leq 0.05$) reduction in serum glucose of participants of G2 and G3. Their mean difference significantly decreased from (90.20±10.1 and 90.66±7.7) to (83.60±5.54 and 84.47±6.31 mg dl^{-1}) respectively, While there was an insignificant difference in TSH hormone of all individuals before and after participating in this study.

These results agree with those of Ali et al. (2015) that clarified the effects of ERS and clover sprouts ECS on the blood sugar level in diabetic rats. The addition of ERS or ECS at 10% to diabetic rats' diet as a semi-modified diet significantly decreased the blood glucose level. Also, Taniguchil et al. (2006) found that JRS decreased the plasma levels of glucose and insulin and increased the insulin sensitivity in rats, indicating that the hypoglycemia caused by the consumption of the radish sprouts could be because of an improved sensitivity or an insulin-like activity not because of to an augment of insulin production (Taniguchi et al., 2006). Moreover, the authors suggested that hypoglycemic activity could be affected by the radical scavenging activity and consequently the antioxidant potential of the phenolic compounds in this food. Indeed, the flavonoids enhanced insulin sensitivity, letting a successful hypoglycemic effect (Amer et al., 2004 and Wu et al., 2004). In addition, Khedr and El Sheikh (2016) assessed the antidiabetic and antiatherosclerotic activity of dried red radish roots on hypercholesterolemic diabetic rats and revealed significantly decreased levels of blood and urine glucose following dried red radish roots.

The antidiabetic nature of radish extracts can be attributed to the next mechanisms: (1) regulating glucose-related hormones, (2) preventing diabetes-induce oxidative stress, and (3) balancing the glucose uptake and absorption (Abinaya, et al., 2019). Ali et al. (2015) suggested that the mechanism of RRS action to decrease blood glucose level could be linked to antioxidants (such as phenols and flavonoids) in RRS that improved insulin sensitivity and led to recovery from deteriorated glucose metabolism as antiglycemic agents. Also, Takaya et al. (2003) reported that a methanol extract of JRS had a better scavenge activity than L-ascorbic acid and that antioxidants involving sinapinic acid esters and flavonoids were responsible for the activity. Chandra et al. (2006) and Kob (2018) reported that cruciferous plants (i.e. cabbage, cauliflower, turnip, radish, mustard, etc.) are very popular foods, particularly in plant-based diets. They have many healthy nutrients, such as phytochemicals with anticarcinogenic, antioxidative, and anti-inflammatory activity. Nevertheless, they also have goitrogens such as glucosinolates and progoitrin, which may interfere with the production or utilization of thyroid hormone

TABLE 7. The effect of red radish sprouts on the serum levels of glucose and thyroxin stimulating Hermon (TSH) in adult females

Groups / Parameters		Group 1	Group 2	Group 3
		Mean ± SD	Mean ± SD	Mean ± SD
Glucose mg dl^{-1}	Before	95.66±7.9	90.20±10.1	90.66±7.7
	After	94.47±3.78[a]	83.60±5.54[b]	84.47±6.31[b]
	% reduction	-1.24%	-7.32%	-6.83%
T. test		0.55	2.31	2.27
Sig.		0.594[NS]	0.036*	0.039*
-TSH (mIUL)	Before	1.89±0.12	1.85±0.19	1.91±0.20
	After	1.88±0.09[a]	1.85±0.18[a]	1.92±0.10[a]
	reduction %	-0.53%	0.00%	0.52%
T. test		1.00	0.00	-0.159-
Sig.		0.334[NS]	1.00[NS]	0.876[NS]

Means within the same rowwith different letters are significantly different ($P \leq 0.05$).

* $P \leq 0.05$, ** $P \leq 0.01$ NS = not significant

In this study, an insignificant difference was observed in the TSH hormone level in participants group 3compared with those in G2 or those in the control group. However, the TSH level was higher in participants of group 3. This is inconsistent withprevious findings by Pasko et al. (2018) after studying the effect of broccoli sprouts on the function of thyroid in imbalanced thyroid rats which may exert a negative impact on thyroid function becausethey are a rich source of glucosinolates, especially glucoraphanin. Although that, the levels of TSH, fT3, and fT4 did notchange after broccoli sprouts ingestion, which was even observed to have a protective effect against sulfa dimethoxine caused thyroid damage. Broccoli sprouts, in animals with hypothyroidism, were noticedto exert a useful effect on the antioxidant balance of the thyroid gland compared with the rats with iodine deficiency.

Conclusion

This study showed that red radish sprouts have a higher amount of phenolic and flavonoid compounds than the seeds. The results indicated that RRS reduced body weight, blood lipids, liver enzymes, and blood glucose . Therefore, red radish sprouts can be effective against obesity, high cholesterol, and high glucose level in humans. Therefore this study encouraged the consumption of red radish sprouts as vital sources of biomolecules with beneficial effects on health. However, more studies are required to study the effect of sprouted red radish on different diseases, inflammations, and oxidation in tissues.

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تأثير براعم الفجل كمضاد للسمنه وكخافض للكوليسترول في الإناث البالغات

تعتبر براعم الفجل الحمراء مصادر غنية بالمواد الكيميائية النباتية المعززة للصحة أكثر من بذورها. في هذا العمل ، تم إختبار براعم الفجل على خفض كولسترول الدم وكمضاد للسمنة في البشر الذين يعانون من السمنة. تم إجراء التجربة على ٤٥ أنثى بمؤشر كتلة28 ≤ و تراوحت أعمارهن بين ٢٥ و ٤٠ سنة واستمرت التجربة لمدة ٨ أسابيع. تم تصنيفهم بشكل عشوائي إلى ثلاث مجموعات رئيسية ، كل مجموعة تحتوي على ١٥ أنثى. المجموعة الأولى هي مجموعة ضابطه تتغذى على النظام الغذائي اليومي المعتاد ، المجموعة الثانية تم تزويدها بنظام غذائي منخفض السعرات الحرارية . أعطيت المجموعة الثالثة نظام غذائي منخفض السعرات الحرارية وتدعيمها ب 100 جرام في اليوم من الفجل المنبت. تم حساب وزن الجسم ومؤشر كتلة الجسم والنسبة بين محيط الخصر إلى محيط الارداف ومحيط الذراع. أيضا تم تقدير (الكوليسترول ، الدهون الثلاثية (TG) ، كوليسترول البروتين الدهني عالي الكثافة (HDL-C) ، كوليسترول البروتين الدهني منخفض الكثافة (LDL-C) ، البروتين الكلي والهرمون المحفز للغدة الدرقية (TSH) ، وظائف الكبد ، وسكر الدم) في مصل الدم وقد تم التقييم قبل بدء هذه التجربة وعند انتهائها. أظهرت النتائج التي تم الحصول عليها أن التدعيم بالفجل المنبت يحد من الارتفاع في وزن الجسم ودهون الدم ، وأنزيمات الكبد ، والجلوكوز.وقد تم استنتاج ان التدعيم بالفجل المنبت كان له دور في خفض الكولسترول وعامل مضاد للسمنة لدى الإناث البالغات .