

Effect of the Diets Supplemented with Artichoke and Shrimp by-Products on Obese Rats

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ABSTRACT

Foods supplemented with functional fiber are an effective means for prevention of diseases like obesity, cardiovascular diseases, and diabetes mellitus. The objective of this study was to estimate the dietary fiber content in artichoke stems by-product powder (ASP) and shrimp by-product powder (SBP) and evaluate the protective effect of diet supplemented with their by-products as natural dietary fiber on weight gain, the blood picture, serum biochemical parameters and liver enzymes activities in obese rats. The results revealed that the crude fiber content was 22.68% in the ASP and 13.65% in SBP. Total dietary fiber fractions were composed of 18.69 and 0.42% soluble dietary fiber, 25.01 and 58.57% insoluble dietary fiber in defatted ASP and SBP, respectively. They also presented high amounts of inulin (18.2 g/100 g artichoke stem) and chitin (58.15 g/100 g shrimp shell). Biological impacts were done on the control group (CG) and compared with obese rat groups which were classified into seven groups; positive group (PC) and groups fed on diet supplemented with ASP and SBP at a level of 5 and 10%, inulin at dose 7.7 %, and chitosan at dose 2.6 %, for 8 weeks. The results showed significant improvement and ameliorated reduction in final body weight, body weights gain (%) and feed efficiency ratio (FER) in all the treated groups compared with the PC. Administration of 10% ASP or SBP significantly decreased body weight by 37.66 and 35.61%, respectively as compared to the high fat diet (HFD) group, while the highest reduction in body weight gain and lower FER were obtained in groups fed on chitosan. Feeding obese rats on diet containing ASP and SBP led to a reduction in the total cholesterol, triglycerides, and low-density lipoprotein cholesterol concentration, decreased in blood glucose level and improved serum liver enzymes activity and antioxidant enzyme activity as compared to the positive group. ASP as a source of inulin and SBP as a source of chitin can be used in the nutraceutical formulation of functional food products and a good source of natural dietary fiber to enhance the nutritional quality for prevention of diseases like obesity, and its associated health risks.

Keywords: Functional fiber, natural dietary fiber, inulin, chitin and nutraceutical.

INTRODUCTION

There is a worldwide interest with natural dietary fiber that possess many beneficial nutritive and physiological effects in humans such as enhancement of immune system, improvement of digestive functions and reduces risk for developing some diseases like obesity, heart disease, diabetes, dyslipidemia, hypertension and osteoarthritis (Fernstrand *et al.*, 2017 and Siracusa *et al.*, 2019).

A promising source of functional compounds is food by-products because of their nutritional and rheological properties where they are composed of protein, fats, nondigestible carbohydrate, bioactive compounds, and phytochemicals. Vegetable-by-product such as artichoke by-product is a source of inulin and rich source of bioactive compounds which protect against heart disease and cancer (Fratianni *et al.*, 2007). Inulin known as fructans, is a polysaccharide, consisting of polymer of fructose with β (2-1) glycosidic linkage. Inulin is a prebiotic non-digestible dietary fiber that beneficially affects the host by selectively stimulating the growth of beneficial bifidobacteria, production of short chain fatty acids (SCFAs), calcium absorption, decrease in body weight gain and thus improves immune health (Franco-Robles and López, 2015 and Mohanty *et al.*, 2018).

Seafood wastes such as shrimp shell is the most abundant source of chitin as a natural biopolymer after cellulose as well as, it contains 30-40% protein, 30-50% calcium carbonate and calcium phosphate (No and Meyers, 1995). Chitin is a linear polymer of anhydro N-acetyl glucosamine, and can be converted into chitosan, chito- oligosaccharides and glucosamine augments its biological properties and applications in various industries such pharmaceuticals, and food industries

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(Muzzarelli, 1985 and Yadav *et al.*, 2019). Approximately 2000 tons of chitosan is produced annually, whose main source of extraction is from shrimp and crab shell residues (GIA, 2005- Muñoz *et al.*, 2018).

The amount of stem resulting from artichoke processing is about 35-30% of the total raw material and shrimp industries caused approximately 60-70% of shrimp shell that usually consist of head, skin, and tail. These wastes cause many environmental problems and becoming a source of pollution (Lertsutthiwong *et al.*, 2002). On the other hand, these wastes which are rich in dietary fiber are soluble and insoluble fibers, and are reported to improve serum lipid profile (Larrosa *et al.*, 2021), lowers blood pressure, (Soliman, 2019) improves blood glucose, (Hopping *et al.*, 2010) promotes of bone health (Dai *et al.*, 2018), appears to enhance of disease resistance through immune function (Sharma *et al.*, 2019 and Rawi *et al.*, 2020), energy and improvement of digestive functions (Grundy *et al.*, 2016).

The recommended daily dietary fiber intake is 28 g/day for adult women and 36 g /day for adult men (USDA, 2005, Anderson and Hanna, 1999).

Dietary fiber is a complex compound that includes non-fermentable and fermentable compounds. The fermentable compounds are fermented to SCFAs produced include butyrate, acetate and propionate which lead to mediate many potential physiological effects such as improved glycemic and insulinaemic responses, improved blood lipid profile, increased satiety and reduced energy intake, increased micronutrient absorption and decrease in pH by the microflora in the large intestine. The increased prevalence of obesity and its associated health risks justify the need to discover effective dietary treatments to weight loss. Dietary fiber from food by-product such as chitin, and inulin to increase satiety and lower energy then weight reduction, requires confirmation in further studies (Mohanty *et al.*, 2018).

Therefore, the aim of this study was to determine the dietary fiber of artichoke and shrimp by-products and to investigate the effect of the diet supplemented with these by-products on weight loss and biochemical measurements in obese rats.

MATERIALS AND METHODS

Artichoke stems by-product powder (ASP)

The Globe artichoke (*Cynara scolymus* L.) stem by-product samples were collected from local market of Alexandria, Egypt. The stem by-product was peeled, sliced and soaked in 1% citric acid solution then dried in a cabinet drier (Universal hot air oven, Tradevel Scientific Industries) at 40°C for 48 h., grounded to pass

through 60 mesh sieve and stored at 20°C until used for analysis.

Shrimp by-product powder (SBP)

Fresh squilla (*Oratosquilla massavensis*) by-product samples were collected from the commercial fish ring at El-Anfoshy and El-Midan local market, Alexandria, Egypt. Shrimp by-product was washed, dried overnight at 40°C using the above-mentioned electric oven, then grounded and stored as mentioned above.

Chemical analysis: Moisture content was determined of ASP and SBP samples by drying at 110°C to a constant weight according to A.O.A.C. method No.945.43 (2000). Crude fiber content was determined according to A.O.A.C. method No.935.53 (2000) method using Fiber analyzer (Ankom 200. Model No. A220, USA). Dietary fiber fractions including neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed after extraction of oil from samples as mentioned in the methods of Goering & Van Soest (1970). Hemicelluloses and cellulose were calculated as follows: Hemicelluloses (%) = % NDF - % ADF, Cellulose (%) = % ADF - % ADL. Soluble dietary fibers (SDF), insoluble dietary fibers (IDF) and total dietary fibers (TDF), were determined as mentioned in A.O.A.C. (2000). Inulin was extracted from ASP sample according to the method of Van Waes *et al.* (1998) and was determined by fructose-resorcinol-hydrochloric acid assay using fructose as sugar standard (Sadasivam and Manickam, 1992). Chitin was extracted and determined in SBP samples according to the procedure of Abouzeed *et al.* (2015). The chemical analysis of samples was run in triplicates.

Animals experiment design

Forty-eight healthy Wistar rats, (weighting from 73 to 86 g), were obtained from the animal house of Home Economics Laboratory, Faculty of Agriculture, Alexandria University, Egypt. Rats were housed under laboratory conditions of temperature at 23± 3°C with a 12 h light–dark cycle and were given standard diet and access to distilled water *ad libitum*. The protocol of the National Institutes of Health (NIH) to the guidelines was followed (Collins, 2008). After seven days, the rats were randomly divided into two groups; control diet group as negative control (CG, n = 6) fed according to Lane-Peter and Person (1971) and high-fat diet group (n = 42) which were fed a high-fat diet (HFD) according to Ble-Castillo *et al.* (2012) for two months to induce obesity. After confirming that the HFD rats were obese the rats were subdivided into seven group (6 rats for each group), HFD positive control (PC) group, and six groups, as follows: Group I and 2: HFD group fed on diet A and B containing 5%, and 10% ASP, respectively. Group 3: HFD group fed on diet C

containing inulin at dosage 7.7 g/kg deit. Group 4 and 5: HFD group fed on diet D and E containing 5% and 10% SBP, respectively. Group 6: HFD group fed on diet F containing chitosan at dosage 2.6 g/kg deit. The quantities of diet prepared every day, and the feeding was carried out for 8 weeks as reported by Reeves *et al.* (1993).

Weight gain and food intake

The feed intake of the rats was recorded daily, and body weights were monitored each week throughout the experiment. Average food intake (AFI), average weight gains (AWG) and the feed efficiency coefficient (FEC) were evaluated according to the method of Chapman *et al.* (1959).

Hematological parameters and biochemical estimations

At the end of the experiment period (two month), rats were sacrificed after overnight fasting under esthesia. Blood samples were collected from the territorial venous plexus and immediately transferred into heparinized micro tubes for hematological assays and non-heparinized tubes for biochemical analysis. Hematological assays included white blood cell (WBC), hemoglobin (Hb), red blood cell (RBC), hematocrit (HCT), mean globular volume (MGV), and mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) and platelets. For serum biochemical investigations, blood samples were centrifuged at 900 xg for 20 min. Serum total lipids (TL) was determined according to Zollner and Kirsch (1962). Triglyceride (TG) was done as described by Fossati and Prencipe (1982) method and total cholesterol (TC) by the method of Tietz (1976). High density lipoprotein cholesterol (HDL-C) was determined according to Wieland and Seidel (1983) method. The low-density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein cholesterol (VLDL-C) levels were calculated using the Friedewald formula (Friedewald *et al.*, 1972 and Warnick *et al.*, 1990). Serum glucose measured by enzymatic GOD/POD kits according to Trinder, 1969. Total protein, albumin, globulin, creatinine, total bilirubin and blood urea nitrogen were determined as described by Lowry *et al.* (1951), Dumas *et al.* (1971), Henry *et al.* (1974), Young (2001) and Vassault, *et al.* (1986), respectively. Serum alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP) activities were assayed using the Bergmeyer *et al.* (1978) method. Serum acid phosphatase (ACP) activity was measured according to the method of Kind and King (1954). the internal organs namely liver,

kidney, heart, brain and lung were excised and weighed from each group.

Estimation of antioxidant enzyme activities: Catalase activity (CAT) was determined according to the method of Sinha (1972), glutathione peroxidase (GSH-Px) by Paglia and Valentine (1967), and the hepatic superoxide dismutase (SOD) activity was measured according to the method of Kakkar *et al.* (1984).

Statistical analysis

All statistics were performed with commercially available software (SPSS ver. 22.0 for Windows, 2010; SPSS, Chicago, IL) Continuous variables were given as means \pm standard Deviation (SD). Statistical analysis of variance was performed using the one-way ANOVA test using Duncan's multiple range test and followed by the least significant difference (LSD) test to locate significantly between all treatments. Differences were considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

Crude and dietary fiber fractions of (ASP) and (SBP)

As shown in Table (1), the value of crude fiber were 22.68% and 13.65% (dry matter) in the ASP and SBP, respectively. The results of crude fiber value of ASP were in agreement and very close with those mentioned by Salman *et al.* (2014) and Attia *et al.* (2016) who reported that the crude fiber content in artichoke floral stem by-product was (24.22 - 24.35% on dry basis) and higher than those reported by Eman *et al.* (2018) who recorded that the crude fiber content of artichoke floral stem by-product was 14.50 % but lower than those found by Claus *et al.* (2015) (44.23% on dry basis). Defatted samples contained high level of total dietary fiber. Defatted SBP had total dietary fiber (TDF) 58.99% which majority was insoluble form, while defatted ASP contains 43.70% TDF. ASP had a better fiber quality than those found in SBP because of ASP had high amounts of soluble dietary fiber (SDF) contents and the insoluble/ soluble dietary fiber (IDF/SDF) ratio (1.34), which was the near-perfect proportion. A higher soluble/insoluble fiber ratio of vegetables possess is considered as an indicator of fiber quality than other sources (Saura-Calixto *et al.*, 2000). A good balance in SDF and IDF is considered important for the nutritional effects and functionality of fiber in the human diet (Vergara-Valencia *et al.*, 2007).

Table 1. Crude and dietary fiber fractions of (ASP) and (SBP) on dry weight basis.

Component (%)	ASP	SBP
Crude fiber	22.68± 0.60	13.65± 0.42
Dietary fiber (DF)		
Insoluble DF	25.01±0.85	58.57± 0.57
Soluble DF	18.69± 0.71	0.42±0.07
Total DF	43.7±1.13	58.99±1.70
IDF/SDF	1.34±0.11	139.45±1.56
Neutral detergent fiber (NDF)	24.91±1.67	16.3±0.02
Acid detergent fiber (ADF)	22.68±0.73	13.57±0.44
Acid detergent lignin (ADL)	18.69±1.24	0.68±0.01
Hemicellulose	2.23 ± 0.94	2.73±0.42
Cellulose	3.99 ±0.51	12.89±0.45
Inulin	8.2±0.07	-----
Chitin	-----	42.27±1.31

Results are expressed as mean ± SD

However, the soluble dietary fibers increase the viscosity of the digesta and increased viscosity in the small intestine might slow gut transit time due to suppressed intestinal contractions (Cherbut *et al.*, 1990) which in turn leads to less mixing of dietary components with endogenous digestive enzymes (Johnston *et al.*, 2003).

The results in Table (1) also indicated that there was a difference between neutral detergent fiber (NDF) which represents hemicellulose, cellulose and lignin along with acid detergent fiber (ADF) and acid detergent lignin (ADL) contents of the two by-products. The yields of the NDF, ADF and ADL of artichoke stem by-product (ASP) were higher than that in shrimp by-product (SBP). On the other hand, cellulose of shrimp by-product was higher than that of artichoke stem by-products. Similar observations have also been reported by earlier researchers. Meneses *et al.* (2007) mentioned that the NDF, ADF and ADL content of artichoke by-product were 42.9, 30.3% and 10.3, respectively. Also, the data in Table (1) showed that the percentages of inulin were 43.87% and 18.76% out of the SDF and TDF of the ASP, respectively. Inulin is the most important nutritional fraction in tubers and has a dietary health benefit which it forms a perfect nutrient medium for bifidobacteria cells in an alimentary tract (Shoaib *et al.*, 2016) and reduces triglycerides, LDL-cholesterol, blood glucose, with improved calcium absorption and inhibits the growth of various kinds of cancer (Whisner and Castillo, 2018). It could be seen from the same Table that, the chitin was found in high quantity and valued 71.66% out of the TDF in SBP. On the other hand, it was higher than that reported by Tokatlı and Demirdoven (2017) who reported that the

chitin yield was 10.13% of the dry weight of the shrimp shell.

Effect of artichoke stem by-product (ASP) and shrimp by-product (SBP) administration on weight gain and feed intake in obese rats

From the present results in Table (2), the average initial weight of different HFD groups of animals (249.33 ± 8.14 - 252.25 ± 0.99 g) was significantly greater than that in the normal control group (149.00 ± 1.00 g). This increment in the body weight was related to increased fat intake by rats which can promote increased visceral fat deposition leading to obesity as it is the most energy-dense macronutrient (Allioua *et al.*, 2015). At the end of 60 days fed, the data presented revealed that there was a significant reduction in body weight and body weight gain (%) of all HFD groups fed different by-product samples when compared to the positive control group. Administration of 10% ASP or SBP significantly reduced body weight by 37.66 and 35.61%, respectively as compared to the positive control group. Administration of chitosan caused a significant reduction in body weight by 6.79 % compared to the negative group and by 42.01 % compared to the positive group as shown in Table (2), while rats fed 7.7% inulin showed significant reduction in body weight by 36.21% compared with that of the positive control and insignificant change when compared with that of the control diet.

Table 2. Changes in body weight gain, food intake and feed efficiency ratio in obese rats fed with artichoke stem by product (ASP), shrimp by-product (SBP), inulin and chitosan and normal diet.

Parameters Experimental group	Initial body weight (g)	Final body weight (g)	Body weight gain (%)	daily Food intake (g/day)	Feed efficiency ratio (FER)
CG (Control diet)	149.00 ± 1.00 ^a	171.67 ± 2.89 ^b	15.21	21.83 ± 0.35 ^{bc}	0.03 ± 0.001 ^d
PC (HFD diet)	252.25 ± 0.99 ^b	275.91 ± 3.61 ^d	9.38	20.56 ± 0.51 ^a	0.18 ± 0.004 ^e
A (ASP 5%)	249.67 ± 0.58 ^b	199.00 ± 1.00 ^c	-20.29	22.50 ± 0.29 ^c	-0.06 ± 0.001 ^c
B (ASP 10%)	249.33 ± 8.14 ^b	172.00 ± 3.00 ^b	-31.02	22.58 ± 0.16 ^{bc}	-0.10 ± 0.001 ^a
C (7.7% inulin)	254.33 ± 4.73 ^b	176.00 ± 6.00 ^b	-30.79	21.61 ± 0.25 ^b	-0.11 ± 0.001 ^a
D (SBP 5%)	253.00 ± 5.00 ^b	184.33 ± 3.21 ^c	-27.14	22.61 ± 0.22 ^c	-0.08 ± 0.001 ^b
E (SBP 10%)	254.00 ± 3.46 ^b	177.67 ± 2.52 ^b	-30.05	22.32 ± 0.28 ^{bc}	-0.08 ± 0.001 ^b
F (2.6% chitosan)	250.00 ± 5.29 ^b	160.00 ± 5.29 ^a	-36.00	24.33 ± 0.33 ^d	-0.11 ± 0.001 ^a

Results are expressed as mean ± SD; Means with different superscript letters in the same column imply significant differences at $P \leq 0.05$.

From the reduction in body weight gain results, it could be arranged the groups fed with by product, in a descending order as follows: Group F (-42.01%), followed by group B (-37.66%), group C (-36.21%), group E (-35.61%), then group D (-33.19%), finally group A (27.87%) when compared with the positive control group. This was due to characteristics, and quantity of the fiber, which may have effects. on body weight gain (Zhong *et al.*, 2007). The treatment at doses 200- 400 mg/kg/ bw artichoke extracts significantly decreased in body weight gain compared with HFD groups (Küçükgergin *et al.*, 2010).

After 60 days fed control diet for group 1 and HFD for the other groups ASP or SBP treated group significantly ($P \leq 0.05$) increased feed intake as compared to the positive control group but non significant ($P \leq 0.05$) as compared to the negative control group. The results showed that HFD group gave the highest FER and while the group either fed 10% ASP (B) and group fed on inulin (C) or group fed on chitosan

(F) had lower FER than the other groups. Group D and E which fed on SBP gave the same FER (-0.08) as shown in Table (2). Similar result with those mentioned by Khambualai *et al.* (2008) and Ogungbemi *et al.* (2020) who stated that the body weight of the rats fed chitosan improved feed intake resulting in increased feed efficiency than those fed HFD diet. Addition of ASP as a source of inulin and SBP as a source of chitin in the diet appears protect against the promotion of energy intake, body weight gain. It could that may be fat mass development induced by a high-fat diet by increasing the fermented and the remainder passes through the colon as an insoluble fiber (Soliman, 2019).

Effect of artichoke stem (ASP) and shrimp by-products (SBP) administration on relative organ weights of rat

The data in Table (3) showed that there were insignificant changes of liver, kidney and heart relative weights in all groups when compared with the negative group.

Table 3. Changes in the relative organ weights of obese rats fed on artichoke stem (ASP), shrimp by-product (SBP), inulin and chitosan and normal diet.

Organs Experimental groups	Liver	Kidney	Heart	Brain	Lung
CG (Control diet)	2.87 ± 0.09 ^a	0.87 ± 0.02 ^{ab}	0.34 ± 0.02 ^{ab}	0.77 ± 0.03 ^{cd}	0.76 ± 0.41 ^{bc}
PC (HFD diet)	3.02 ± 0.08 ^a	1.01 ± 0.03 ^b	0.35 ± 0.03 ^b	0.80 ± 0.03 ^d	0.80 ± 0.48 ^c
A (ASP 5%)	2.62 ± 0.03 ^a	0.80 ± 0.01 ^a	0.28 ± 0.04 ^a	0.75 ± 0.03 ^{bcd}	0.67 ± 0.42 ^{ab}
B (ASP 10%)	2.86 ± 0.05 ^a	0.84 ± 0.01 ^{ab}	0.34 ± 0.06 ^{ab}	0.77 ± 0.03 ^{cd}	0.62 ± 0.38 ^a
C (7.7% inulin)	2.92 ± 0.03 ^a	0.86 ± 0.01 ^{ab}	0.32 ± 0.04 ^{ab}	0.72 ± 0.04 ^{abc}	0.72 ± 0.30 ^b
D (SBP 5%)	2.79 ± 0.03 ^a	0.84 ± 0.01 ^{ab}	0.31 ± 0.03 ^{ab}	0.69 ± 0.03 ^{ab}	0.69 ± 0.38 ^{ab}
E (SBP 10%)	2.57 ± 0.05 ^a	0.82 ± 0.01 ^a	0.34 ± 0.06 ^{ab}	0.67 ± 0.05 ^a	0.73 ± 0.26 ^{bc}
F (2.6% chitosan)	2.77 ± 0.08 ^a	0.84 ± 0.01 ^{ab}	0.33 ± 0.02 ^{ab}	0.72 ± 0.07 ^{abc}	0.68 ± 0.30 ^{ab}

Results are expressed as mean ± SD; Means with different superscript letters in the same column imply significant differences at $P \leq 0.05$.

Rats fed with SBP were showed a significantly lower of brain relative weight compared with the normal or HFD diet groups. On the other hand, rats in the C and F groups had significantly lower brain relative weights when compared to the positive control. All treated groups showed significant decreases in lung relative weights except the E group (SBP 10%) when compared with the positive control. Chitosan oligosaccharide prevented increases in organ weight in mice fed on a high fat diet (Sumiyoshi *et al.*, 2006). Huang *et al.* (2015) showed that the liver index of the high fat group significantly differed from those of chitosan groups.

Blood picture examination of obese rats fed on artichoke stem by product (ASP) and shrimp by-product (SBP)

As shown in Table (4), there were insignificant changes observed in most parameters examined after 8 weeks such as hemoglobin (Hb), red blood cells (RBC), mean corpuscular hemoglobin (MCH), mean cell volume (MCV), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDW-CV) red cell distribution width standard deviation (RDW-SD), and platelets count (PLT). However, a significant reduction was noted after 8 weeks for all treated groups in the white blood cells (WBC) and hematocrit (HCT) when compared to the positive group. Administration of artichoke leaves extract (200–400 mg/kg) for one-month rats increased the levels of WBC, RBC, Hb, MCV, MCH, and platelets to near normal values ($p \leq 0.001$) in alloxan induced diabetic obesity rats (Salem *et al.*, 2019).

Serum lipid profile of obese rats fed on artichoke stem by-product (ASP) and shrimp by-product (SBP)

The data recorded in Table (5) showed that there were significant increment in serum levels of TC, TG, and LDL-C of the positive control group by, 10.26, 12.09, and 45.23%, respectively when compared to the control negative group. Moreover, there were significant decrement in serum levels of HDL-C of the positive control group 54.97% compared to the control negative group. It is clear from Table (5) that groups fed with ASP and SBP showed improvement with significant reduction in lipid profile levels when compared to the positive group.

Meanwhile, there were insignificant changes in serum TC, TG, TL, HDL-C, LDL-C, C\LDL, LDL\HDL when compared to the group fed normal diet. The highest reduction in TC was obtained in group B (13.18%), followed by group A (12%) then group E (11.24%). Moreover, there were decrement in serum levels of TG level 14.53, 11.15, 11.86, 12.58, 10.52 and 12.18% for group A, B, C, D, E and F, respectively when compared to the control positive

group. The rats fed on SBP showed no significant increment in serum HDL-C compared to the group of rats given ASP. Conversely, there were significant increases in serum HDL-C by 115.12% in each of rats given 5 % and 10% SBP when compared to the positive group. Serum LDL-C showed a significant decrement by 34.44% and 32.68 in rats fed on 10% ASP and SBP, respectively when compared to the control positive group. Inulin at dosage 7.7 g/kg bw and chitosan at dosage 2.6 g / kg bw were significantly reduced in LDL-C level by 29.57 and 29.97 %, respectively as compared to positive group. These results are in agreement with those obtained by-Delzenne and Kok (1999) and Causey *et al.* (2000). According to Gebhardt (1998), administration of *Cynara scolymus* leaves extracts for two months showed ethanol extract (EEA) from leaves of *C. scolymus* inhibited lipase activity in the plasma in HFD groups, which made a decrease in serum TC, LDL-C, and TG levels as well as a significant reduction in the calculated atherogenic index (AI). Bonsu and Johnson (2012) reported that there was no significant change in lipid profile in rats given 10g/day inulin in individuals diagnosed with type 2 diabetes. The results of chitosan agreed with that study of Jiang *et al* (2019) who reported that chitosan consumption can improve lipid profiles of coronary heart disease (CHD) patients. Chitosan and artichoke leaf extracts had significant therapeutic potential in hypercholesterolemia, cardio protective effects and exerts the amelioration of the imbalance of circulated cholesterol and lipoprotein levels in HF diet-fed rats (Küçükgergin *et al.*, 2010 and Chiu *et al.*, 2020).

Effect of administration of artichoke stem by-product (ASP) and shrimp by-product (SBP) on serum biochemical parameters liver and antioxidant enzymes and kidney function of obese rat

Some biochemical parameters

As shown in Table (6) the results revealed that administration of ASP 5 %, ASP 10%, inulin, SBP 5%, SBP 10%, and chitosan to fed obese rats significantly reduced and improvement in blood glucose levels, total protein, albumin and globulin compared to the positive group after 8 weeks. It can be seen that the glucose levels decreased by 9.87, 8.73, 10.19, 7.42, and 9.46 % in for group A, B, C, D, E and F, respectively as compared to the glucose level of the positive group. While there was no significant change in values of total protein, albumin and globulin in serum rats as compared to the negative control group (Table 6).

Table 4. Change in blood picture of control rats and obese rats fed with artichoke by product (ASP), shrimp by-product (SBP), inulin and chitosan for 8 weeks.

Parameters \ Groups	CG (Control diet)	PC (HFD diet)	A (ASP 5%)	B (ASP 10%)	C (7.7% inulin)	D (SBP 5%)	E (SBP 10%)	F (2.6% chitosan)
WBCS	9.5 ± 0.75 ^a	11.2±0.69 ^b	9.5 ± 0.32 ^a	9.3±0.40 ^a	9.6±0.19 ^a	9.6±0.24 ^a	9.3±0.68 ^a	9.6±0.29 ^a
Hb	15.0±0.34 ^a	14.7±0.30 ^a	15.2±0.59 ^a	15.3±0.42 ^a	15.2±0.70 ^a	15.1±0.43 ^a	15.2±0.51 ^a	15.3±0.38 ^a
RBC	7.5±0.36 ^a	6.4± 0.87 ^a	7.0 ± 0.33 ^a	7.19 ± 0.32 ^a	7.38±0.34 ^a	7.26 ±0.59 ^a	7.12±0.48 ^a	7.35±0.41 ^a
HCT	32.86±1.34 ^a	39.6±1.58 ^b	33.4±1.78 ^a	35.0±1.82 ^a	35.1±2.95 ^a	36.0±1.69 ^a	37.0±3.69 ^a	33.2±1.43 ^a
MCV	52.0±3.71 ^a	56.5±2.17 ^a	52.3±0.75 ^a	53.7±1.13 ^a	55.2±2.25 ^a	54.7±1.73 ^a	52.5±1.41 ^a	53.6±1.00 ^a
MCH	21.8±1.25 ^a	21.9±0.82 ^a	21.5±1.13 ^a	22.1±1.21 ^a	22.0±1.32 ^a	21.3±1.03 ^a	21.5±1.04 ^a	21.2±1.28 ^a
MCHC	31.9±14.07 ^a	38.9±0.57 ^a	39.4±1.48 ^a	39.9±1.38 ^a	37.9±3.19 ^a	38.8±1.39 ^a	40.5±1.01 ^a	38.5±2.43 ^a
RDW-CV	14.7± 1.47 ^a	15.0±0.29 ^a	13.6±0.11 ^a	14.0±0.57 ^a	14.9±1.01 ^a	14.7±0.52 ^a	14.4±0.59 ^a	14.8±0.66 ^a
RDW-SD	29.7±2.14 ^a	28.8±2.68 ^a	29.00±0.49 ^a	28.9±0.56 ^a	29.3±0.44 ^a	29.1±0.66 ^a	28.9±0.19 ^a	28.9±0.50 ^a
PLT	605.0±43.0 ^a	573.0±7.97 ^a	612.2±31.1 ^a	608.0±58.7 ^a	601.8±52.4 ^a	603.4±36.9 ^a	603.2±54.6 ^a	602.4±21.6 ^a

WBC: white blood cell, Hb: hemoglobin, RBC: red blood cell, HCT: hematocrit, MCV: mean corpuscular volume, MCH :mean cell hemoglobin, MCHC: mean cell hemoglobin concentration, RDW-CV: red cell distribution width, RDW-SD: red cell distribution width standard deviation and PLT: platelets count. Results are expressed as mean ± SD Means with different letters in the same row imply significant differences at P≤0.05.

Table 5. Effect of administration of artichoke by product (ASP), shrimp by-product (SBP), inulin and chitosan on serum lipid profile in obese rats

Parameters \ Groups	CG Control diet	PC (HFD diet)	A (ASP 5%)	B (ASP 10%)	C (7.7% inulin)	D (SBP 5%)	E (SBP 10%)	F (2.6% chitosan)
Total lipids (TL)	237.80±5.72 ^a	267.20±3.27 ^b	235.20±4.49 ^a	236.60±1.52 ^a	231.60±3.21 ^a	233.20±2.95 ^a	232.00±2.35 ^a	238.57±5.47 ^a
Triglyceride (TG)	96.38±1.10 ^a	108.03±1.97 ^b	92.33±1.85 ^a	95.98±3.35 ^a	95.22±3.11 ^a	94.44±3.76 ^a	96.66±3.48 ^a	94.87±3.15 ^a
Total Cholesterol (TC)	127.77 ±1.53 ^b	140.88±4.09 ^c	123.97±1.57 ^{ab}	122.31±1.23 ^a	126.34±3.09 ^{ab}	128.17±2.20 ^b	125.05±3.03 ^{ab}	126.16±3.27 ^{ab}
HDL-C	38.20±1.79 ^b	17.20±1.30 ^a	36.80±1.64 ^b	36.20±3.70 ^b	35.40±3.05 ^b	37.00±2.55 ^b	37.00±1.58 ^b	35.71±2.54 ^b
LDL-C	70.29±0.91 ^a	102.08±5.43 ^b	68.70±2.51 ^a	66.92±3.27 ^a	71.89±6.41 ^a	72.28±4.16 ^a	68.72±1.89 ^a	71.48±5.11 ^a
VLDL-C	21.61±0.39 ^b	21.61±0.39 ^b	18.47 ± 0.37 ^a	19.20±0.67 ^a	19.04±0.62 ^a	18.89±0.75 ^a	19.33±0.70 ^a	18.97±0.63 ^a
C\LDL	1.81±0.05 ^b	1.38± 0.03 ^a	1.80± 0.09 ^b	1.83±0.09 ^b	1.76±0.12 ^b	1.77±0.08 ^b	1.82±0.02 ^b	1.77±0.09 ^b
LDL\HDL	1.84±0.10 ^a	5.95±0.70 ^b	1.87±0.2 ^a	1.85±0.30 ^a	2.03±0.4 ^a	1.95±0.20 ^a	1.86±0.10 ^a	2.00±0.20 ^a

TL: total Lipid, TG: Triglyceride, TC: Total Cholesterol, HDL-C: High Density Lipoprotein, LDL-C: Low Density Lipoprotein and VLDL-C: Very Low- Density Lipoprotein, C\LDL: cholesterol\ low density lipoprotein and LDL\HDL: low density lipoprotein\ high density lipoprotein. Results are expressed as mean ± SD; Means with different superscript letters in the same row imply significant differences at P≤0.05.

Table 6. Means of serum biochemical parameters, liver and antioxidant enzymes activities in obese rats fed with artichoke by-product (ASP), shrimp by-product (SBP), inulin and chitosan.

Parameters	Experimental groups							
	CG Control diet	PC (HFD diet)	A (ASP 5%)	B (ASP 10%)	C (7.7% inulin)	D (SBP 5%)	E (SBP 10%)	F (2.6% chitosan)
Glucose (mg/dl)	109.90±1.63 ^a	122.6±4.55 ^b	110.50±1.7 ^a	111.90 ± 1.66 ^a	110.10±0.97 ^a	113.5±0.62 ^a	112.00±1.75 ^a	111.0±0.87 ^a
Total protein (mg/dl)	6.15±0.17 ^a	7.69±0.28 ^b	6.29±0.12 ^a	6.52±0.39 ^a	6.31±0.19 ^a	6.65±0.10 ^a	6.23±0.23 ^a	6.57±0.37 ^a
Albumin(mg/dl)	3.54±0.18 ^a	4.10±0.21 ^b	3.64±0.05 ^a	3.66±0.05 ^a	3.57±0.04 ^a	3.68±0.06 ^a	3.48±0.08 ^a	3.70±0.07 ^a
Globulin (mg/dl)	2.61±0.09 ^a	3.59±0.14 ^b	2.65±0.07 ^a	2.86±0.40 ^a	2.74±0.17 ^a	2.97±0.06 ^a	2.75±0.17 ^a	2.87±0.36 ^a
Antioxidant enzyme								
CAT (U/L)	359.20±5.67 ^c	319.8± 4.60 ^a	348.4±7.02 ^{bc}	344.6±4.83 ^b	349.6±5.50 ^{bc}	354.6±8.08 ^{bc}	343.6±4.28 ^b	358.6 ±5.5 ^c
GSH-Px (U/l)	352.4±6.31 ^b	324.2±3.27 ^a	348.0±5.70 ^b	345.0±7.07 ^b	349.4±9.18 ^b	348.4±7.44 ^b	345.2±10.51 ^b	343.6±10.44 ^b
SOD (U/l)	162.00±3.58 ^b	125.0±4.36 ^a	158.2±6.57 ^b	159.0±5.48 ^b	160.2±3.96 ^b	158.8±7.79 ^b	156.6±10.60 ^b	159.8±7.69 ^b
Liver enzymes								
AST (U/L)	85.57± 3.82 ^a	96.08± 5.6 ^b	84.93± 5.53 ^a	83.97± 4.1 ^a	84.77 ±1.88 ^a	86.13±2.02 ^a	84.72 ± 2.47 ^a	85.82± 4.55 ^a
ALT (U/L)	84.73± 5.8 ^a	95.36± 2.03 ^b	78.69± 1.14 ^a	81.45± 1.22 ^a	82.45± 1.86 ^a	81.57± 5.55 ^a	80.33± 2.16 ^a	78.66± 3.68 ^a
ALP (U/mg protein)	83.59± 2.83 ^a	96.70± 4.54 ^b	84.33± 3.69 ^a	83.63± 4.10 ^a	80.53± 1.84 ^a	85.91± 2.02 ^a	82.18± 1.79 ^a	83.45± 1.29 ^a
ACP (U/L)	15.02± 0.89 ^a	16.10 ± 0.53 ^b	14.73± 0.38 ^a	14.93 ± 0.15 ^a	14.43 ± 0.47 ^a	14.23 ± 0.42 ^a	14.87± 0.15 ^a	14.53± 0.40 ^a
Kidney functions								
Urea (mg/dl)	52.51± 1.70 ^b	57.89± 3.36 ^c	42.20± 0.64 ^a	41.41± 1.96 ^a	43.91 ± 2.22 ^b	42.72 ± 0.72 ^a	43.12 ± 4.33 ^a	42.89± 3.38 ^a
Creatinine (mg/dl)	1.55 ±0.02 ^b	1.72±0.03 ^c	1.40 ±0.01 ^a	1.46±0.04 ^a	1.42±0.02 ^a	1.40 ±0.04 ^a	1.44 ±0.03 ^a	1.45±0.04 ^a
Bilirubin (mg/dl)	1.46± 0.04 ^b	1.69±0.05 ^c	1.36± 0.11 ^a	1.34± 0.03 ^a	1.33± 0.03 ^a	1.38± 0.03 ^a	1.33± 0.02 ^a	1.38± 0.05 ^a

Results are expressed as mean ± SD; Means with different superscript letters in the same row imply significant differences at P≤0.05.

In the same respect Table (6) showed, that the HFD group had significant increased in serum levels of total protein, albumin, and globulin by 25.04, 15.82 and 37.62% respectively when compared to the negative control group. These results are in agreement with Zhong *et al.* (2007), who found that administration of dietary fibers, i.e., sugar cane fiber and cellulose decreased glucose in serum rats. The dietary fiber as a prebiotics' stimulate the growth of beneficial bacteria in intestinal microbiota to produce SCFAs which had physiological benefits such as decreased the insulin response and glucose uptake; induce lower blood lipid levels; enhancement of mineral bioavailability (Rawi *et al.*, 2020).

Liver enzymes activities

The results in Table (6) showed that the effect of different by-product on serum liver enzymes AST, ALT in obese rats. In the positive group, there were highly significant elevation in ALT, AST and ALP enzymes activity as compared with the other group. Administration of ASP, SBP, inulin at dosage 7.7 g /kg bw and chitosan at dosage 2.6 g/kg bw for 8 weeks to rats fed high fat showed remarkably amelioration the reduction in ALT, AST and ALP enzymes activity compared with the positive group. It was clear from Table (6) that administration of ASP at dose 5% to rats showed significantly decrement by 17.48% in serum ALT enzyme when compared to the positive group and no significant reduction as compared to the negative group. In contrast, there was a significant decrement in serum ALP enzyme by 34.08% in rats given ASP at dose 10% when compared to the negative control group. Inulin at dosage 7.7g kg bw caused significant decrement in the level of AST, ALP and AST enzyme when compared to the control group. Hepatocellular damage is identified by ALT and AST, where Cirrhosis, chronic hepatitis, alcoholic hepatitis, acute viral hepatitis, and toxic ischemic injury are all known to cause an increase in these aminotransferases (Yap and Aw. 2010).

Activity of antioxidant enzymes

As shown in Table (6), the results revealed that administration of ASP 5%, ASP 10%, inulin, SBP 5%, SBP 10%, and chitosan to fed obese rats significantly elevated and improvement in catalase (CAT) levels, glutathione peroxidase (GSH-Px), and superoxide dismutase (SOD) compared to the positive group after 8 weeks. It could be saw that the (SOD) levels were increased by 26.56, 27.2, 28.16, 27.04, 25.28 and 27.84 % in for group A, B, C, D, E and F respectively as compared to the (SOD) level of the positive group.

These results were in agreement with Wu and Chen. (2011), who found that inulin enhanced the antioxidative defense systems by upregulating the gene

expressions of glutathione peroxidase and catalase in the colonic mucosa and superoxide dismutase and catalase in the liver. Furthermore, promoted antioxidative status in the blood by elevating the R-tocopherol level. Inulin was well-fermented in rats and increased the concentration and daily excretion of fecal SCFAs, especially acetate and butyrate. These results suggest that *in vivo* utilization of inulin stimulated both local and systemic antioxidative defense systems in rats. Sia (2017) reported that chitosan 0.18 g/day) elevated T-SOD and G3SH-PX concentrations in treatment group compared with normal group. More importantly, this study found that chitosan group performed the most efficiently in suppressing oxidative stress by elevating GSH-PX levels.

kidney function

As seen from the data in Table (6), the mean serum urea, and bilirubin values were not different in serum of rats' groups given all doses of ASP and SBP, while there were significant decrement in those treated groups compared to the positive control group. In the control group, this reduction was associated with decrement in kidney relative weight. Rats fed on inulin showed insignificantly reduction in serum urea, while it showed significantly decrement in creatinine and bilirubin when compared to the normal diet group. However, the creatinine values were higher in serum of HFD control group than the other treated group. These results are in agreement with Jiang *et al.* (2019) who showed that there was a significant reduction in serum creatinine in obesity rats treated with chitosan extract. The filtering ability of the kidneys declines as the disease progresses, resulting in the loss of essential blood proteins in the urine. The kidneys lost their ability to remove waste products like creatinine and urea, which could be tested in the blood to see how much kidney disease had progressed (Swaminathan 2004).

CONCLUSION

From our data we can concluded that the diet containing artichoke stem by-products (ASP), shrimp by-products (SBP) and either inulin as soluble fiber or chitin asinsoluble fiber decreased food intake and hence reduction weight gain, improved blood glucose level, reduced lipid levels of obese rat when compared to high fat diet rats. However, these food processing by- products can be used in the nutraceutical formulation of functional food products and a good source of natural dietary fiber to enhances the nutritional quality for prevention of diseases like obesity, and its associated health risks.

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الملخص العربي

تأثير تناول الوجبات المدعمة بمتبقيات عمليات التصنيع للخرشوف والجمبري على الفئران البدينة

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١٨.٦٩ و ٠.٤٢٪ ألياف ذائبة و ٢٥.٠١ و ٥٨.٥٧٪ ألياف غير ذائبة في ASP و SBP منزوع الدهن على التوالي. كما تميزت بارتفاع محتواها من الأينولين حيث يبلغ ١٨.٢ جم / ١٠٠ جم في سيقان الخرشوف والكيتين حيث يبلغ ٥٨.١٥ جم / ١٠٠ جم قشر جمبري. وتم دراسة التقييم البيولوجي على مجموعة تم تغذيتها علي وجباتيغاسية (كنترول) ومقرانها بمجموعة من الفئران البدينة، وتم تقسيمهم الى سبع مجموعات كالتالي مجموعة موجبة (PC) ومجموعات تم تغذيتها بـ ASP و SBP بتركيز ٥ و ١٠٪ و اينيولين بتركيز ٧.٧ جم/كجم من الوجبة و كيتوزان بتركيز ٢.٦ جم /كجم من

تساهم الأغذية المدعمة بالألياف الغذائية الوظيفية في الوقاية من بعض الأمراض مثل السمنة وأمراض القلب والأوعية الدموية ومرض السكري. لذا أجريت الدراسة لتقدير محتوى الألياف الغذائية في متبقيات عمليات التصنيع للخرشوف (ASP) والجمبري (SBP) وتقييم التأثير الوقائي للوجبة المدعمة بتلك المتبقيات الغنية بالألياف الغذائية الطبيعية على وزن الجسم، صورة الدم، المقاييس الكيميائية الحيوية وأنشطة إنزيمات الكبد في الفئران البدينة. وقد أظهرت النتائج أن محتوى الألياف الخام كان ٢٢.٦٨٪ في ASP و ١٣.٦٥٪ في SBP. وتتكون الألياف الغذائية الكلية من

انخفاض تركيز الكوليسترول والجليسريدات الثلاثية والليبوبروتينات منخفضة الكثافة، وانخفاض معنوي في تركيز جلوكوز الدم وانخفاض نشاط إنزيمات الكبد وزيادة في الانزيمات المضادة للأكسدة مقارنة بالمجموعة الإيجابية. لذلك يمكن الاستفادة من ASP كمصدر للإينولين و SBP كمصدر للكيتين كمغذيات وكمنتجات غذائية وظيفية ومصدر جيد للألياف الغذائية الطبيعية لتحسين الجودة التغذوية للوقاية من الأمراض كالسمنة وما يرتبط بها من مخاطر صحية.

الكلمات المفتاحية: الألياف الوظيفية، الألياف الغذائية الطبيعية، الإينولين، الكيتين، المغذيات.

الوجبة لمدة ٨ اسابيع وقورنت بالمجموعة الكنترول التي تم تغذيتها بالوجبة القياسية. وقد أوضحت النتائج حدوث تحسن وانخفاض معنوي في كلا من وزن الجسم النهائي (%) ومعدل الزيادة في وزن الجسم (%) ومعدل كفاءة التغذية (FER) في جميع المجاميع التجريبية المعاملة بالمقارنة بالمجموعة الموجبة وقد ادي اضافة ١٠٪ ASP أو SBP إلى انخفاض معنوي ($P \leq 0.05$) في وزن الجسم بنسبة ٣٧.٦٦ و ٣٥.٦١٪ على التوالي بالمقارنة بمجموعة الموجبة PC بينما سجل أعلى انخفاض في زيادة وزن الجسم وأقل معدل في FER في المجموعات التي تغذت على الشيتوزان. أدت تغذية الفئران البدينة على وجبة محتوية علي ASP و SBP إلى