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Chemical and nutritional studies on extracts of food processing by-products and their effects on obesity complications in rats

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Abstract: The present study aims to investigate Chemical and nutritional studies on extracts of food processing by-products and their effects on obesity complications in rats. The results showed that the moisture content for the all selected food processing by-products i.e. orange peel powder (OPP), banana peel powder (BPP) and tomato pomace powder (TPP) were ranged 7.62 -9.01%, total protein was 2.98 -4.96 %, crude fat was 2.11 - 3.64 %, crude fiber was 19.56 -23.98 %, and ash content was 1.88 -2.86 %. Also, the total carotenoids content was 159.24to 397.65 $mg.100g^{-1}$ and total phenolics was 913 to 1270 EGA.100 g^{-1}. Feeding of rats on diet induced obesity (DIO) leads to increase the body weight (BW) than the control group. At the end of the experiment (8 weeks), rats of the normal group recorded 82.80%for the BW while obese group was 140.12%. Replacement of the diet with OPP, TPP, BPP and their mixture induced significant decreasing on BW of the obese rats by different rates. Also, Obesity induced a significant increased ($p \leq 0.05$) in serum glucose (37.70%) and serum lipid profile (TG, 28.28%; TC, 29.80; LDL, 81.39%; VLDL, 28.28%) while significant decreased ($p \leq 0.05$) in HDL (36.59%) compared to normal controls. Repblcement of the rat's diets with 1% w/w by OPP, TPP, BPP and their mixture extracts induced significant decreasing rates on serum glucose concentrations, TG, LDL and VLDL. The same result was recorded for the oxidants concentration (TBARS) in plasma. The higher amelioration effect induced in rats was recorded for the mixture extracts treatment followed by TPP, BPP and OPP extracts, respectively. In conclusion, these findings provide a basis for the use of the selected food processing by-products in some important therapeutic nutrition applications such the prevention and early treatment of obesity and its complications.

Keywords: Orange peel, banana peel, tomato pomace, extracts, serum glucose, serum lipids profile, TBARs.

Introduction

According to the Faculty of Public Health, obesity is "an excess of body fat frequently resulting in a significant impairment of health and longevity **(Nammi *et al.,* 2004).** Body fatness is most commonly assessed by body mass index (BMI) which is calculated by dividing an individual's weight measured in kilogrammes by their height in metres squared. Overweight is generally defined as a BMI greater than 25; individuals with a BMI greater than 30 are classified as obese. Obesity can be described as the "New World Syndrome". Its prevalence is on continuous rise in all age groups of many of the developed countries in the world. Statistical data reveals that the problem of obesity has increased from 12–20% in men and from 16–25% in women over the last ten years **(Callaway *et al.,* 2006).** Recent studies suggest that nearly 15–20% of the middle aged European population are obese **(IOM, 2009)** and that in USA alone it is responsible for as many as 3,00,000 premature deaths each year **(Catalano and Ehrenberg , 2006).** Obese patients have been associated with increased risk of morbidity and mortality relative to those with ideal body weight **(Birdsall *et al.,* 2009)**. Even modest weight reduction in the range of 5–10% of the initial body weight is associated with significant improvements in a wide range of co-morbid conditions **(WHO, 1999).**

Industrialization of agriculture in the Arab world represent a large proportion of waste was estimated at 18.14 million tonnes per year and represent remnants of fruit and vegetables manufacture about 6.14% of this amount . Waste in the food industry is characterized by a high ratio of product-specific waste. This not only means that the generation of this waste is unavoidable, but also that the amount and kind of waste produced, which consists primarily of the organic residue of processed raw materials, can scarcely be altered if the quality of the finished product is to remain consistent. The utilization and disposal of product specific waste is difficult, due to its inadequate biological stability, its potentially pathogenic nature, its high water content, its potential for rapid autoxidation, as well as its high level of enzymatic activity. The diverse types of waste generated by various branches of the food industry can be quantified based upon each branches' respective level of production.

Among food processing by-products orange (*Citrus sinensis* L.) peel contain an impressive list of other essential nutrients, including both glycaemic and non-glycaemic carbohydrate (sugars and fiber), potassium, folate, calcium, thiamin, niacin, vitamin B_6, phosphorus, magnesium, copper, riboflavin, pantothenic acid and a variety of phytochemicals. In addition, citrus contains no fat or sodium and, being a plant food, no cholesterol. It was showed that orange peel essential oil treatment could decrease serum malondialdehyde (MDA), immunoglobulin A (IgA), immunoglobulin G (IgG), immunoglobulin M (IgM) levels and increase antioxidant enzymes activities. Banana (*Musa SPP*) fruit peel has a broad spectrum of biological activities and include be used as a good source of antioxidant and antitumor agent **(Kumar *et al.*, 2019)**. In addition to banana peels extracts are promising sources of natural antioxidants total phenol **(Kumar, 2015)** and Bioactive compounds such as alkaloids, anthocyanin, flavonoids, glycosides, phlobatannins, tannins and terpenoids Finally, tomato (*Solanum lycopersicum*) skin extracts are especially rich in lycopene. (**Baysal *et al.,* 2000**) clearly stated that a large quantity of carotenoids is lost as waste in tomato processing. Lycopene is an especially powerful antioxidant because its multiplicity of conjugated double bonds makes it a good quencher of free radicals. Lycopene is also usually one of the most common carotenoids in the blood serum. Therefore, it can be an important part of the antioxidant defense system and may function as an anticancer agent, lower heart disease risk and inhibits cholesterol synthesis (**Betty, 2002**). Also, the antioxidant defense system of other bioactive compounds found in tomato pomace includes vitamins (C and E), minerals (selenium and copper), phytonutrients (β-carotene and lutein), and biological products (bilirubin, coenzyme Q10) that protect tissues from oxidative damage

Several studies reported that all of the previous plant parts are rich sources of bioactive compounds including vitamins (C, E and β-carotene), polyphenols, organo-sulphur compounds, dietary fiber etc (**Elhassaneen *et al.,* 2016**). Varied bioactive components at different levels may be responsible for the offered health protection. A number of experiments indicate that such by-products added to laboratory animals diet had positive effects on serum lipid profile, liver and kidney functions and serum glucose (**Coskun *et al.,* 2005; Gorinstein *et al.*,**

2006 and Matsunaga *et al.,* 2014). In the present study we will try to open new avenue for extending the using of such four food processing by-products (orange and banana peel and tomato pomace) in therapeutic nutritional applications through mixing them in feeds to improve the obesity disease complications in rats.

Materials and Methods

Materials

Food by-products: Orange (*Citrus sinensis* L.) and banana (*Musa sapientum*) peels and Tomato (*Lycopersicon esculentum* MILL.) pomace was obtained from Shebin ElKom market, Menoufiya Governorate, Egypt during the 2019 harvesting period. The collected samples were transported to the laboratory and used immediately for cauliflower peels preparation.

All chemicals, solvents and buffers (except mentioned on site) were purchased from Al-Gomhoryia Company for Trading Drugs, Chemicals and Medical Instruments, Cairo, Egypt.

Methods

Preparation of food by-products peel powder

Orange (OPP) and banana (BPP) peels powder

Orange (OPP) and banana (BPP) peels powder were washed and then dried in a hot air oven (Horizontal Forced Air Drier, Proctor and Schwartz Inc., Philadelphia, PA) at 55 ^{0}C for 14. The dried skins were ground into a fine powder in high mixer speed (Moulinex Egypt, Al-Araby Co., Egypt). The material that passed through an 80 mesh sieve was retained for use.

Tomato pomace powder (TPP)

Tomato fruits were minced by using high speed mixer machine (ElAraby Toshiba, Benha, Egypt) and sieving by using stainless- steel sieve,10 mesh/inch^2. The resulted pomace were collected and dried in a hot air oven (Horizontal Forced Air Drier, Proctor and Schwartz Inc., Philadelphia, PA) at 55 ^{0}C until arriving by the moisture in the final product to about 10%. The dried pomace was ground into a fine powder in high mixer speed (Moulinex Egypt, Al-Araby Co., Egypt). The material that passed through an 80 mesh sieve was retained for use.

Analytical methods

Chemical analysis of plant parts

Plant parts were analyzed for moisture, protein (T.N. × 6.25, micro - kjeldahl method using semiautomatic apparatus, Velp company, Italy) , fat (soxhelt miautomatic apparatus Velp company, Italy , petroleum ether solvent), ash and fiber contents were determined using the methods described in the. Carbohydrates calculated by differences:
Carbohydrates (%) = 100 - (% moisture + % protein + % fat + % Ash + % fiber) .

Total phenolics and carotenoids in selected plant parts were analyzed as follow: one gram of each by-product powder samples was extracted with 80% acetone and centrifuged at 10,000g for 15 min. The supernatant obtained from both samples were used for the analysis of total phenolics, carotenoids and antioxidant activity.

Antioxidant activity

Antioxidant activity of tested spices extracts and standards (α-tocopherol, BHA, ans BHT; Sigma Chemical Co., St. Louis, Mo) was determined according to the β-carotene bleaching method following a modification of the procedure described by **Marco (1968)**. Various concentrations of BHT, BHA, and α-tocopherol in 80% methanol was used as the control.

Antioxidant activity was calculated in four different ways. In the first, absorbance was plotted against time, as a knit curve, and the absolute value of slope was expressed as antioxidant value (AOX). Antioxidant activity (AA) was all calculated as percent inhibition ralative to control using the following equation (**Al-Saikhan *et al*., 1995**).

$$AA = (R_{control} - R_{sample}) / R_{control} \times 100$$

Where:

$R_{control}$ and R_{sample} were the bleaching rates of beta-carotene in reactant mixture without antioxidant and with plant extract, respectively.

The third method of expression based on the oxidation rate ratio (ORR) was calculated according to the method of **Marinova et al., (1994)** using the equation:

$$ORR = R_{sample} / R_{control}$$

Where:

$R_{control}$ and R_{sample} are the same in the previous equation.

In the fourth method, the antioxidant activity coefficient (AAC) was calculated as described by **Mallet *et al.,* (1994).**

$$(AAC) = (Abs_{S\,120} - Abs_{C\,120}) / Abs_{C\,0} - Abs_{C\,120}) \times 1000$$

Where:

$Abs_{S\,120}$ was the absorbance of the antioxidant mixture at time 120 min, $Abs_{C\,120}$ was the absorbance of the control at time 120 min, $Abs_{C\,0}$ was the absorbance of the control at zero time.

Determination of total phenolics and carotenoids

Total phenolics in selected plant parts were determined using Folin-Ciocalteu reagent according to **Singleton and Rossi, (1965).** Two hundreds milligrams of sample was extracted for 2 h with 2 mL of 80% MeOH containing 1% hydrochloric acid at room temperature on an orbital shaker set at 200 rpm. The mixture was centrifuged at 1000g for 15 min and the supernatant decanted into 4 mL vials. The pellets were combined and used for total phenolics assay. One hundred microliters of extract was mixed with 0.75 mL of Folin-Ciocalteu reagent (previously diluted 10-fold with distilled water) and allowed to stand at 22 ^{0}C for 5 min; 0.75 ml of sodium bicarbonate (60g/L) solution was added to the mixture after 90 min at 22 0C, absorbance was measured at 725 nm. Results are expressed as gallic acid and equivalents (GAE). The total carotenoids in 80% acetone extract were determined by using the method reported by **Litchenthaler (1987).**

Biological Experiments

Materials

Casein was obtained from Morgan Chemical Co., Cairo, Egypt.

The rest of chemicals, reagents and solvents were of analytical grade and purchased from El-Ghomhorya for Drugs, Chemicals and Medical Instruments Trading Co. (Cairo, Egypt).

Animals

Animals used in this study, adult male albino rats (140+10 g per each) were obtained from Research Institute of Ophthalmology, Medical Analysis Department, Giza, Egypt.

Basal Diet

The basic diet prepared according to the following formula as mentioned by **(AIN, 1993)** as follow: protein (10%), corn oil (10%), vitamin mixture (1%), mineral mixture (4%), choline chloride (0.2%), methionine (0.3%), cellulose (5%), and the remained is corn starch

(69.5%). The used vitamin mixture component was that recommended by **(Campbell, 1963)** while the salt mixture used was formulated according to (**Hegsted and Perkins 1941**).

Experimental design

All biological experiments performed a complied with the rulings of the Institute of Laboratory Animal Resources, Commission on life Sciences, National Research Council (**NRC, 1996**). Rats (n=36 rats), were housed individually in wire cages in a room maintained at 25 ± 2 ^{0}C and kept under normal healthy conditions. All rats were fed on basal diet for one-week before starting the experiment for acclimatization.

After one week period, the rats were divided into two main groups, the first group (Group 1, 6 rats) still fed on basal diet and the other main group (30 rats) was feed with diet-induced obesity (DIO, product no.D1245, Research Diets, Inc. NJ, (See Table 4) for 8 weeks which classified into sex sub groups as follow: group (2), fed on diet-induced obesity (DIO) as a positive control; group (3), fed on DIO containing 1 %orange peel powder exctract(OPPE); group (4), fed on DIO containing 1 %banana peel powder exctract(BPPE); group (5), fed on DIO containing 1 % TPPE, group (6), fed on DIO containing 1 % mixture, OPPE, BPPE and TPPE by equal parts. All rats were weighted per two weeks to calculate the body weight gain (RWG).

Blood sampling

At the end of experiment period, 8 weeks, blood samples were collected after 12 hours fasting using the abdominal aorta and rats were scarified under ether anesthetized. Blood samples were received into clean dry centrifuge tubes and left to clot at room temperature, then centrifuged for 10 minutes at 3000 rpm to separate the serum according to **Drury and Wallington, (1980).** Serum was carefully aspirate, transferred into clean covet tubes and stored frozen at -20^{o}C until analysis.

Haematological analysis

Serum glucose

Enzymatic determination of serum glucose was carried out colorimetrically according to **Yound, (1975**).

Blood lipids profile

Triglycerides (TG), Total cholesterol (TC) and HDL-Cholesterol were determined in serum using specific kits purchased from El-Nasr

Pharmaceutical Chemicals Company, Cairo, Egypt. Low density lipoprotein cholesterol (LDL-c) and very low density lipoprotein cholesterol (VLDL-c) were assayed according to the equations of **Fniedewald *et al.,* (1972**) *as* follow:

Very low density lipoprotein (VLDL cholesterol) = TG/5

LDL cholesterol = Total cholesterol – HDL cholesterol – V LDL cholesterol

Malonaldialdehyde content (MDA)/TBARS

Malonaldialdehyde content (MDA)/TBARS content was measured as thiobarbituric acid reactive substances (TBARS) as described by Half milliliter of plasma were added to 1.0 ml of thiobarbituric acid reagent, consisting of 15% TCA, 0.375% thiobarbituric acid (TBA) and 0.01% butylated hydroxytoluene in 0.25 N HCl. Twenty-five microliters of 0.1 M $FeSO_4.7H_2O$ was added and the mixture was heated for 20 min in boiling water. The samples were centrifuged at 1000 rpm for 10 min and the absorbance was read at 535 nm using Labo-med. Inc., spectrophotometer against a reagent blank. The absorbance of the samples was compared to a standard curve of known concentrations of malonicdialdehyde.

Statistical Analysis

All measurements were done in triplicate and recorded as mean±SD. Statistical analysis was performed with the Student *t*-test and MINITAB 12 computer program (Minitab Inc., State College, PA).

Results and Discussion

Proximate chemical composition of food processing by-products

The proximate composition of selected plant parts and their mixture is shown in Table (1). The results showed that the moisture content was ranged from 7.62 ± 1.76 -9.01 ± 1.01%, total protein was 2.98 ± 0.09-4.96 ± 0.96%, crude fat was 2.11 ± 0.56-3.64 ± 0.87%, crude fiber was 19.56 ± 2.65-23.98 ± 4.36%, and ash content was 1.88 ± 0.80-2.86 ± 0.29%. The selected plant parts mixture was recorded the highest content of protein (4.43 ± 0.85 %) while the highest values of crude fat, protein, fat, fiber and ash were recorded for BPP, TPP, Mix, OPP and TPP , respectively. The proximate composition reported was accordance with that observed **by Marcos *et al.,* (2006) and, Loza *et al*., (2017)** reported that banana flour contains 6% - 5.5% total fiber, 2.6% - 3.5% ash, 2.5% - 3.3% protein and 0.3% - 0.8% lipids. Also each

100 g from bananas contains 22.84 g Carbohydrates and 12.23 g Sugars. **Marcos *et al.,* (2006**) reported that samples of tomato pomace were analyzed for moisture content, total and soluble sugars, protein, fat, soluble and total fiber, as well as mineral content. From the results obtained we can conclude that tomato pomace composition (in dry weight basis) is as follows: 59.03% fiber, 25.73% total sugars, 19.27% protein, 7.55% pectins, 5.85% total fat and 3.92% minerals. The present data with the other **Vasso and Constantina, (2007)** confirmed that varieties of plant affected well on the chemical composition of peels/skins. Data of the present study with the others confirmed that such selected plant parts could be used successfully in food technology and/or nutritional applications due to their high nutritional value, good sources for protein, fiber and ash.

Table 1. Proximate chemical composition ($g.100g^{-1}$) of food processing by-products*

Parameters	Banana peel powder (BPP)	Tomato pomace powder (TPP)	Orange peel powder OPP	Mixture (Mix)
Moisture	9.01 ± 1.01	8.06 ± 1.15^{a}	8.56 ± 0.83^{a}	7.62 ± 1.76^{ab}
Total protein	2.98 ± 0.09	4.96 ± 0.96^{a}	3.16 ± 1.05^{b}	4.43 ± 0.85^{ab}
Crude fat	2.67 ± 0.22	2.11 ± 0.56^{c}	3.05 ± 0.43^{c}	3.64 ± 0.87^{b}
Crude fiber	22.15 ± 2.11	19.56 ± 2.65^{c}	24.65 ± 5.22^{a}	23.98 ± 4.36^{b}
Ash	2.86 ± 0.29	2.67 ± 0.87^{c}	1.88 ± 0.80^{ab}	2.65 ± 1.03^{a}
Carbohydrates (by difference)	60.33± 3.45	62.64± 4.11^{a}	58.7± 3.66^{c}	57.68± 4.01^{b}

* Each value represents the mean of ten replicates ±SD. Mean values with the different superscript letters in the same raw mean significantly different at level p≤0.05. Mix, mixture of BPP, TPP and OPP by equal parts.

Total carotenoids and phenolics contents of food processing by-products

Total carotenoids and phenolics contents of selected plant parts are shown in Table (2). The results showed that the total carotenoids content was 159.24± 5.76 to 397.65 ± 14.97 $mg.100g^{-1}$ and total phenolics ranged 913 ± 87 to 1270 ± 110 mg EGA.100 g^{-1}. The OPP was recorded the highest content of total carotenoids while BPP recorded the highest values of total phenolics. In similar studies, **Ajila *et al.,* (2007)** found that polyphenol, carotenoid and dietary fiber contents in raw and ripe peels of Raspuri and Badami mango varieties, which ranged from 55 to 110 mg GAE/g, 387 to 3337 mg/g, 44 to78%, respectively. Thus, total carotenoid and SDF contents determined in the present study were higher than that reported by the others. Also, studying the bioactive compounds in PPP, MPP and OSP showed that the total dietary fiber content was ranged 47.87-64.80 $g.100g^{-1}$, total carotenoids was 89-348 $mg.100g^{-1}$ and total phenolics was 1679-8946 mg EGA.100 g^{-1} in (**Ahmed, 2014**). Finally,**sayed- Ahmed, (2016)** found that the total carotenoids was 92.43-412.14 $mg.100g^{-1}$ and total phenolics was 1104-7129 mg EGA.100 g^{-1} in different food by-products including red onion skin, cauliflower leaves, mango peels and potato peel powders. In general, Data of the present study with the others confirmed that such selected food processing by-products could be constituted a good position in food sciences and nutritional applications through their high content of bioactive compounds including phytochemicals and dietary fibers. In this concern, **Al-Weshahy and Rao (2012)** reviewed that dietary fiber (DF) is well known as a bulking agent, increasing the intestinal mobility and hydration of the feces. Several authors have reviewed the importance of consumption of moderate amounts of DF for human health **(Ballesteros et al., 2001).** It is a broad term that includes several carbohydrates; cellulose, hemicelluloses, lignins, pectins, gums etc. **(Gallaher and Schneeman, 2001).** The study of **Camire *et al.,* (1993)** concluded that DF are primarily insoluble, and can bind bile acids *in-vitro*. It is believed that binding of bile acids is one of the mechanisms whereby certain sources of DF lower plasma cholesterol. Also, studied the hypocholesterolemic effect of DF from potato peels and found that after four weeks of feeding on their, rats showed 40 % reduction in plasma cholesterol content and 30% of hepatic fat cholesterol levels were reduced as compared with animals fed only with cellulose supplemented diet. Defects of DF on lipid-profile influence several health related issues. High concentrations of low-density lipoprotein (LDL) cholesterol, other dyslipidemia (high concentration of triglycerides and low concentration of high-density lipoprotein [HDL] cholesterol), leads to blood platelets aggregation **(Bagger *et al.,* 1996),** risk factors for cardiovascular diseases (CVD) **(Erkkila and Lichtenstein, 2006)**, and hypertension **(Alonso *et al.,* 2006).** Moreover, high intake of DF has a positive influence on blood glucose profile and it is related health complications, in healthy and diabetic individuals of both types. By altering the gastric emptying time, dietary fibers are able to affect the absorption of other simple sugars. The effect of dietary fibers on blood glucose and insulin response has been demonstrated by many other authors as well **(Onyechi et al., 1998 , Chandalia *et al.,* 2000** and reviewed in **Al-Weshahy and Rao,2012**).

On the other side, phenolic compounds and carotenoids are found by significant amounts in all food processing by-products shows a variety of pharmacological and nutritional effects such as growth-inhibition of tumor and microbial cells, immunostimulatory properties, enhancing reproduction, improving the growth performance (body weight gain, feed consumption, and feed conversion), reduction of cancer risk and protection against cardiovascular diseases, diabetes as well as ageing (**; Kamal and Daoud 2003; Campos *et al*., 2003; and sayed- Ahmed, 2016)**. Also, the ability of these compounds to acts as antioxidants has been demonstrated in the literature. Several researchers have investigated the antioxidant activity of phenolic compounds such as flavonoid and have attempted to define the structural characteristics of flavonoids that contribute to their activity (**Nieto *et al*., 1993)**. Also, Phenolic acids, such as caffeic, chlorogenic, ferulic, sinapic, *p*-coumaric acids, vanillic, syringic and *p*-hydroxybenzoic appear to be active antioxidants (**Larson, 1988 and El-Sadany, 2001**). Antioxidant activity is fundamental property important for life. Many of the biological functions, such as antimutagenicity, anticarcinogenicity, antiaging and antiobesity, among others, originate from this property (**Elhassaneen *et al.,* 2016**).

Antioxidant activities of food processing by-products

The antioxidant activities of three plant parts and their mixture are shown in Table (3). From such data it could be noticed that the plant parts extracts and their mixture showed slightly differences in antioxidant activity (AA= 87.67±7.32% - 93.26±8.19%). All of the selected food processing by-products and their mixture showed strong activity because of their high phytochemicals content (phenolic compounds and carotenoids). Such data are in accordance partially with that observed by **Elhassaneen *et al.,* (2016)** and **Sayed-Ahmed, (2016)** who found that some food processing by-products including onion skin, mango peel powder, eggplant peel and potato peel high in their antioxidant activity due to their phenolic compounds high content.

Table 2. Total carotenoids and phenolics contents of selected plant parts*

Parameters	Banana peel Powder (BPP)	Tomato pomace powder (TPP)	Orange peel powder OPP	Mixture (Mix)
Total carotenoids ($mg.100g^{-1}$)	186.25 ± 6.41 [b]	159.24± 5.76 [c]	397.65 ± 14.97 [a]	238.40 ± 10.65 [b]
Total phenolics ($mg\ GAE.100\ g^{-1}$)	1270 ± 110[d]	1130 ± 91 [c]	913 ± 87 [b]	1028 ± 135 [b]

* Each value represents the mean of ten replicates ±SD. Mean values with the different superscript letters in the same raw mean significantly different at level p≤0.05. Mix, mixture of BPP, TPP and OPP by equal parts

Table 3. Antioxidant activity of food processing by-products

Samples	Antioxidant activity AA (%) [a]
Banana peel powder (BPP)	90.04± 6.21
Tomato pomace powder (TPP)	92.88± 5.44
Orange peel powder (OPP)	87.67± 7.32
Mixture (Mix) [c]	93.26± 8.19
Control	0.00± 0.00
a-toc, 50 mg/L	98.68± 1.51
BHT, 50 mg/L	92.95± 1.14

[a] Antioxidant activity (AA, %) = (R control - R sample) / R control x 100 where: R control and R sample were the bleaching rates of beta-carotene in reactant mixture without antioxidant and with plant extract, respectively, [b] Each value represents mean ±SD, [c] Mix, mixture of BPP, TPP and OPP by equal parts.

Finally, data of the present study with that carried out by the others could be represent the mile stone towards the extension of using parts such OPPE, BPPE, TPPE and their mixture, as natural antioxidants in many different nutritional applications. Synthetic antioxidants such as butylated hydroxyanisole (BAH) and butylated hydroxytoluene (BHT) have been used as antioxidants since the beginning of the last century. Restrictions on the use of these compounds, however, are being imposed because of their carcinogenicity. Thus, the interest in natural antioxidants has increased considerably year after year.

Biological experiments

The effect of food processing by-products extracts on body weight of obese rats

The effect of food processing by-products extracts on body weight (% of change) of obese rats was shown in Figure (1). From such data it could be noticed that feeding of rats on diet induced obesity (DIO) leads to increase the body weigh than the control group. At the end of the experiment (8 weeks), rats of the normal group recorded 82.80%for the BW while obese group was 140.12%. Replacement of the diet with OPP, TPP, BPP and their mixture induced significant decreasing on BW of the obese rats by different rates. The higher effect on weigh decreasing was recorded for the Mix followed by BPP, OPP and TPP, respectively. The effect of different plant parts in the control of obesity is the main subjects of many studies (**El-Nashar, 2007; Bonet., 2015; Sayed Ahmed, 2016**). The positive effects of such plant parts regarding the control of the obesity could be attributed to their high level content of different classes phytochemical compounds including flavonols, phenolic acids, anthocyanins, alkaloids, carotenoids, phytosterols and organosulfur compounds (**Beattic *et al.*, 2005; and sayed Ahmed, 2016**). Such bioactive compounds and their

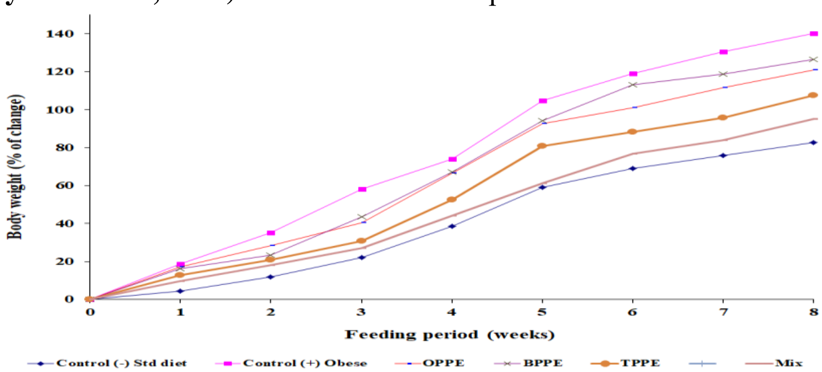

Figure 1. The effect of food processing by-products extracts on body weight gain (% of change) of obese rats*

* OPP, orange peel powder;; TPP, tomato pomace powder; BPP, banana peel powder extracts and Mix, mixture extracts of OPP, TPP and BPP by equal parts.

conversion products have been shown to impact gene expression and cell (including adipocyte) function through multiple mechanisms, notably by: (a) interacting with several transcription factors of the nuclear receptor superfamily, (b) interfering with the activity of other transcription factors, (c) modulating signaling pathways which are associated with inflammatory and oxidative stress responses; and (d) through extragenomic actions including scavenging of reactive species, retinoylation **(Bonet *et al.,* 2015; Sayed Ahmed, 2016)** .

Effect of selected Food processing by-products extracts on serum glucose concentration of obese rats

Glucose concentration in serum of obese rats consumed selected Food processing by-products extracts were shown in Table (4). From such data it could be noticed that obesity induced a significant increased ($p \leq 0.05$) in serum glucose (37.70%) compared to normal controls. replacement of the rat's diets with 1% w/w by OPP, TPP, BPP and their mixture induced significant decreasing on serum glucose concentrations which recorded 19.24, 12.56, 16.43 and 8.97 (% of control), respectively. The higher amelioration effect in serum glucose rising induced by obesity in rats was recorded for the Mix treatment followed by TPP, BPP and OPP, respectively. In similar study, **Sayed Ahmed (2016)** recorded the same results when feeding obese rats with bread samples replacement with food processing by-products including potato peels, cauliflower leaves, red onion skin and mango peels powders. In human, **Avenell *et al.,* (2004)** found that in patients with type-2 diabetes, weight loss of around 5 kg is associated with a reduction in fasting blood glucose of between 0.17 mmol/L to 0.24 mmol/L at 12 months. The reduction in serum glucose as the result of feeding selected food processing by-products was observes many studies. The organosulfur compounds S-methylcysteine sulfoxide and S-allylcysteine sulfoxide were linked to significant amelioration of weight loss, hyperglycemia, low liver protein and glycogen, and other characteristics of diabetes mellitus in rats **(Sheela *et al.,* 1995).** Onion peel extract might improve glucose response and insulin resistance associated with type 2 diabetes by alleviating metabolic dysregulation of free fatty acids, suppressing oxidative stress, up-regulating glucose uptake at peripheral tissues, and/or down-regulating inflammatory gene expression in liver which was reported by **Jung *et al.,* (2011).** Moreover, in most cases, Citrus is most commonly thought of as a good source of vitamin C. However, like most other whole foods, citrus fruits also contain an impressive list of other essential nutrients, including both glycaemic and non-glycaemic carbohydrate (sugars and fiber), potassium, folate, calcium, thiamin, niacin, vitamin B_6, phosphorus, magnesium, copper, riboflavin, pantothenic acid and a variety of phytochemicals. In addition, citrus contains no fat or sodium and, being a plant food, no cholesterol. The average energy value of fresh citrus is also low which can be very important for consumers concerned about putting on excess body weight . In addition to banana peels extracts are promising sources of natural antioxidants total phenol **(Kumar, 2015)**. and Bioactive compounds such as alkaloids, anthocyanin, flavonoids, glycosides, phlobatannins, tannins and terpenoids . Also, the antioxidant defense system of other bioactive compounds found in tomato pomace includes vitamins (C and E), minerals (selenium and copper), phytonutrients (β-carotene and lutein), and biological products (bilirubinandcoenzyme Q10) that protect tissues from oxidative damage induced in diabetic cases . Additionally, the mixture treatment gave maximum hypoglycemic yield when compared with the tested by-products separated. It could be mean that a combination of different food processing by-products may be more efficient for reducing the serum glucose level because the interactive effects occurred by different categories of bioactive compounds of food by-products parts used. Such data are in accordance with that observed by **Sayed Ahmed, (2016)**

Effect of selected Food processing by-products extracts on blood lipids profile concentration of obese rats

The effect of selected Food processing by-products extracts on blood lipids profile concentration of obese rats were shown in Table (5). From such data it could be noticed that obesity induced a significant increased ($p \leq 0.05$) in TG

Table 4. Effect of selected Food processing by-products extracts on serum glucose concentration (mg/dL) of obese rats*

Value	Control (-) Std diet	Control (+) Obese diet	Food processing by-products extracts (1%, w/w)			
			OPP	**TPP**	BPP	Mix
Mean	101.34	139.55	120.83	114.07	117.99	110.43
SD	4.23	5.34	3.08	4.22	3.21	6.24
% of change	0.00	37.70	19.24	12.56	16.43	8.97

* OPP, orange peel powder;; TPP, tomato pomace powder; BPP, banana peel powder extracts and Mix, mixture extracts of OPP, TPP and BPP by equal parts. Means in the same row with different superscript letters are significantly different at p≤ 0.05.

(28.28%), TC (29.80%) and LDL (81.39%), VLDL (28.28%) while significant decreased ($p \leq 0.05$) in HDL (36.59%) compared to normal controls. Replacement of the rat's diets with 1% w/w by OPP, TPP, BPP and their mixture induced significant improvements on blood lipid profile through decreasing the TG, TC, LDL and VLDL by different ratios. The opposite direction was observed for the HDL levels. The higher effects in improving of the blood lipid profile disorders induced by obesity in rats were recorded for the Mix treatment followed by TPP, BPP and OPP, respectively. In the same context, modeling based on systematic reviews of RCTs suggests that modest and sustained weight loss (5-10 kg) in patients with overweight or obesity is associated with reductions in low density lipoprotein, total cholesterol and triglycerides and with increased levels of high density lipoprotein (**Avenell *et al.,* 2004; Poobalan *et al.,* 2004; and Bales and Buhr, 2008**). In similar study, **Sayed Ahmed, (2016)** recorded the same results when feeding obese rats with bread samples supplemented with food processing by-products including potato peels, cauliflower leaves, red onion skin and mango, eggplant peels powders. In this context, coronary heart disease (CHD) is a major health problem in both industrial and developing countries including Egypt. Many studies have now shown that blood elevated concentrations of total or low density lipoprotein (LDL) cholesterol in the blood are powerful risk factors for CHD, whereas high concentrations of high density lipoprotein (HDL) cholesterol or a low LDL (or total) to HDL (reviewed in **Bedawy, 2008**).The composition of the human diet plays an important role in the management of lipid and lipoprotein concentrations in the blood. Reduction in saturated fat and cholesterol intake has traditionally been the first goal of dietary therapy in lowering the risk for cardiovascular disease. In recent years, however, the possible hypocholesrerolemic effects of several dietary components, such as found in our selected food processing by-products (OPP, TPP and BPP) including, flavonols, phenolic acids, anthocyanins, alkaloids, carotenoids, phytosterols and organosulfur compounds etc have attracted much interest. Also, phenolic compounds found in such food processing by-products exerts its beneficial effects on cardiovascular health by antioxidant and anti-inflammatory activities **(Anonymous, 1998; Kuhlmann *et al.,* 1998, and Sayed Ahmed, 2016).**

Table 5. Effect of selected Food processing by-products extracts on blood lipids profile concentration of obese rats*

Value	Control (-) Std diet	Control (+) Obese diet	Food processing by-products extracts (1%, w/w)			
			OPP	TPP	BPP	Mix
Triglycerides (TG, mg/dL)						
Mean	49.97	64.1	59.90	57.46	59.81	55.02
SD	4.19	6.95	4.22	5.70	4.10	3.98
% of Change	0.00	28.28	19.87	14.99	19.69	10.10
Total cholesterol (TC, mg/dL)						
Mean	111.67	144.95	133.12	125.55	129.34	121.78
SD	5.11	7.34	6.72	6.34	6.10	5.29
% of Change	0.00	29.80	19.21	12.43	15.82	9.05
High density lipoprotein (HDL, mg/dL)						
Mean	44.33	28.11	34.06	36.38	34.09	39.12
SD	4.11	3.99	2.67	1.88	4.18	3.78
% of Change	0.00	-36.59	-23.17	-17.93	-23.10	-11.75
Low density lipoprotein (LDL, mg/dL)						
Mean	57.35	104.02	87.08	77.68	83.29	71.66
SD	5.09	5.11	6.11	6.34	5.34	7.10
% of Change	0.00	81.39	51.85	35.46	45.24	24.96
Very low density lipoprotein (VHDL, mg/dL)						
Mean	9.99	12.82	11.98	11.49	11.96	11.00
SD	3.67	2.65	2.56	3.56	2.59	3.11
% of Change	0.00	28.28	19.87	14.99	19.69	10.10

* OPP, orange peel powder;; TPP, tomato pomace powder; BPP, banana peel powder extracts and Mix, mixture extracts of OPP, TPP and BPP by equal parts. Means in the same row with different superscript letters are significantly different at $p \leq 0.05$.

Effect of food processing by-products extracts on oxidants concentration of obese rats

Oxidative stress status in obese rats feeding some selected food processing by-products was assessed by measuring some oxidants concentration in plasma including thiobarbituric acid reactive substances (TBARS) (Table 6). From such data it could be noticed that obesity induced a significant increased ($p \leq 0.05$) in TBARS concentration in plasma by 34.56% compared to normal controls. Supplementation of the rat diets with 1% w/w by TPP, BPP and OPP and their mixture induced significant decreasing ($p \leq 0.05$) on these parameter concentration in plasma by the different ratio. The higher amelioration effect in plasma TBARS concentration rising induced by obesity in rats was recorded for the by-product mixtures treatment followed by TPP, BPP and OPP, respectively. In similar studies, clinical evidences for obesity-associated oxidative stress (OS) have been provided by measurement of either biomarkers or end-products of free radical-mediated oxidative processes **(Sayed Ahmed, 2016).** For instance, lipid peroxidation markers such as malondialdehyde (MDA), one of the most important compounds in TBARS and major products of the oxidation of polyunsaturated fatty acids,, lipid hydroperoxides and conjugated dienes are found to be increased in plasma from obese subjects in many clinical studies **.** Systemic metabolic alterations associated with obesity contribute to the increase in oxidative stress have been reported by many authors. For example, hyperglycemia as a hallmark of type II diabetes, a metabolic complication of obesity, induces oxidative stress through activation of the polyol and hexosamine pathways, production of advanced glycation end-products (AGE), and increase of diacylglycerols (DAG) synthesis **(DCCTRG, 1993).** Excess of circulating lipids induces ROS formation pathways, which contribute to the increase in lipid oxidation and protein carbonylation **(Jensen *et al.,* 1989).** Leptin and angiotensin II, secreted at high levels by adipocytes, are inducers of ROS generation and might therefore promote inflammation and lipid peroxidation **(Bouloumie *et al.,* 1999).**

Table 6. Effect of selected food processing by-products on plasma thiobarbituric acid reactive substances (TBARS, nmol/mL) concentration of obese rats*

Value	Control (-) Std diet	Control (+) Obese diet	Food processing by-products extracts (1%, w/w)			
			OPP	TPP	BPP	Mix
Mean	2.98	4.01	3.45	3.31	3.34	3.18
SD	0.69	0.98	1.01	0.78	0.55	0.41
% of Change	0.00	34.56	15.77	11.07	12.08	6.71

* OPP, orange peel powder;; TPP, tomato pomace powder; BPP, banana peel powder extracts and Mix, mixture extracts of OPP, TPP and BPP by equal parts. Means in the same row with different superscript letters are significantly different at $p \leq 0.05$.

Long time ago, interest in the possible significance of MDA on human health has been stimulated by reports that are mutagenic and carcinogenic compound **(Shamberger *et al*., 1974)**. The positive effects of food processing by-products extracts on oxidants formation/ concentration of obese rats could be attributed to several mechanisms induced by their bioactive components content. In this context, **Coskun *et al.,* (2005)** found that quercetin, domainant flavonoid such as found in our selected food processing by-products extract, have anti-oxidative and anti-inflammatory activities. Such dietary phenolics found in tested plant by-products are metabolized in liver, inhibiting liver injury induced by diabetes i.e. enhancing lipid metabolism, reducing oxidative stress may be particularly effective, consequently. Additionally, the mixture treatment gave maximum reduction yield of plasma MDA when compared with the tested food processing by-products separated. It could be mean that a combination of different plant by-products may be more efficient for reducing plasma MDA level, the biomarkers of oxidative stress and inflammation in the body, because the interactive effects occurred by different categories of bioactive compounds of different food processing by-products used.

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دراسات كميائية وتغذوية على مستخلصات المنتجات الثانوية لتصنيع الاغذية وتاثيراتها على مضاعفات السمنة لدى الفئران

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الملخص العربى:

تهدف الدراسة الحالية إلى اجراء الدراسات الكيميائية والتغذوية على مستخلصات المنتجات الثانوية لتصنيع الأغذية وتأثيراتها على مضاعفات السمنة لدى الفئران.

أوضحت النتائج أن المحتوى الرطوبي لكل المنتجات الثانوية المختارة لتصنيع الأغذية مثل مسحوق قشر البرتقال OPP) ومسحوق ثقل الطماطم (TPP)و مسحوق قشر الموز (BPP) تراوحت بين ٩.٠١ % – ٧.٦٢ وكان اجمالى البروتين ٤.٩٦ %– ٢.٩٨، كانت الدهون الخام ٣.٦٤% – ٢.١١ والالياف الخام ٢٣.٩٨ % – ١٩.٥٦ ، ومحتوى الرماد ٢.٨٦ % - ١.٨٨ ، وايضا كان اجمالى محتوى الكاروتينات ١٥٩.٢٤ الى ٣٩٧.٦٥ مجم لكل ١٠٠جم وكان اجمالى الفينولات ٩١٣الى ١٢٧٠ ملجم لكل ١٠٠جم ، وكانت تغذية الفئران على السمنه التى يسببها النظام (DIO) يؤدى الى زيادة وزن الجسم (BW) عن المجموعه الضابطة .

وفى نهاية التجربة (٨ اسابيع) سجلت الفئران فى المجموعة الطبيعية ٨٢.٨٠ % للوزن الحى بينما المجموعه البدينة ١٤٠.١٢ % .

وادى استبدال النظام الغذائي OPP و BPP و TPP ومزيجها الى انخفاض كبير فى وزن الفئران البدينة بمعدلات مختلفة . وايضا تسببت السمنه فى زيادة كبيرة فى جلوكوز الدم (٣٧.٧٠ %) و دهون الدم (TG ٢٨.٢٨ TG ٢٩.٨٠ LDL ٨١.٣٩ VLDL ٢٨.٢٨) بينما انخفضت بشكل ملحوظ ($P\leq0.05$) فى HDL (٣٦.٥٩ %) مقارنة بعناصر التحكم العادية .

ادى تكميل حمية الفئران بنسبة ١ % من الوزن بواسطة OPP . TPP . OPP ومستخلصات خليطهما الى انخفاض كبير فى تركيزات الجلوكوز فى الدم و TG و TG و LDL و VLDL .

تم تسجيل نفس السلوك لتركيز المؤكسدات(TPARS) فى البلازما .

تم تسجيل تاثير التحسن الاعلى المستحث فى الفئران لمعالجة خلاصات الخليط متبوعة بمستخلصات TPP و BPP و OPP على التوالى فى الختام توفر هذه النتائج أساسا لاستخدام المنتجات الثانوية المختارة لتصنيع الاغذية فى بعض تطبيقات التغذية العلاجية الهامة مث الوقاية والعلاج المبكر للسمنة ومضاعفاتها .

الكلمات المفتاحية: قشر البرتقال، قشر الموز، تفل الطماطم، المستخلصات، جلوكوز الدم، صورة دهون الدم، المواد الفعالة لحامض الثيوباربتيوريك .