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Abstract:

Obesity increases the risk of several debilitating, and deadly diseases, including diabetes, heart disease, and some cancers. Pharmacological therapy of obesity is costly and associated with multiple side effects led to patient non-compliance. In this study, an alternative natural remedy through the use of three vegetable parts by-products of food processing (orange peel, eggplant peel, and tomato pomace) was applied in a dietary intervention to improve the complications of obesity in rats. Rats (n=36 rats) were divided into two main groups, the first group (Group 1, 6 rats) still fed on basal diet as a normal and the other main group (30 rats) was feed with diet-induced obesity (DIO) for 8 weeks which classified into five sub groups as follow: group (2), fed on diet-induced obesity (DIO) as a positive control; groups (3,4,5 and 6), fed on DIO containing plus 7.5% OPP, EPP, TPP and Mix (OPP+ EPP + TPP by equal parts), respectively. At the end of the experiment (8 weeks), rats of the normal group recorded increasing on body weight rate by 75.82% from the starting point of the experiment while obese group was 116.40%. Dietary intervention with OPP, TPP, EPP and their mixture on the diet by 7.5% induced significant decreasing on body weight of the obese rats by the rate of 99.13, 98.20, 87.10 and 82.80% from the starting point, respectively. Also, dietary intervention with OPP, TPP, EPP and their mixture induced significant ameliorative effect in different complications induced by obesity including increase the plasma non-enzymes antioxidant (GSH, and GSSG), improve the liver functions and serum lipid profile, and decrease the blood glucose level and TBARS (biological indicator of lipid oxidation). The highest ameliorative effects was recorded for the Mix followed by EPP, TPP and OPP, respectively. In conclusion,_the present data support the benefits of dietary modification, including bioactive compounds supplementation, in alleviating some complications associated obesity.

Keywords: orange peel, eggplant peel, tomato pomace, bogy weight, serum lipid profile, glutathione fractions, TBARS.

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مستخلص البحث:

تزيد السمنة من خطر الإصابة بالعديد من الأمراض المنهكة والمميتة، بما في ذلك مرض السكري وأمراض القلب وبعض أنواع السرطان .العلاج الدوائي للسمنة مكلف ويرتبط بآثار جانبية متعددة أدت إلى عدم امتثال المريض .في هذه الدراسة، تم تطبيق علاج طبيعي بديل من خلال استخدام ثلاثة أجزاء نباتية من المنتجات الثانوية لتصنيع الأغذية (قشر البرتقال، قشر الباذنجان، وثفل الطماطم) في التدخل الغذائي لتحسين مضاعفات السمنة لدى الفئران .تم تقسيم الفئران (عددها = 36 فأرًا) إلى مجموعتين رئيسيتين، المجموعة الأولى (المجموعة 1، 6 فئران) لا تزال تتغذى على النظام الغذائي الأساسي كالمعتاد والمجموعة الرئيسية الأخرى (30 فأرًا) تتغذى على السمنة الناجمة عن النظام الغذائي (.(DIO) لمدة 8 أسابيع والتي تم تقسيمها إلى خمس مجموعات فرعية على النحو التالي: المجموعة (2)، التي تغذت على السمنة الناجمة عن النظام الغذائي (DIO) كمجموعة تحكم إيجابية؛ المجموعات (3،4،5 و6)، التي يتم تغذيتها على DIO التي تحتوي على 7.5 % OPP وEPP وTPP وMix (OPP+ EPP + TPP بأجزاء متساوية)، على التوالي .وفي نهاية التجربة (8 أسابيع) سجلت فئران المجموعة الطبيعية زيادة في معدل وزن الجسم بنسبة 75.82% عن نقطة بداية التجربة بينما بلغت نسبة السمنة 116.40 .%أدى التدخل الغذائي باستخدام OPP و TPP و EPPوخليطهم على النظام الغذائي بنسبة 7.5% إلى انخفاض معنوي في وزن الجسم لدى الجرذان السمينة بمعدل 99.13 و98.20 و87.10 و82.80% من نقطة البداية على التوالي .أيضًا، أدى التدخل الغذائي باستخدام OPP و TPPو EPPوخليطهم إلى إحداث تأثير تحسيني كبير في المضاعفات المختلفة الناجمة عن السمنة بما في ذلك زيادة مضادات الأكسدة غير الإنزيمية في البلازما GSH) و(GSSG، وتحسين وظائف الكبد ومستوى الدهون في الدم، وتقليل نسبة الدهون في الدم .مستوى السكر في الدم و TBARS) المؤشر البيولوجي لأكسدة الدهون .(تم تسجيل أعلى التأثيرات التحسينية للمزيج يليهEPP ، TPPوOPP، على التوالي .في الختام، تدعم البيانات الحالية فوائد تعديل النظام الغذائي، بما في ذلك مكملات المركبات النشطة بيولوجيا، في التخفيف من بعض المضاعفات المرتبطة بالسمنة .

الكلمات المفتاحية:

قشر البرتقال، قشر الباذنجان، ثفل الطماطم، وزن البوجي، صورة الدهون في المصل، جزيئات الجلوتاثيون، TBARS.

Introduction

Obesity is a state of excess adipose tissue mass. Although often viewed as equivalent to increase body weight, this need not be the case-lean but very muscular individuals may be overweight by numerical standards without having increased adiposity. Obesity is defined by assessing its linkage to morbidity or mortality. Although not a direct measure of adiposity, the most widely used method to gauge obesity is the *body mass index* (BMI), which is equal to weight/height^2 (in kg/m^2). BMIs for the midpoint of all heights and frames among both men and women range from 19–26 kg/m^2 (Elhassaneen and Salem, 2015). Large-scale epidemiologic studies suggest that all-cause, metabolic, cancer, and cardiovascular morbidity begin to rise (albeit at a slow rate) when BMIs are ≥25, suggesting that the cut-off for obesity should be lowered. A BMI between 25 and 30 should be viewed as medically significant and worthy of therapeutic intervention, especially in the presence of risk factors that are influenced by adiposity, such as hypertension and glucose intolerance. Also, obesity, is correlated with several diseases, particularly cardiovascular diseases (CVD), diabetes mellitus type 2, certain types of cancer, osteoarthritis, asthma, and neurological and immunological disorders (Aronne and Segal, 2003; Caterson, 2009; Elhassaneen and Salem, 2014; Elmaadawy et al., 2016; Elhassaneen et al., 2019; Elhassaneen et al., 2020-a; Mehram et al., 2021; Shalaby and Elhassaneen, 2021).

In obesity treatment/prevent strategies, both hypocaloric diets and increased physical activity lead to loss of body weight (obesity). With these traditional approaches to weight loss, potential therapeutic agents could be important tools in such strategies i.e. preventing and/or treating obesity and associated metabolic diseases. Number of pharmacological approaches have been investigated in recent years but few therapeutically effective and safe products have been sophisticated (Jandacek and Woods, 2004). By other meaning, the up to date pharmacological therapy is costly and associated with multiple side effects led to patient non-compliance. Therefore, there is a need to explore alternative therapies particularly from natural sources does't have those previous problems. In this direction, different plant parts have been utilized as anti-obesity agents by several authors (Elbasouny, et al., 2019; El-Harby, 2019; Almutairiu, 2020; Alqallaf, 2021; Elhassaneen et al., 2019; Elhassaneen et al., 2020 a-d; Essa, 2021; Shalaby and Elhassaneen, 2021; Elhassaneen et al, 2022). These plant parts have taken different forms such as powders, extracts and other herbal combinations, all of which have shown effective effects in the prevention and treatment of obesity and its complications in experimental animals. Therefore, the results of those studies constituted an important factor for expansion in this field, which is to increase the search for more and new parts of different plants that are widespread in local, regional and global environments to be used for this purpose.

In the present study, we will try to open new avenue for extending the using of such three food processing by-products (orange peel, eggplant peel, and tomato pomace) in therapeutic nutritional applications through feeding intervension to improve the obesity disease complications in rats

Material and Methods

Materials

Plant fruits

Eggplant (*Solanum melongena*) , orange (*Citrus sinensis* L.) and Tomato (*Lycopersicon esculentum* MILL.) fruits were purchased from Port Said City markets, Port Said Governorate, Egypt. The collected samples was transported to the laboratory and used immediately for peels and pomace powders preparation.

Chemicals

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

Equipment's

Absorbance and fluorescence for different assays were measured using Labo-med. Inc., spectrophotometer, CA and Schematzu fluorescence apparatus, Japan, respectively.

Methods

Preparation of food by-products peel powder

Orange and eggplant peels powder

Orange (OPP) and eggplant (EPP) peels powder were prepared by the method of Elhassaneen et al., (2020-c). Orange (OPP) and Eggplant (BPP) peels powder were washed and then dried in a hot air oven at 60 ^{0}C for 8 hours. The dried peels were ground into a fine powder in high mixer speed (Moulinex, Al-Araby Co., Benha, Egypt). The material that sieved at 80 mesh sieve was retained for use.

Tomato pomace powder (TPP)

Tomato pomace powder (TPP) was prepared by the method of Elhassaneen et al., (2020-c). 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 tomato pomace was collected and dried in a hot air oven at 55 ^{0}C until arriving by the moisture in the final product to about 8%. 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.

Biological Experiments

Animals

Animals used in this study, adult male albino rats (145±4.42g per each) were obtained from Research Institute of Ophthalmology, Medical Analysis Department, Giza, Egypt.

Basal Diet (BD)

The BD 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 and the salt mixture used were formulated according to Reeves et al., (1993).

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 24 ± 3 ^{0}C and kept under normal healthy conditions. All rats were fed on BD 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, for 8 weeks which classified into sex sub groups as follow: group (2), fed on diet-induced obesity (DIO) as a positive control; groups (3,4,5 and 6), fed on DIO containing plus 7.5% OPP, EPP, TPP and Mix (OPP+ EPP + TPP by equal parts, respectively. All rats were weighted each week to calculate the body weight gain (RWG).

Blood sampling

At the end of experiment period (8 weeks), after 12 hours fasting, rats were scarified under ether anesthetized and blood samples were collected using the abdominal aorta. Samples were received into clean dry centrifuge tubes and left to clot at room temperature, then centrifuged for 15 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.

Hematological analysis

Serum glucose

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

Liver functions

Alanine aminotransferase (ALT) and serum aspartate aminotransferase (AST) activities were measured in serum using the modified kinetic method of Tietz, (1976) while alkaline Phosphatase (ALP) activity was determined using modified kinetic method of Vassault *et al.*, (1999).

Serum lipid profile

Triglycerides (TGs), total cholesterol (TC), HDL-Cholesterol, and LDL-cholesterol and VLDL-cholesterol were determined in serum according to the methods of Fossati and PrenPPE (1982), Richmod (1973), Lopes-Virella et al., (1977) and Ahmadi et al., 2008, respectively.

Glutathione content

GSH content was measured colorimetrically in serum samples such as described by Ellman, (1959).

TBARS

TBARs content were measured as thiobarbituric acid reactive substances (TBARS) as described by **Buege and Aust, (1978)**. 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

Effect of dietary intervention with selected plant parts from food processing by-products on body weight of obese rats

Effect of dietary intervention with selected plant parts from food processing by-products on body weight of obese rats was shown in Table (1) and Figures (1 and

2). Such data indicated that at the end of the experiment (8 weeks), rats of the normal group recorded increasing on body weight rate by 75.82% from the starting point of the experiment while obese group was 116.40%. Dietary intervention with OPP, TPP, EPP and their mixture on the diet by 7.5% induced significant decreasing on body weight of the obese rats by the rate of 99.13, 98.20, 87.10 and 82.80% from the starting point, respectively. Thus, the highest effect on body weight decreasing was recorded for the Mix followed by EPP, TPP and OPP, respectively. Such data are in accordance with that observed by several authors where control/treatment of obesity by intervention with the different part parts (Elhassaneen and Salem, 2014; Elbasouny, et al., 2019; El-Harby, 2019; Almutairiu, 2020; Alqallaf, 2021; Elhassaneen et al., 2019; Elhassaneen et al., 2020 a-d; Essa, 2021; Elhassaneen et al, 2022). All of these studies agreed that the positive effects of such plant parts regarding the control/ treatment of the obesity attributed to their high level content of different categories of bioactive compounds including phenolics, carotenoids, anthocyanins, alkaloids, flavonoids, phytosterols and organosulfur compounds etc. Such bioactive compounds could manage/control/ treatment the obesity through impact gene expression and adipocyte function through several mechanisms as follow: 1) interacting with several transcription factors of the nuclear receptor superfamily, 2) interfering with the activity of other transcription factors, 3) modulating signaling pathways which are associated with the oxidative stress responses; and 4) epigenetic effects including scavenging of reactive species, inhibition of the lipid oxidation etc., (Bonet *et al.*, 2015; Sayed Ahmed, 2016; EL-Harbi, 2108; Elhassaneen et al, 2022; Arafa, 2023) .

Table 1. Effect of dietary intervention with selected plant parts from food processing by-products on body weight (g) of obese rats

Groups	Feeding period (weeks)								
	0	1	2	3	4	5	6	7	8
Control (-) Std diet	151.96	156.56	161.71	174.17	197.46	220.96	242.00	251.78	267.16 ^{d}
Control (+) Obese	151.96	162.37	180.67	216.68	238.35	280.22	299.99	315.48	328.83^{a}
OPP	151.96	160.54	175.66	192.35	228.07	263.91	275.06	289.53	302.60 ^{b}
TPP	151.96	155.59	165.31	187.42	220.05	256.97	273.64	290.53	301.18 ^{b}
EPP	151.96	154.53	165.59	179.30	209.08	238.49	257.74	267.85	284.31 ^{c}
Mix	151.96	158.83	170.14	185.76	210.58	241.81	257.02	267.41	277.77 ^{cd}

Each value represents the mean of six rats. Means with different superscript letters in the same row are significantly different ($p \leq 0.05$). OPP, orange peel powder, TPP, tomato pomace powder, EPP, eggplant peel powder, Mix, mixture powder of OPP, TPP and EPP by equal parts

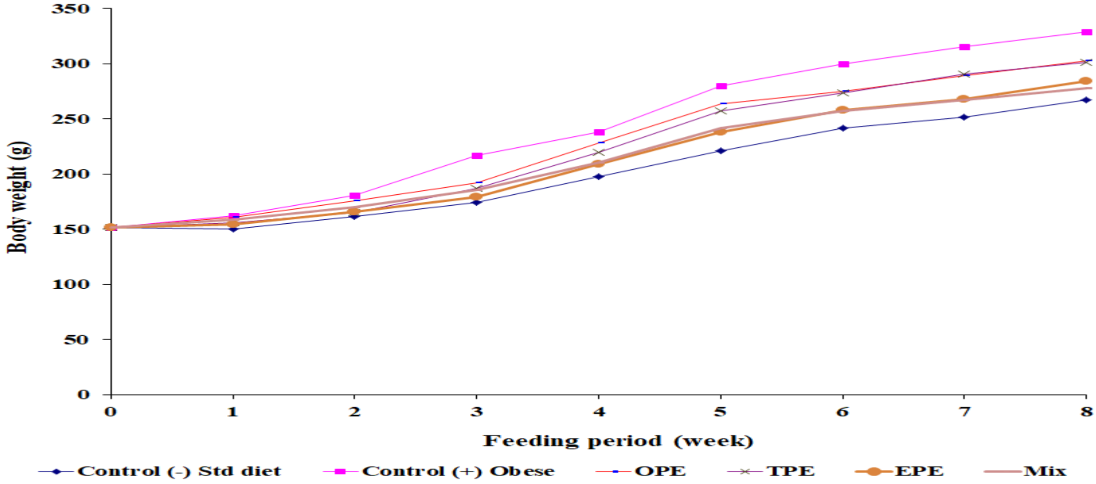

Figure 1. Effect of dietary intervention with selected plant parts from food processing by-products on body weight (g) of obese rats

Each value represents the mean of six rats. Means with different superscript letters in the same row are significantly different ($p\leq 0.05$). OPP, orange peel powder, TPP, tomato pomace powder, EPP, eggplant peel powder, Mix, mixture powder of OPP, TPP and EPP by equal parts

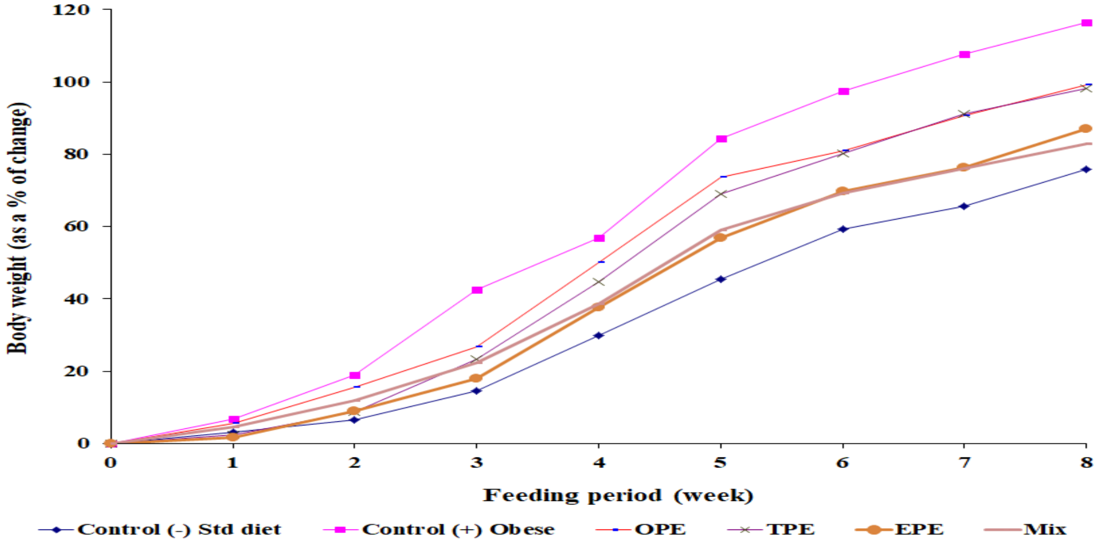

Figure 2. Effect of dietary intervention with selected plant parts from food processing by-products on body weight (% of change from the start point) of obese rats

Each value represents the mean of six rats. Means with different superscript letters in the same row are significantly different ($p \leq 0.05$). OPP, orange peel powder, TPP, tomato pomace powder, EPP, eggplant peel powder, Mix, mixture powder of OPP, TPP and EPP by equal parts

Effect of dietary intervention with selected plant parts from food processing by-products on liver function of obese rats

The effect of dietary intervention with selected plant parts from food processing by-products on liver function of obese rats were shown in Table (2). Such data indicated that obesity induced a significant increased (p≤0.05) in AST (33.11%), ALT (41.19%) and ALP (31.56%) compared to normal control group. Dietary intervention with OPP, TPP, EPP and their mixture on the diet by 7.5% induced significant decreasing on liver AST, ALT and ALP activities by the ratio of 21.59, 14.64, 21.86 and 12.37%; 21.72, 14.87, 15.70 and 7.04%; and 23.41, 21.26, 19.88 and 15.71%, from the starting point, respectively. Thus, the higher effects in manipulation of the liver enzymes activity disorders induced by obesity in rats were recorded for the Mix followed by TPP, EPP and OPP, respectively. Such data are in partially match with that observed by several authors where control/treatment of obesity by intervention with the different part parts (Elbasouny, et al., 2019; El-Harby, 2019; Almutairiu, 2020; Alqallaf, 2021; Essa, 2021).

In general, aminotransferases are normally intracellular enzymes and the presence of their elevated levels in the plasma indicates damage to cells rich in them (Pagana and Pagana, 1997). These enzymes are elevated in nearly all liver diseases, but are particularly high in conditions that the causes extensive cell necrosis. Serial enzyme measurements are often useful in determining the course of liver damage (Pagana, and Pagana, 1997; Hong et al., 2002; Elbasouny et al., 2019; Elsemelawy et al., 2021). Also, ALP is an enzyme which catalyzes the hydrolysis of phophate esters at an alkaline pH to give pi and the corresponding alcohol, phenol or sugar. The highest concentrations are found in the liver, biliary tract, epithelium and bone (Pagana and Pagana, 1997). Elevated serum and leukocytic AP leaves in patients with Hodgkin`s and non-Hodgkin`s lymbhoma were reported by several investigators (Gobbi *et al*., (1982; Thyss *et al*., 1985).

Data of the present study with the others indicated that plant parts are a rich source of different categories of bioactive compounds such phenolics, anthocyanins, alkaloids, carotenoids, phytosterols, organosulfur compounds etc (Elhassaneen and Sanad, 2009; Elbasouny et al., 2019; Abd Elalal et al., 2021; Elhassaneen et al., 2022 (a,b,c); Elhassaneen et al., 2023 a and b). Such bioactive compounds could manage/control/ treatment the liver function enzymes activity disorder induced by different carbon tetrachloride, benzo(*a*)pyrene and nitrosamine. For example, El-Nashar, (2007), found that different doses of cinnamon extract showed slight-decreased in serum AST, GLT and ALP after 12 week of feeding when compared with control group. The same observation was reported in rats injected with nitrosamine and treated with apricot kernel extracts (Hassan, 2011). Also, the addition of tested plant parts such Henada *(Jasonia Montana)*, lemon balm leaves (*Melissa officinalis*), hawthorn leaves *(Crataegus azorolus)*, rose of jericho *(Anastatica hierochuntica)* and corn cob silk *(zea mayz)* to the diet in the presence of CCl_4 induced significant improvements in serum AST, ALT and ALP activities (El-Sayed *et al.,* 2012). Furthermore, sweet violet (*Viola odorata* L.) blossom powder prevented partially the rise of mean serum ALT, AST and ALP activities induced by CCl_4 injection (Abd El-Fatah., 2013 and Elhassaneen *et al.,* 2013). Flavonoids found in all the tested by-products are known to block the hepatocellular uptake of bile acids (Dawson, 1998). Also, they are improved the antioxidant activity of the liver (Beattic *et al.*, 2005). Furthermore, El-Nashar, (2007) found that flavonoids have exhibited strong antioxidant activity, acting as scavengers, against reactive oxygen species (ROS) *in vitro*. Additionally, pre-treatment with apricot kernel extract rich in bioactive compounds such as found in the present studied plant parts were able to reduce the damage of liver through the improvement of antioxidant defense system in RBC's (Hassan, 2011). Take in our consideration all of these mechanisms of actions, the higher improvement in liver function parameters recorded in rats feeding Mix samples could be attributed to the antagonism effects induced by their content of different bioactive compounds categories.

Table 2.. Effect of dietary intervention with selected plant parts from food processing by-products on liver function of obese rats

Value	Control (-) Std diet	Control (+) Diabetic	Food processing by-products powder (7.5%, w/w)			
			OPP	TPP	EPP	Mix
Serum alanine aminotransferase (ALT) activity (U/L)						
Mean	24.91 [b]	35.18 [a]	30.33 [ab]	28.62 [b]	28.83 [b]	26.67 [b]
SD	1.88	1.99	2.60	3.11	2.47	4.11
% of Change	0.00	41.19	21.72	14.87	15.70	7.04
Serum Aspartate aminotransferase (AST)activity (U/L)						
Mean	44.48 [b]	59.20 [a]	54.08 [a]	50.99 [ab]	54.20 [a]	49.98 [b]
SD	4.09	6.11	2.78	5.67	7.09	4.09
% of Change	0.00	33.11	21.59	14.64	21.86	12.37
Serum alkaline phosphatase (ALP,U/L)						
Mean	123.21 [c]	162.10 [a]	152.06 [a]	149.40 [ab]	147.71 [b]	142.56 [b]
SD	11.89	5.90	9.17	12.79	7.14	9.44
% of Change	0.00	31.56	23.41	21.26	19.88	15.71

Each value represents the mean of six rats. Means with different superscript letters in the same row are significantly different ($p \leq 0.05$). OPP, orange peel powder, TPP, tomato pomace powder, EPP, eggplant peel powder, Mix, mixture powder of OPP, TPP and EPP by equal parts

Effect of dietary intervention with selected plant parts from food processing by-products on serum glucose concentration of obese rats

The effect of dietary intervention with selected plant parts from food processing by-products on serum glucose concentration of obese rats were shown in Table (3). Such data indicated that obesity induced a significant increased ($p \leq 0.05$) in serum glucose (36.64%) compared to normal control group. Dietary intervention with OPP, TPP, EPP and their mixture on the diet by 7.5% induced significant decreasing on blood glucose concentration by the ratio of 21.26, 15.54, 16.77 and 11.85%, from the starting point, respectively. Thus, the higher effects in manipulation of the blood glucose elevation induced by obesity in rats was recorded for the Mix followed by TPP, EPP and OPP, respectively. Such data are in partially match with that observed by several authors where control/treatment of obesity by intervention with the different part parts (Sayed Ahmed, 2016; Elbasouny, et al., 2019; El-Harby, 2019; Almutairiu, 2020; Alqallaf, 2021; Essa, 2021; Elhassaneen et al., 2021-c). Data of the present study with the others indicated that orange peel contain an impressive list of 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 (Whitney and Rolfs, 1999). All of these compounds have good roles in amelioration the effects of blood levels elevations (Elbasouny et al., 2019; Essa, 2021). Also, the antioxidant defense system of other bioactive compounds found in tomato pomace includes vitamins (C and E), minerals (selenium, copper), phytonutrients (β-carotene, lutein), and biological products (bilirubin, coenzyme Q10) that protect tissues from oxidative damage induced in diabetic cases (Jacob and Burri, 1996). Finally, the Mix treatment gave maximum hypoglycemic yield when compared with the tested by-products individually because the interactive effects occurred by different categories of bioactive compounds found in plant parts used.

Table 3. Effect of dietary intervention with selected plant parts from food processing by-products on serum glucose concentration (mg/dL) of obese rats*

Value	Control (-) Std diet	Control (+) Obese diet	Food processing by-products powder (7.5%, w/w)			
			OPP	**TPP**	EPP	Mix
Mean	94.09 ^{c}	128.56 ^{a}	114.09 ^{b}	108.71 ^{b}	109.87 ^{b}	105.24 ^{b}
SD	8.00	11.56	9.70	9.24	9.34	5.62
% of Change	0.00	36.64	21.26	15.54	16.77	11.85

Each value represents the mean of six rats. Means with different superscript letters in the same row are significantly different ($p \leq 0.05$). OPP, orange peel powder, TPP, tomato pomace powder, EPP, eggplant peel powder, Mix, mixture powder of OPP, TPP and EPP by equal parts

Effect of dietary intervention with selected plant parts from food processing by-products on blood lipids profile concentration of obese rats

Effect of dietary intervention with selected plant parts from food processing by-products on blood lipids profile concentration of obese rats were shown in Table (4). Such data indicated that obesity induced a significant increased ($p \leq 0.05$) in TG (39.40%), TC (32.34%) and LDL (78.20%) and VLDL (39.40%) while significant decreased ($p \leq 0.05$) in HDL (-26.91%) compared to normal control group. Dietary intervention with OPP, TPP, EPP and their mixture on the diet by 7.5% induced significant decreasing on serum lipid profile, TG, TC, LDL and VLDL by the ratio of 28.12, 19.52, 22.88 and 18.80%; 25.46, 21.49, 21.03 and 15.11%; 61.05, 49.27, 51.91 and 33.89%; and 28.12, 19.52, 22.88 and 18.80%, from the starting point, respectively. The opposite direction was observed for the HDL levels. The highest effects in manipulating of the blood lipid profile disorders induced by obesity in rats were recorded for the Mix treatment followed by TPP, EPP and OPP, respectively. Such data are in partially match with that observed by several authors where control/treatment of obesity by intervention with the different part parts (Sayed Ahmed, 2016; Elbasouny, et al., 2019; El-Harby, 2019; Almutairiu, 2020; Alqallaf, 2021; Essa, 2021). Also, weight loss in patients with overweight /obesity is associated with reductions in LDL, TC and TG and with increased levels of HDL (Christensen *et al.*, 2007; and Bales and Buhr, 2008). Also, several studies reported that blood elevated concentrations of TC and LDL-c are powerful risk factors for cardiovascular disease (Bedawy, 2008). On the other side, the composition of the human diet plays an important role in the management of blood lipid profile. The possible hypocholesrerolemic effects of several dietary constituents such as found in the plant parts (OPP, TPP, EPP and their mixture) including, phenolics, anthocyanins, alkaloids, carotenoids, phytosterols and organosulfur compounds have considered much interest. Such bioactive compounds exert beneficial effects on cardiovascular health by antioxidant and anti-inflammatory activities (Kuhlmann *et al.*, 1998, Sayed Ahmed, 2016 and El-Harbi, 2018; Abd Elalal et al., 2021; Elhassaneen et al., 2023 a and b).

Table 4. Effect of dietary intervention with selected plant parts from food processing by-products on blood lipids profile concentration of obese rats

Value	Control (-) Std diet	Control (+) Obese diet	Food processing by-products powder (7.5%, w/w)			
			OPP	TPP	EPP	Mix
Triglycerides (TG, mg/dL)						
Mean	43.59 [c]	60.76 [a]	55.84 [ab]	52.10 [b]	53.56 [b]	51.78 [b]
SD	2.99	3.09	4.10	3.58	5.09	3.98
% of Change	0.00	39.40	28.12	19.52	22.88	18.80
Total cholesterol (TC, mg/dL)						
Mean	102.11 [c]	135.14 [a]	128.11 [ab]	124.05 [b]	123.58 [b]	117.54 [bc]
SD	7.10	10.88	7.31	8.62	11.09	6.24
% of Change	0.00	32.34	25.46	21.49	21.03	15.11
High density lipoprotein (HDL, mg/dL)						
Mean	41.33 [a]	30.21 [b]	33.09 [b]	35.92 [ab]	33.7 [b]	37.47 [a]
SD	3.94	4.11	3.16	5.23	3.22	4.11
% of Change	0.00	-26.91	-19.93	-13.09	-18.26	-9.33
Low density lipoprotein (LDL, mg/dL)						
Mean	52.06 [c]	92.78 [a]	83.85 [ab]	77.71 [b]	79.09 [b]	69.71 [bc]
SD	4.11	6.78	6.62	4.99	7.09	5.51
% of Change	0.00	78.20	61.05	49.27	51.91	33.89
Very low density lipoprotein (VHDL, mg/dL)						

Mean	8.72 [c]	12.15 [a]	11.17 [a]	10.42 [b]	10.71 [ab]	10.36 [b]
SD	0.60	0.91	0.77	1.07	0.74	0.90
% of Change	0.00	39.40	28.12	19.52	22.88	18.80

Each value represents the mean of six rats. Means with different superscript letters in the same row are significantly different ($p \leq 0.05$). OPP, orange peel powder, TPP, tomato pomace powder, EPP, eggplant peel powder, Mix, mixture powder of OPP, TPP and EPP by equal parts

Effect of dietary intervention with selected plant parts from food processing by-products on plasma reduced glutathione level of obese rats

Effect of dietary intervention with selected plant parts from food processing by-products on plasma reduced glutathione level of obese rats were shown in Table (5). Such data indicated that obesity induced a significant decreased ($p \leq 0.05$) in serum GSH (-30.87%) compared to normal control group. Dietary intervention with OPP, TPP, EPP and their mixture on the diet by 7.5% induced significant increasing on blood glucose concentration by the ratio of -24.22, -19.00, -18.11 and -10.64%, from the starting point, respectively. Thus, the highest effect in manipulation of the GSH decline induced by obesity in rats was recorded for the Mix followed by EPP, TPP and OPP, respectively. Such data are in partially match with that observed by several authors where control/treatment of obesity by intervention with the different part parts (Elbasouny, et al., 2019; El-Harby, 2019; Almutairiu, 2020; Alqallaf, 2021; Essa, 2021). Reduced glutathion (GSH) is a tripeptide-thiol that has received more attention related to its biosynthesis, regulation, and various intracellular functions (Reed and Beatty, 1980; Larsson *et al*., 1983; Elhassaneen, 1996). Amongst of these function are two constructing roles in detoxifications. The first is known as a key conjugate of electrophilic intermediates in phase II metabolism. The second is considered as an important antioxidant. The antioxidant functions of GSH includes its role in the activities of GSH enzymes family including glutathione peroxidase (GSH-Px) and glutathione reductase (GSH-Rd). In addition, GSH can apparently serve as a nonenzymatic scavenger of oxyradicals (Halliwell and Gutteridge, 1985, Elhassaneen, 2004 and Elhassaneen *et al.*, 2016). With the same contex, Bedard and Krause (2007) found that various enzymes in different cells including adipocytes can also produce reactive oxygen species (ROS). The plant parts used in the current study and their mixtures intervension are rich in bioactive constituents which exhibited antioxidant activities against ROS formation as the obesity development through several mechanism of action including the raising of redox status including GSH in the body. Similar observations were reported by several authors who studied the oxidative stress and antioxidant defense systems status in obese rats feeding some plant parts such tomato, eggplant, pomegranate, onion and potato peels (ElMaadawy *et al.*, 2016; El-Harbi 2018; Elhassaneen, et al., 1919; Elhassaneen et al., 2020-a).

Table 5. Effect of the selected food processing by-products powder on plasma reduced glutathione (GSH, µmol /L) level of obese rats*

Value	Control (-) Std diet	Control (+) Obese diet	Food processing by-products powder (7.5%, w/w)			
			OPP	TPP	EPP	Mix
Mean	11.12 [a]	7.69 [c]	8.43	9.01 [b]	9.11 [ab]	9.94 [a]
SD	0.55	0.52	0.76	0.61	0.76	0.68
% of Change	0.00	-30.87	-24.22	-19.00	-18.11	-10.64

Each value represents the mean of six rats. Means with different superscript letters in the same row are significantly different ($p \leq 0.05$). OPP, orange peel powder, TPP, tomato pomace powder, EPP, eggplant peel powder, Mix, mixture powder of OPP, TPP and EPP by equal parts

Effect of dietary intervention with selected plant parts from food processing by-products on plasma oxidative stress, thiobarbituric acid reactive substances (TBARS) level of obese rats

The effect of dietary intervention with selected plant parts from food processing by-products on plasma oxidative stress parameter (thiobarbituric acid reactive substances, TBARS) level of obese rats were shown in Table (6). Such data indicated that obesity induced a significant increased ($p \leq 0.05$) in serum TBARs 41.00%) compared to normal control group. Dietary intervention with OPP, TPP, EPP and their mixture on the diet by 7.5% induced significant decreasing on blood TBARs concentration by the ratio of 25.94, 14.58, 19.10 and 5.58% , from the starting point, respectively. Thus, the highest effect in manipulation of the TBARs elevation induced by obesity in rats was recorded for the Mix followed by TPP, EPP and OPP, respectively. Such data are in partially match with that observed by several authors where control/treatment of obesity by intervention with the different part parts (Elbasouny, et al., 2019; El-Harby, 2019; Almutairiu, 2020; Alqallaf, 2021; Essa, 2021). In several clinical studies for obesity-associated oxidative stress have been provided by measurement of biomarkers and/or end-products of free radical-mediated oxidative processes (Elhassaneen and Salem, 2014, Sayed Ahmed, 2016 and El-Harbi, 2018). For example, lipid peroxidation markers such as TBARS, the major products of the oxidation of polyunsaturated fatty acids, lipid hydroperoxides and conjugated dienes are found to be increased in plasma from obese subjects (Vincent and Taylor, 2006; Elhassaneen and Salem, 2014). Systemic metabolic alterations associated with obesity contribute to the increase in oxidative stress have been observed by several authors. For instance, hyperglycemia as a principal mark of type II diabetes, a metabolic complication of obesity, induces oxidative stress (DCCTRG, 1993 and Le Lay *et al.*, 2014). Excess of circulating lipids induces ROS formation pathways, which contribute to the increase in lipid oxidation and protein carbonylation (Jensen *et al.,* 1989). Interest in the possible significance of TBARs on human health has been reports that some of them are mutagens and carcinogens (Shamberger *et al*., 1974). The positive effects of the selected plant parts on oxidants formation/level of obese rats could be attributed to several mechanisms induced by their bioactive components content. For example, several studies found that phenolic compounds such as found in our selected plant parts have anti-oxidative, anti-inflammatory and scavenging activities (Elhassaneen and Sanad, 2009; Aly et al., 2017; Abd Elalal et al., 2021; Elhassaneen et al., 2023 a and b). They also proposed that phenolics are metabolized in liver and lead to enhance the lipid metabolism and reduce the oxidative stress. Finally, the Mix treatment gave the maximum reduction yield of plasma TBARs when compared with the tested plant parts individually because the interactive effects occurred by different classes of bioactive constituents of different plant parts used.

Table 6. Effect of the selected food processing by-products powder on oxidative stress (thiobarbituric acid reactive substances, TBARS, nmol/mL) level of obese rats*

Value	Control (-) Std diet	Control (+) Obese diet	Food processing by-products powder (7.5%, w/w)			
			OPP	**TPP**	EPP	Mix
Mean	2.85 [c]	4.02 [a]	3.59 [a]	3.27 [b]	3.40 [ab]	3.01 [b]
SD	0.15	0.51	0.19	0.20	0.29	0.20
% of Change	0.00	41.00	25.94	14.58	19.10	5.58

Each value represents the mean of six rats. Means with different superscript letters in the same row are significantly different ($p \leq 0.05$). OPP, orange peel powder, TPP, tomato pomace powder, EPP, eggplant peel powder, Mix, mixture powder of OPP, TPP and EPP by equal parts

In conclusion, obesity is nowadays considered as a top risk factor in the development of several diseases and is causative of morbidity of patients suffering from metabolic syndrome. Pharmacological therapy of obesity is costly and associated with multiple side effects led to patient non-compliance. In the present study, an alternative natural remedy through the use of three vegetable parts by-products of food processing (orange peel, eggplant peel, and tomato pomace) was applied in a dietary intervention to improve the complications of obesity in rats. Dietary intervention with such plant parts and their mixture induced significant ameliorative effect in different complications induced by obesity including increase the plasma non-enzymes antioxidant (GSH, and GSSG), improve the liver functions and serum lipid profile, and decrease the blood glucose level and TBARS (biological indicator of lipid oxidation). The highest ameliorative effects were recorded for the Mix followed by EPP, TPP and OPP, respectively. Therefore,_data of the present studysupport the benefits of dietary modification, including bioactive compounds supplementation, in alleviating some complications associated obesity.

Reference

Abd Elalal, N., Ghada M. El Seedy and Yousif A. Elhassaneen (2021): Chemical Composition, Nutritional Value, Bioactive Compounds Content and Biological Activities of the Brown Alga (*Sargassum Subrepandum*) Collected from the Mediterranean Sea, Egypt. Alexandria Science Exchange Journal, 42, (4): 893-906. [DOI: 10.21608/asejaiqjsae.2021.205527].

Abd El-Fatah, A. (2013): Active ingredients in sweet violet and their relation with liver diseases in experimental animals: Biochemical, therapeutic and histopathological studies. Ph.D. Thesis in Nutrition and Food Science, Faculty of Home Economics, Minoufiya University, Egypt

Ahmadi SA, Boroumand M-A, Gouhari MK, Tajik P, Dibaj S-M. The impact of low serum triglyceride on LDL-cholesterol estimation. Arch Iran Med. 2008;11(3):318–21.

Almutairiu, F. M. (2020). Potential effects of phyto-bioactive and aversive on obesity and its complications in rats". M.Sc. Thesis in Nutrition and Food Science, Faculty of Specific Education, Benha University, Benha, Egypt

Aly, A.; Ghada, S.; Elbassyouny, M. and yousif A. Elhassaneen (2017): Studies on the antioxidant properties of vegetables processing by-products extract and their roles in the alleviation of health complications caused by diabetes in rats. Proceeding of the 1st International Conference of the Faculty of Specific Education, Kafrelsheikh University, "Specific Sciences, their Developmental Role and Challenges of Labor Market" PP 1-24, 24-27 October, 2017, Sharm ElSheikh, Egypt.

Aronne, L.J. and Segal, K.R. (2003): Weight Gain in the Treatment of Mood Disorders. Journal of Clinical Psychiatry 64, Supplement 8: 22-29.

Beattic, J.; Crozier, A. and Duthie, G. (2005). Potential Health Benefits of berries. Current Nutrition and Food Science. 1: 71-86.

Bedard, K. and Krause, K. (2007): The NOX family of ROS-generating NADPH oxidases: physiology and pathophysiology. Physiological Reviews, 1: 245–313.

Bedawy, O. (2008). Relationship between phyto-sulphur compounds and lipid of blood in experimental animals. M. Sc. Thesis in Nutrition and Food Science, Faculty of Home Economics, Minoufiya University, Egypt

Bonet, M.; Jose A.; Joan R. and Andreu P. (2015): Carotenoids and their conversion products in the control of adipocyte function, adiposity and obesity. Archives of Biochemistry and Biophysics, 572: 112–125.

Buege, J.A. and Aust, S.D. (1978): Microsomal lipid peroxidation in Packer L., (ed), Methods in enzymology, New York, NY, Academic, 52: 302 - 310.

Caterson, I.D. (2009): Medical Management of Obesity and its Complications. Annals Academy of Medicine, 38 (1):22-28

Christensen, R. Bartels, E.M.and Astrup, A. (2007): Bliddal H. Effect of weight reduction in obese patients diagnosed with knee osteoarthritis: a systematic review and meta-analysis. Ann Rheum Dis. 66(4):433-9

Dawson, R. M. (1998): The toxicology of microcystins. Toxicon., 36: 953- 962.

DCCTRG, The Diabetes Control and Complications Trial Research Group (1993): The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulindependent diabetes mellitus. The New England Journal of Medicine. 329 (14): 977-986.

Drury, R.A. and Wallington, E.A. (1980): Carleton’s Histological Technique. 5th Edition, Oxford University Press, New York.

Elbasouny, G.; Shehata, N. and Elhassaneen, Y. (2019). Feeding of some selected food industries by-products induced changes in oxidants/antioxidant status, lipids profile, glucose and immunological parameters of blood obese rats. The 6th Scientific and 4th International Conference "The Future of Specific Education and people with Special Needs in Light of the Concept of Quality "

Elbasouny, G.; Shehata, N. and Elhassaneen, Y. (2019): Feeding of some selected food industries by-products induced changes in oxidants/antioxidant status, lipids profile, glucose and immunological parameters of blood obese rats. The 6th Scientific and 4th International Conference "The Future of Specific Education and people with Special Needs in Light of the Concept of Quality ", 24-26 February 2019, Faculty of Specific Education, Ain Sokhna University, El-Ain El-Soghna, Egypt

EL-Harbi, E. N. (2018): Nutritional and technological Studies on some plant parts and their Effects on obesity complications induced in experimental animals, M.Sc. thesis, faculty of Specific Education, Benha University, Egypt

EL-Harbi, E. N. (2018): Nutritional and technological Studies on some plant parts and their Effects on obesity complications induced in experimental animals, M.Sc. thesis, faculty of Specific Education, Benha University, Egypt

El-Harby, E. N. (2019). Nutritional and Technological Studies on some Plant Parts and their effects on Obesity Complications Induced in Experimental Animals ". MSc. Thesis in Nutrition and Food Science, Faculty of Specific Education, Benha University, Benha, Egypt

Elhassaneen Y., El-Shaer, M. El-Dashlouty, S. and Soliman, G. (2020-d): Anti-obesity Effect of Date Palm Pith in High- Fat Induced Obese Rats. Journal of Home Economics: 107-124.

Elhassaneen Y., Ragab S., El-Beltagi A., and Emad A. (2013): Mango peel powder: A potential source of phenolics, carotenoids and dietary fiber in Biscuits preparations 2nd International-16 th Arab Conference of Home Economics "Home Economics in the Service of Industry"10-11 September, Faculty of Home Economics, Minoufiya University, Shebin El-Kom, Egypt.

Elhassaneen, Y. A. (1996): Biochemical and technological studies on pollution of fish with pesticides and polycyclic aromatic hydrocarbons. Ph.D. Thesis., Faculty of Agriculture, Mansoura University, Egypt.

Elhassaneen, Y. A. and Sanad, M. I. (2009): Phenolics, Selenium, Vitamin C, Amino Acids and Pungency Levels and Antioxidant Activities of Two Egyptian Onion Varieties. *American J. of Food Technology* 4(6): 241-254. [ISSN 1557- 4571] [http://direct.bl.uk/bld/SearchResults.do].

Elhassaneen, Y. and Salem, A. (2014): Biochemical/Nutritional Studies on some Obesity Cases in Egypt. Journal of Home Economics, 24(1): 121-137.

Elhassaneen, Y. Elbasouny, G.; and Shehata, N. (2019). Feeding of some selected food industries by-products induced changes in oxidants/antioxidant status, lipids profile, glucose and immunological parameters of blood obese rats. The 6^{th} Scientific and 4^{th} International Conference "The Future of Specific Education and people with Special Needs in Light of the Concept of Quality ", 24-26 February 2019, Faculty of Specific Education, Ain Sokhna University, El-Ain El-Soghna, Egypt

Elhassaneen, Y. Mohamed Sameer El-Dashlouty and El-Gamal, N. (2020-a). Effects of brown algae (*Sargassum subrepandum*) consumption on obesity induced changes in oxidative stress and bone indices. Journal of Home Economics, 30 (4): 687-708. [DOI: 10.21608/mkas.2020.161411]

Elhassaneen, Y.' Sara A. Sayed Ahmed; Safaa A. Elwasef and Sarah A. Fayez (2022). Effect of brown algae ethanolic extract consumption on obesity complications induced by high fat diets in rats. Port Saied Specific Research Journal (PSSRJ), 15 (1): In Press. [DOI: 1 10.21608/pssrj.2021.98769.1148

Elhassaneen, Y., Areeg A. Nour El-Deen and Amal Z. Nasef (2023-a). Ultraviolet-c Radiation Induced Changes on Bioactive Compounds Content, Antioxidant Capacity and Microbial Quality of Minimally Processed Molokhia (Corchorus Olitorius L.) Leaves. Journal of Agriculture and Crops, 9 (3): 309-322, [DOI: 10.32861/jac.93.309.322].

Elhassaneen, Y., Ghada M. ElBassouny, Omar A. Emam and Sherouk H. Hashem (2023-b). Influence of Novel Freezing and Storage Technology on Nutrient Contents, Bioactive Compounds and Antioxidant Capacity of Black Eggplant. Journal of Agriculture and Crops, 9 (3): 338-352, 2023 [DOI: 10.32861/jac.93.338.352].

Elhassaneen, Y., Omar Emam; Ghada ElBasouny and Genan El-Qalaaf (2022-a): Effect of cabbage and radish leaves on obesity biological changes induced in rats. Journal of the College of Specific Education for Educational and Specific Studies, 7 (19):1-33 [DOI: 10.21608/sjse.2022.63320.1061]

Elhassaneen, Y., Sherif Ragab, Abeer Abd El-Rahman, Safaa Arafa (2021-c): Vinca (*Catharanthus roseus*) Extracts Attenuate Alloxan-Induced Hyperglycemia and Oxidative Stress in Rats. American Journal of Food Science and Technology. 9(4), 161-172 [DOI:10.12691/ajfst-9-4-8].

Elhassaneen, Y., Sobhy E. Hassab El-Nabi, Mohammed Z. Mahran, Asmaa I. Bayomi and Esraa Z Badwy (2022-b): Potential Protective Effects of Strawberry (*Fragaria Ananassa*) Leaves Against Alloxan Induced Type 2 Diabetes in Rats: Molecular, Biological and Biochemical Studies. Sumerianz Journal of Biotechnology, 5(1): 1-15 [DOI: https://doi.org/10.47752/sjb.51.1.15

Elhassaneen, Y.; Ragab, S. and Essa E. (2020-c). Chemical and nutritional studies on extracts of food processing by-products and their effects on obesity complications in rats. Journal of Home Economics, 30 (2): 1-26. DOI: 10.21608/mkas.2020.156506.

Elhassaneen, Y.; Sherif Ragab and Raghda Mashal. (2016): Improvement of Bioactive Compounds Content and Antioxidant Properties in Crackers with the Incorporation of Prickly Pear and Potato Peels Powder. International Journal of Nutrition and Food Sciences, 5 (1): 53-61.

Ellman،G.L.(1959):Tissue suphydryl groups.Arch.Biochem.Biophys.82:70-77

Elmaadawy A., Arafa R. and Elhassaneen Y. (2016): Oxidative Stress and antioxidant defense systems status in obese rats feeding some selected food processing by-products applied in bread. Journal of Home Economics, 26 (1): 1-38.

El-Nashar, N. G. (2007): Development of primary liver cell culture from fish as a valuable tool in nutrition and biotechnology research. Ph.D. Thesis, Faculty of Home Economics, Minoufiya University, Egypt.

El-Sayed, M.; El- Sherif. F.; Elhassaneen, Y. and Abd El-Rahman, A. (2012): Potential Therapeutic Effects of some Egyptian Plant Parts on Hepatic Toxicity Induced by Carbon Tetrachloride in Rats. Life Sci. J., 9(4): 3747-3755

Elsemelawy, S., Mai A Gharib and Yousif A Elhassaneen (2021). Reishi Mushroom (*Ganoderma lucidum*) Extract Ameliorate Hyperglycemia and Liver/Kidney Functions in Streptozotocin-induced Type 2 Diabetic Rats. Bulletin of the National Nutrition Institute of the Arab Republic of Egypt. 57: 74-107.[DOI: 10.21608/bnni.2021.221596]

Essa, E.M. (2021). Chemical and nutritional studies on extracts of food processing by-products and their effects on obesity complications in rats". MSc. Thesis in

Nutrition and Food Science, Faculty of Home Economics, Minoufiya University, Shebin El-Kom, Egypt

Fossati, P.and principe,I. (1982):Triglyceride enzymatic colorimetric method .J.of Clin.Chem.,(28):2077.

Gharib, M., Hanan A. Radwan, and Yousif A. Elhassaneen (2022-c): Nutrients and Nutraceuticals Content and *In Vitro* Biological Activities of Reishi Mushroom (*Ganoderma lucidum*) Fruiting Bodies. Alexandria Science Exchange Journal, 43, (2): 301-316. [DOI: 10.21608/asejaiqjsae.2022. 245271].

Gobbi ,P. G.; Parrinello, G. A. and Diprisco, U. (1982): Eur. J. Cancer Clin. Oncol.,18,1243

Halliwell, B. and Gutteridge, J.M. (1985): Free radicals in biology and medicine. Clarendon Press. Oxford. UK.

Hassan, A. (2011): The effect of phytochemicals on prevention and/or treatment of liver cancer induced by some food pollutants" Ph.D. Thesis in Nutrition and Food Science, Faculty of Home Economics, Minoufiya University, Egypt

Hong, C. H.; Hur, S. K.; Oh, O. J.; Kim, S. S.; Nam, K. A. and Lee, S. K. (2002): Evaluation of natural products on inhibition of inducible cyclooxygenase (COX-2) and nitric oxide synthase (iNOS) in cultured mouse macrophage.cells. Journal of Ethnopharmacology, 83: 153–159.

Jacob, R.A. and Burri, B.J. (1996). Oxidative damage and defense, Am. J. Clin. Nutr., 63: 985S-990S.

Jandacek RJ and Woods SC (2004): Pharmaceutical approaches to the treatment of obesity. Drug Discov Today, 9: 874-80

Jensen, M.D.; Haymond, M.W.; Rizza, R.A.; Cryer, P.E. and Miles J.M. (1989): Influence of body fat distribution on free fatty acid metabolism in obesity. Journal of Clinical Investigation. 83 (4): 1168–1173.

Kuhlmann, M.; Burkhardt, G.; Horsch, E.; Wagner, M. and Kohler, H. (1998): Inhibition of oxidant-induced lipid peroxidation in cultured renal tublar epithelial cells by quercetin. Free Rad. Res, 29: 451-460

Larsson, A.; Orrenius, S.; Holmgren, A. and Mannervik, B. (1983): Eds., Functions of glutathione, Raven Press, New York

Le Lay, S.; Gilles S.; Maria, C. and Ramaroson, A. (2014): Oxidative stress and metabolic pathologies: from an adipocentric point of view. Oxidative Medicine and Cellular Longevity. volum: 1-18 (Article ID 908539).

Lopes-Virella, M. F.; Stone, S.; Ellis, S. and Collwellm J. A. (1977): Cholesterol determination in high-density lipoproteins separated by three different methods. Clin. Chem.; 23 (5): 882-893.

Mehram, E., Alaa O. Aboraya and Yousif A. Elhassaneen (2021). Potential Effects of Food Processing Byproducts on Neurological and Immunological Disorders of Obese Rats. Alexandria Science Exchange Journal, 42, (2): 509-522. [DOI: 10.21608/asejaiqjsae.2021.178864].

NRC, National Research Council (1996): Guide for the Care and Use of Laboratory Animals Washington: National Academy Press

Pagana, K.D. and Pagana, T.J. (1997): Mosby's diagnostic and laboratory test references. 3 rd ed., Mosby-year Book, Inc., New York.

Reed, D.J. and Beatty, P.W. (1980): in Reviews in Biochemical Toxicology, Vol. 2, E. Hodgson, J.R. Bend and R. Phillpot, Eds., Elsevier/North Holland, New York, pp.213 – 241.

Reeves, P.G.; Nielsen, F.H. and Fahey Jr. G.C. (1993): AIN-93 Purified Diets for Laboratory Rodents: Final Report of the American Institute of Nutrition Ad Hoc Writing Committee on the Reformulation of the AIN-76A Rodent Diet. J. Nutr., 11(123): 1939-1951

Sayed Ahmed, S. (2016): Nutritional and technological studies on the effect of phytochemicals on obesity injuries and their related diseases by using experimental animals. Ph.D. Thesis in Home Economics (Nutrition and Food Science), Faculty of Specific Education, Port Said University, Egypt.

Shamberger, R.J.; Andreone, T.L. and Willis, C.E. (1974): Antioxidants and cancer. IV. Malonaldehyde has initiating activity as a carcinogen. J. Natr. Cancer Inst. 53: 1771.

Thyss, A.; Schneider, M.; Caldani, C.; Viot, M. and Bourry, J. (1985):Br.J.Cancer,52,183.

Tietz, N.W. (1976). Fundamental of Clinical Chemistry. Philadelphia, W.B. Saunders,P. 243

Vassault, A.; Grafmeyer, D.; Graeve, J.; Cohen, R.; Beaudonnet, A.; and Bienvenu, J. (1999): Quality specifications and allowable standards for validation of methods used in clinical biochemistry. Ann Biol Clin (Paris). 57(6): 685-95.

Vincent, H.K. and Taylor, A.G. (2006): Biomarkers and potential mechanisms of obesity-induced oxidant stress in humans. International Journal of Obesity. 30: 400-418.

Whitney E, Rolfes S (1999): Understanding nutrition. In: W Rolfes (Ed) Belmont, Ca., USA, West/Wadsworth

Yound D. S. (1975): Determination of GOT. Clin. Chem., 22 (5): 21-27.