Effect of Feeding on Crackers Enrichment with Beetroot Powder and Flaxseeds in Obese Anemic Rats Induces by Phenylhydrazine

Eman A. A. Abdrabou[1]; Doaa O. M. Gouda[2]

ABSTRACT

The present study aimed to produce nutritional and acceptable crackers enrichment with flaxseeds, beetroot powder and their mixture and examined the sensory, chemical and biological evaluation of cracker samples. Also, the biological study was carried out on obese anemic rats fed on 100% crackers after feeding rats on a high-fat diet and flowed by injection by phenylhydrazine to induce anemic. Sensory evaluation showed that all crackers are acceptable. The chemical composition and biological study are done on crackers containing 0%, 15% flaxseeds, 30% beetroot and 15% flaxseeds and +30% beetroot. The result showed that enriched crackers with flaxseeds, beetroot powder and their mixture caused a significant increase in fiber, ash, phenolic, flavonoids contents and antioxidant value. Besides feeding obese anemic rats on cracker samples contaning 0%, 15% flaxseeds, 30% beetroot and 15% flaxseeds +30% beetroot led to a significant decrease in body weight, lipid profile, glucose and liver enzymes as compared to the positive control group. In addition, the group fed on 15% flaxseeds +30% beetroot has the best evaluation compared to the other groups. This result is due to the contents of beetroot and flaxseeds as minerals, vitamins, fiber, flavonoids and phytochemicals that enhance biological evaluation. So, it can be enrichment bakery products with mixed flaxseeds and beetroot to produce acceptable and healthy bakery products that can be used to treat or prevent obesity and anemic and improve glucose levels, liver and kidney functions and protect the diseases related to them.

Keywords: flaxseeds, beetroot, obesity, anemia, phenylhydrazine.

INTRODUCTION

Customer's attention to healthy eating is headed in the direction of the health benefits of particular foods and dietary components (Elshehy et al., 2018). Moreover, overweight and obesity are the most important risk factors for non-communicable diseases (Jackson et al., 2020). Also, there is an occurrence of food deficiency among people with obesity, than in those with an ideal body weight of the same sex and equal age (Kobylińska et al., 2022). There are powerful relationships among aging, autoimmune diseases, chronic diseases, obesity, anemia, hepato-renal impairment and chronic infection. Improved hepcidin levels may prevent iron free from cells by affecting ferroportin levels (Saad and Qutob, 2022). On the other hand, oral iron pharmaceutical supplementation is widely used to improve blood hemoglobin levels and it frequently results in adverse consequences like nausea, vomiting, and stomach discomfort, but at the expense of elevated oxidative stress (Cho *et al.*, 2017). Additionally, eating whole grains, seasonal, dry fruits, and dietary fiber can assist obese teenagers lose weight, enhance their hematological status, particularly their iron and hemoglobin levels, and reduce inflammation (Aune, 2019).

Beetroot (Beta vulgaris) is a root vegetable also named table beet, garden, red beet or just beet. It is abundant in essential elements like iron, manganese, potassium, fiber, and folate (vitamin B9), iron, protein, carbohydrate and dietary fiber vitamins such as B12 and C (Sakhare et al., 2019), which the body needs to produce new hemoglobin and red blood cells. So, beetroot powder is an addition to anaemic schoolchildren cookies (Alshehry et al., 2021). Correspondingly, it is consumed as fresh besides boiled, dried,fried, canned and pickled (Tran et al., 2017 and Ceclu & Nistor, 2020). Also, it is widely used as a natural pigment reddish purple with nontoxicity properties (Masih et al., 2019). It is rich in polyphenols, flavonoids, antioxidants, vitamins and minerals (Kovarovič et al., 2017). So, it is used as a health promoter, disease preventer and treatment for diseases such as cancer, heart disease, diabetes and other chronic illnesses (Ceclu and Nistor, 2020).

The flax plant, an annual herb, is the source of flaxseeds (*Linum usitatissimum* L.). There are several ways to ingest flaxseeds, including whole, ground, oil, and baked goods (Noreen *et al.*, 2023 and Nowak & Jeziorek, 2023). Flaxseeds is rich in fat, protein, total dietary fiber, ash and photochemical. So, is used as a functional food for anti-inflammatory, anti-hypercholesterolemic, and anti-atherogenic activity to prevent diabetes, obesity, cancer, heart disease, and

---

DOI: 10.21608/asejaiqjsae.2025.425882
[1]Associate Professor in Nutrition & Food Science,
Home Economics Department, Faculty of Specific Education,
Aswan University, Egypt emanabd458@gmail.com
[2]lecture Nutrition & Food Science, Home Economics Department,
Faculty of Specific Education, Sohag University, Egypt.
doaa.gouda8521@gmail.com
Received, March 20, 2025, Accepted, April 25, 2025.

issues with the gastrointestinal, renal, and skeletal systems (Tang et al., 2020; Mudgil et al., 2023 and Noreen et al., 2024). Besides, flaxseeds has a high content of fibre, lignans and alpha-linolenic acid. It could be used in combination with other treatments to reduce central obesity (Motlagh et al., 2021). Moreover, flaxseeds gums, incorporated flaxseeds into many staple products. A blend of flaxseeds and beetroot can used as a functional food to improve blood vessel health and reduce the chance of CVD and improve liver and cardiac status (Elgazzar, 2022). So, industry bakery goods such as cakes, cookies, candies, snacks, etc features to produce functional food products, which decrease the hazard of diseases and drug effects (Evstigneeva et al., 2020).

Thyme (*Thymus vulgaris* L.) is a medicinal plant, which belongs to the Lamiaceae family, is grown all over the world for its culinary, medicinal, and cosmetic applications (Sobhy *et al.,* 2020 and Hammoudi Halat *et al.,* 2022). Consequently, thyme powder and its essential oil reduced liver tissue damage by drastically lowering the levels of lipid peroxidation (Sobhy *et al.,* 2020). Numerous phenolic components, including volatile phenols and polyphenols, are abundant in the extracts of thyme, which also show a wide range of biological activity. The thymus treats numerous illnesses, such as those of the digestive, circulatory, genital, cutaneous, urinary, neurological, and respiratory systems (Elbouny *et al.,* 2022).

For these reasons, this study was carried out to produce acceptable, oriental and healthy crackers enrichment with different levels of beetroot powder or flaxseeds and both beetroot and flaxseeds. And show the best cracker samples and study the chemical composition. Then the effect of feeding experimental obese anemic rats on on nutrition and growing parameters, serum lipid, liver and kidney functions, serum glucose and hematological parameters.

MATERIALS AND METHODS

MATERIALS:

Beetroot, flaxseeds, rosted chickpea, wheat (Triticum aestivum) flour (all-purpose), hen eggs, corn oil, salt, thyme, garlic and onion powder were purchased from a local market in Sohag government, Egypt.

30 wester albino male rats 175- 205 g were optioned for the experimental animal unit, faculty of medicine, Sohag University. Casein, starch, vitamins mixer, minerals mixture, phenylhydrazine and all chemical analysis kits were purchased from El-Gomhoryia, company, Assiut City, Egypt.

Preparation of beetroot and flaxseeds powder:

Flaxseeds impurities were removed from the seeds. Beetroot were washed well by running water to remove the silt, then the roots were boiled for 3 min. After cooling at room temperature, they were peeled manually using a sharp knife and then grated using the manual grater, the grated beetroot were spread in trays to be dried in the sun for 48 h. After that, the roasted chickpea and dried beetroot were ground using a high-speed mixer electric grinder (Moulinex-LM2428EG). The powder was sieved through a 250 μm sieve and the powder was kept at 4 °C until used on crackers formula and analysis.

Preparation of crackers sample:

The cracker samples wree enriched with flaxseeds, beetroot and their mixtures were prepared using the formula in Table (1). The method of preparation is according to A.A.C.C. (2000). Meanwhile, in a deep bowl, all the dried ingredients were mixed well, after that, the corn oil, hen eggs and water and were mixed well until getting a soft dough. Then, the dough was formed into a thin layer and shaped into rectangles, it was baked in an electric oven for 18 min at 180 oC and cooled for 45 min, packed in plastic bags, and stored at room temperature until analysis.

Ethical approval:

All the processes used in the present investigation were approved by the Research Ethics Committee at Aswan University, Egypt.

Chemical analysis:

Proximate chemical composition:

Moisture, ash, crude fibers, crude protein, and fat contents were determined according to A.O.A.C. (1995). Total carbohydrates content was calculated by difference according to the following equation :

Total carbohydrates (%) = 100 - (% moisture + % protein + % fat + % ash).

Minerals content such as calcium, sodium, magnesium, manganese, copper, iron, zinc, selenium, phosphorus and potassium content were estimated by the method of Sundarrao *et al.* (1991).

Total phenolics were determined using the Folin-Ciocalteu reagent according to Singleton and Rossi (1965). Total flavonoids contents of samples powder were estimated using a colorimetric assay as described by Zhishen et al. (1999).

Antioxidant activity (AA) of samples powder extracts and standards (α-tocopherol and BHT was determined according to the β-carotene bleaching (BCB) method described by Marco (1968).

Table 1. The formula of crackers sample:

Ingredients (g) / Samples	Control crackers (0%)	Beetroot crackers			Flaxseeds crackers			Beetroot+Flaxseeds crackers		
		10%	20 %	30%	10%	15%	20 %	15 %F +10%B	15% F +20 %B	15% F +30% B
Wheat flour	90	80	70	60	80	75	70	65	55	45
Chickpea powder	10	10	10	10	10	10	10	10	10	10
Flaxseeds powder	-	-	-	-	10	15	20	15	15	15
Beetroot powder	-	10	20	30	-	-		10	20	30
Corn oil	5	5	5	5	5	5	5	5	5	5
Hen eggs	25	25	25	25	25	25	25	25	25	25
Thyme powder	3	3	3	3	3	3	3	3	3	3
Garlic powder	1	1	1	1	1	1	1	1	1	1
Onion powder	1	1	1	1	1	1	1	1	1	1
Salt	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Packing powder	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

B: Beetroot; F: Flaxseeds.

All samples were assayed. Several concentrations of BHT, BHA, and α-tocopherol in 80% methanol was used as the control. Antioxidant activity (AA) was all calculated as percent inhibition relative to control using the equation (Al-Saikhan *et al.*, 1995) AA= (R control - R sample) / R control x 100. R control and R sample were the bleaching rates of beta-carotene in reactant mixture without antioxidant and with plant extract, respectively. Antioxidant activity using the 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay was determined using the method proposed by Katalinic *et al.* (2006).

Sensory evaluation:

Sensory evaluation was carried out using 9-scale hedonic. Forty undergraduate students from the University of Aswan performed the sensory evaluation. They rated the crackers on colour, flavour, taste, crispiness and overall acceptance attributes based on likeness according to Nurhanan *et al.* (2021).

The biological examination:

Experimental design:

30 Wister albino male rats were housed in plastic cages at a controlled temperature and relative humidity, and 12 h dark/12 h light. After one week of acclimatization, the rats have been divided randomly into 2 groups:

First group (G1): negative control group was fed on 100% standard diet until the end of the experiment.

Second group: fed on a high-fat diet containing 30% (oil and tallow) to induce obesity for 15 days, after that injected by phenyl hydrazine PHZ dissolved in 0.9% NaCl intraperitoneally at 40 mg/kg body mass for 2 days at 9 am and 6 pm as described previously (Moreau *et al.*, 2012).

Thereafter, the second group of rats was divided randomly into 5 groups (n=5) and divided as follows:

(G2): positive control group was fed on 100% standard diet.

(G3): group was fed on control crackers.

(G4): group was fed on 100% crackers containing 15% flaxseeds.

(G5): group was fed on 100% crackers containing 30% beetroot.

(G6): group was fed on 100% crackers containing (30% beetroot and 15% flaxseeds).

Rats were housed separately in cages with good ventilation. Body weight was documented each week and at the termination of testing. At the end of termination testing, rats were deprived of food an entire night and benumbed administering diethyl ether. After collection, the blood from the rat was centrifuged. The serum was taken out for analysis. The serum was aspirated carefully, transferred into sterile cuvette tubes, and frozen at -20 °C for analysis. After the end of the experiment, the kidney, liver, heart, spleen, and lung were removed, and their relative ratios to the final body weight were calculated according to the technique of Chapman *et al.* (1959). Using the flowing equation: Relative organ weight = organ weight/ body weight *100.

Biochemical analysis:

Serum total cholesterol and triglycerides were determined according to Allain (1974) and Fossati *et al.* (1980), respectively, HDL and LDL were assayed according to Abcam (2019), VLDL-c was calculated at mg/dl according to Lee and Nieman (1996) using the following equation: VLDL-c (mg/dl) = Triglycerides / 5. Atherogenic index was calculated by: LDL-c / HDL-c according to Castelli and Levitar (1977).

Liver functions were examined as serum ALT, AST and ALP levels were determined according to Young (1990); Sherwin (1984) and Klin (1972), respectively. The determination of kidney function: serum urea, creatinine and uric acid levels were assayed according to Young (1990); Tietz (2006) and Fossati *et al.* (1980), respectively. Also, serum glucose was assayed according to Carroll *et al.* (1970).

Hemoglobin, red blood cell counts (RBC), white blood cell counts (WBC), hematocrit (Hct%), mean corpuscular volume (MCV) and mean corpuscular Hb concentration (MCHC) examined by using Rayto RT. 7600- 20170421 auto hematology analyzer – (Shenzhen, P.R. China).

Statistical analysis:

All data were analyzed using the Statistical Package for Social Science (SPSS) version 17.00 (SPSS Inc., Chicago, IL, USA) to perform an ANOVA according to SPSS (2008). Statistical analysis was performed using one-way analysis of variance (ANOVA) followed by Duncan's multiple test. Statistical significance was considered at $p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.001$.

RESULTS AND DISSECTION

Sensory evaluation of cracker samples:

The data in Table (2) presented that the sensory evaluation of crackers as affected by enrichment with beetroot and flaxseeds the result is conformed with that of Sinha and Masih (2014) who reported that the colour of noodles fortified with red beetroot became darkened as the level of beetroot pomace was increased. Also, beetroot pomace powder improves the acceptability of food goods due to well taste, flavour and colour. This result agrees with that of Amnah (2013) who found that the addition of red beetroot to biscuits increases acceptability. Also, Alshehry *et al.* (2021) reported that it can be substituted with beetroot red powder up to 10% in acceptable cookies without compromising their quality.

The result showed that all crackers enrichment with flaxseed are acceptable, this result is in harmoney with that of Al-Hassawi et al. (2023) who found that enhancing the pan of white wheat flour with 8% whole flaxseed indicated a softer texture by reducing the compression force but did not have any influence in flavour and texture. So, can be suggested for producing baked goods with favorable nutritional and sensory attributes. Also, Al-Hassawi et al. (2023) indicated that staple pan bread and Arabic bread had nutritional qualities and good sensory when utilizing up to 8% of either whole or crushed flaxseed. Also, Nassef et al. (2023) found that flaxseed integration for snacks did not alter the colour, flavour, or taste of typical recipes. Both 20% and 30% fortification amounts in recipes were acceptable. Also, adding reddish-brown flaxseed has improved the texture and flavour of snacks while adding a pleasant nutty flavour.

The chemical composition of chickpea, flaxseeds and beetroot powder and their cracker samples:

The data in Table (3) displayed the chemical composition of chickpea powder had the highest content of carbohydrates in compared to those of flaxseeds and beetroot powder. The chemical composition of flaxseed powder is agreed with that of Viveky *et al.* (2015) and Bhavana *et al.* (2021) who found that brown canadian flaxseed contains 41, 20, 28, 7.7 and 3.4% fat, protein, total dietary fiber, moisture, and ash, respectively.

Table 2. Sensory evaluation of crackers as affected by enrichment with beetroot and flaxseeds powder

Parameters	Samples	Colour	Flavour	Crispness	Taste	Overall acceptability
Control crackers	0%	$9.64^{a}\pm0.28$	$8.86^{ab}\pm0.70$	$9.29^{a}\pm0.18$	$9.43^{a}\pm0.30$	$9.57^{a}\pm0.43$
Beetroot crackers	10%B	$9.57^{a}\pm0.30$	$8.29^{b}\pm0.61$	$9.0^{ab}\pm0.38$	$9.43^{a}\pm0.30$	$9.64^{a}\pm0.24$
	20%B	$8.71^{ab}\pm0.18$	$8.43^{ab}\pm0.57$	$8.71^{ab}\pm0.18$	$8.43^{ab}\pm0.30$	$9.57^{a}\pm0.30$
	30%B	$8.75^{ab}\pm0.45$	$9.13^{a}\pm0.23$	$8.88^{ab}\pm0.44$	$9.06^{ab}\pm0.33$	$9.13^{ab}\pm0.40$
Flaxseed crackers	10%F	$9.25^{a}\pm0.41$	$9.56^{a}\pm0.18$	$9.13^{a}\pm0.23$	$9.38^{a}\pm0.26$	$9.43^{ab}\pm0.37$
	15%F	$8.86^{ab}\pm0.40$	$9.0^{ab}\pm0.49$	$9.0^{ab}\pm0.31$	$8.71^{ab}\pm0.36$	$9.37^{ab}\pm0.32$
	20%F	$8.36^{b}\pm0.62$	$8.71^{ab}\pm0.42$	$8.57^{b}\pm0.20$	$7.93^{b}\pm0.54$	$8.57^{ab}\pm0.48$
Flaxseed-Flaxseed crackers	15 F+10%F	$8.64^{ab}\pm0.18$	$9.14^{a}\pm0.55$	$9.93^{a}\pm0.38$	$9.0^{ab}\pm0.44$	$8.71^{ab}\pm0.52$
	15%F 20%B	$8.50^{ab}\pm0.57$	$9.0^{ab}\pm0.58$	$8.07^{b}\pm0.35$	$8.79^{ab}\pm0.21$	$8.57^{ab}\pm0.20$
	15%F+30% B	$8.42^{b}\pm0.43$	$8.86^{ab}\pm0.51$	$7.71^{c}\pm0.36$	$8.14^{b}\pm0.55$	$8.29^{b}\pm0.61$
$p \leq$		*	-	*	*	*

B: Beetroot; F: Flaxseeds. Each statistic is the average of three replicates. SEM: Standard Error of means. (a, b, c, and d): means within the same column differ significantly at $p \leq 0.05$ when accompanied by a different superscript. * $p \leq 0.05$.

Table 3. The chemical composition of chickpea, flaxseeds and beetroot powder and their cracker samples g/100 g

Parameters / Samples	Componants					
	Moisture	Crude protein	Fat	Crude fiber	Ash	Carbohydrate
Chickpea powder	7.8^{a}±0.06	32.1^{a}±0.05	4.15^{b}±0.09	2.5^{c}±0.14	3.24^{c}±.08	52.71^{b}±0.19
Flaxseeds	6.21^{c}±0.2	20.82^{b}±0.01	40.2^{a}±0.12	26.5^{a}±.06	3.67^{b}±0.04	29.1^{c}±0.06
Beetroot	7.1^{b}±0.06	12.5^{c}±0.14	1.41^{c}±0.01	20.11^{b}±0.06	11.5^{a}±0.14	67.49^{a}±0.09
P ≤	***	***	***	***	***	***
Cracker samples						
Control	10.09^{a} ± 0.65	12.00^{b} ± 0.78	1.92^{b} ± 0.23	2.06^{d} ± 0.29	1.34^{d} ± 0.08	75.99^{a}± 3.78
15 % Flaxseeds	9.62^{a} ± 0.54	14.21^{ab} ± 0.64	7.78^{a} ± 0.11	2.84^{c}± 0.07	1.74^{c} ± 0.11	66.65^{c}± 2.09
30% Beetroot	9.88^{a} ± 0.48	12.95^{b} ± 1.01	1.35^{c} ± 0.23	9.43^{b} ± 0.95	3.24^{b} ± 0.52	72.58^{b}± 1.67
15%Flaxseeds+30 % Beetroot	9.42^{a} ± 0.43	15.17^{a} ± 1.03	7.81^{a} ± 0.41	10.21^{a} ± 0.77	3.63^{a} ± 0.49	63.97^{cd}± 1.72
p ≤	--	*	***	***	***	***

Each statistic is the average of three replicates. SEM: Standard Error of means. (a, b, c, and d): means within the same column differ significantly at $p \leq 0.05$ when accompanied by a different superscript. * $p \leq 0.05$; *** $p \leq 0.001$.

Also, Tirgar *et al.* (2017) reported that whole flaxseed contains 40%–45% lipids, 20%–25% protein and 20%–25% fiber on the dry weight. Similarly, the chemical composition of chickpea powder were in agreement with those of Abdrabou and Mostafa (2024). Moreover, the chemical composition of beetroot powder agrees with that of Alshehry *et al.* (2021) who pointed out that beetroot powder protein, fat, crude fiber, ash and total carbohydrates contents were 12.8, 1.36, 20.40, and 11.30 mg /100 g and 54.06% on dry weight, respectively.

The result in the same Table showed that the chemical composition of cracker samples containing beetroot, or flaxseeds and mix flaxseeds and beetroot have higher protein, fat, ash and crude fiber contents are increased but it have low contents of carbohydrates compared to control cracker sample. Moreover,the cracker samples containing flaxseeds and beetroot has the highest contents of crude protein, fat, ash and crude fiber but it has the lowest contents of carbohydrates compared to other creaker samples, this result due to the chemical composition of flaxseeds and beetroot. Moreover, the result of crackers containing flaxseed is agreement with that of Al-Hassawi et al. (2023) who reported that pan bread and Arabic bread fortified with 8% flaxseed had significantly increased in fat, ash, protein, and dietary fiber contents. Also, Nassef et al. (2023) reported that considerable reduction in carbohydrates of snacks content as a result of the addition of flaxseeds to crackers. This might be dueto flaxseeds contain fewer carbohydrates than those of wheat and maize flour.

Minerals content of crackers sample:

The data in Table (4) showed that all minerals content are increased as enrichment crackers with beetroot or flaxseeds and both flaxseeds and beetroot.

Table 4. Mineral content of cracker samples mg/100 g

Parameters / Samples	Control	15 % Flaxseeds	30% Beetroot	15% Flaxseeds +30% Beetroot	*p*≤
K	202.61^{d} ± 3.78	303.36^{c} ± 5.17	883.90^{b} ± 12.76	984.64^{a} ± 20.32	***
Na	8.00^{d}± 0.54	23.32^{c}± 2.87	157.81^{b} ± 6.94	173.14^{a} ± 5.90	***
Ca	30.02^{d} ± 1.44	64.42^{c} ± 4.11	65.26^{b} ± 5.98	99.66^{a} ± 6.21	***
Mg	38.46^{d} ± 1.56	92.40^{b} ± 2.07	89.29^{c} ± 6.11	143.24^{a} ± 3.95	***
P	129.49^{d} ± 3.52	209.04^{b} ± 5.90	192.27^{c} ± 13.56	271.82^{a} ± 11.06	***
Fe	1.87^{d} ± 0.08	2.50^{c} ± 0.21	2.93^{b} ± 0.12	3.56^{a} ± 0.72	***
Zn	1.31^{c} ± 0.03	1.79^{b} ± 0.00	1.82^{b} ± 0.30	2.30^{a} ± 0.20	***
Mn	0.48^{d} ± 0.02	0.55^{c} ± 0.03	0.67^{b} ± 0.09	0.74^{a} ± 0.11	**
Cu	0.34^{c} ± 0.01	0.42^{b} ± 0.00	0.44^{b} ± 0.04	0.51^{a} ± 0.02	**
Se	0.19^{b} ± 0.00	0.21^{b} ± 0.01	0.21^{b} ± 0.02	0.24^{a} ± 0.00	*

Each statistic is the average of three replicates. SEM: Standard Error of means. (a, b, c, and d): means within the same row differ significantly at $p \leq 0.05$ when accompanied by a different superscript. * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

So, cracker sample contain 15% flaxseeds and +30% beetroot have the highest contents of all minerals, this result of enrichment with beetroot is agree with that of Sinha and Masih (2014) who reported that fortified noodles with beetroot powder caused the increase in phosphorus and iron contents compared to noodls free of beetroot. Moreover, the result of enrichment crackers with flaxseeds agrees with that of Elshehy et al. (2018) who reported that traditionally biscuits aren't typically thought of as a good source of minerals. So, biscuits fortified with flaxseed at levels of 10%, 20% and 30% was increased calcium from 25.6 to 175.0 mg/100 g. Therefore, it is advised to supplement diets with flaxseed to improve the body's use of calcium and ω-3 fatty acids for stronger bones. Also, Nassef et al. (2023) reported that Ca, K, P, Mg, Fe, and Zn contents of cracker samples made from flaxseed had more of these elements compared to wheat and corn crackers.

Total phenolic, flavonoid contents and antioxidant activities of cracker samples:

The data presented in Table (5) displayed that the total phenolic and flavonoids are increased with increasing replacement beetroot or flaxseed in cracker samples. Moreover, cracker sample contain (15% beetroot + 30% beetsroot) has the highest contents of total phenolic and flavonoids compared to other crackers. So, this cracker has the highest value of antioxidant activity in contrast to other cracker samples. This result is due to that both beetroot or flaxseeds have higher contents of flavonoids and phenolic by comparing to wheat flour. Furthermore, the result of crackers containing beetroot agrees with that of Mitrevski et al. (2023) who reported that increased enrichment of biscuits with different levels of beetroot powder caused an increase in phenolic, flavonoids and antioxidant activity. Also, the result of enrichment cracker sample with flaxseed caused an increase in total phenolic, flavonoids in compared to control that containing wheat flour. Moreover, Kaur et al. (2018) found that increasing levels of enrichment cookies with beetroot caused increasing in phenolic and flavonoid contents and antioxidant activity values. Also, Pourabedin et al. (2017) stated that addition flaxseed flour to toast caused increasing total flavonoid and phenolic contents.

Nutrition and growing parameters of obese anemic rats feeding on cracker samples:

The data in Table (6) displayed that the nutrition and growing parameters of obese anemic rats feeding on crackers, the results presented that there are significant difference between groups of cracker samples compared to a negative control group and other groups. The highest decrease is found in the group fed on cracker sample containing 15% beetroot in comparison to other rat groups. The result of the group fed on control cracker sample may be due to it containing chickpeas flour which has low energy value, glycemic load, and moderate protein that can provide an integration as anti-obesity as found by Hernández-Ruiz *et al.* (2025).

Table 5. Total phenolic, flavonoid contents and antioxidant activities of cracker samples

Parameters / Samples	Control	15 % Flaxseeds	30% Beetroot	15%Flaxseeds +30% Beetroot	*p* ≤
Total phenolic (mg GAE/100 g, d.b.)	$61.56^{d} \pm 2.45$	$97.34^{c} \pm 5.17$	$114.09^{b} \pm 7.19$	$131.65^{a} \pm 6.07$	***
Flavonoids (mg CE/100 g, d.b.)	$12.98^{d} \pm 1.03$	$17.93^{c} \pm 2.65$	$24.87^{b} \pm 1.23$	$29.90^{a} \pm 1.19$	***
Antioxidant activities					
AA (%)	$39.78^{d} \pm 2.89$	$53.76^{c} \pm 3.93$	$59.56^{b} \pm 5.21$	$65.43^{a} \pm 3.72$	***
AA [% of BHT (50 mg/ml)]	$44.72^{d} \pm 0.02$	$60.44^{c} \pm 0.02$	$66.96^{b} \pm 0.01$	$73.56^{a} \pm 0.02$	***
AA [% of BHT (100 mg/ml)]	$41.82^{d} \pm 0.08$	$56.52^{c} \pm 0.07$	$62.62^{b} \pm 0.02$	$68.79^{a} \pm 0.02$	***
α-tocopherol (50 mg/ml)]	$41.01^{d} \pm 003$	$55.42^{c} \pm 0.02$	$61.40^{b} \pm 0.04$	$67.45^{a} \pm 0.02$	***
BHT (50 mg/ml)	$88.95^{a} \pm 0.04$	$88.95^{a} \pm 0.5$	$88.95^{a} \pm 0.06$	$88.95^{a} \pm 0.03$	-
BHT (100 mg/ml)	$95.12^{a} \pm 0.03$	$95.12^{a} \pm 0.06$	$95.12^{a} \pm 0.05$	$95.12^{a} \pm 0.06$	-
α -tocopherol (50 mg/ml)	$97.01^{a} \pm 0.05$	$97.01^{a} \pm 0.04$	$97.01^{a} \pm 0.08$	$97.01^{a} \pm 0.1$	-
Antioxidant activity by 2,2-di-phenyl-1-picrylhydrazyl (DPPH) (QE mg/mg dw)	$0.017^{d} \pm 0.002$	$0.024^{c} \pm 0.001$	$0.032^{b} \pm 0.006$	$0.041^{a} \pm 0.004$	***

B: Beetroot; F: Flaxseeds. Each statistic is the average of three replicates. SEM: Standard Error of means. (a, b, c, and d): means within the same row differ significantly at $p \leq 0.05$ when accompanied by a different superscript. *** $p \leq 0.001$.

Table 6. Nutrition and growing parameters of obese anemic rats feeding on cracker samples

Parameters / Samples	Initial body	body weight after obesity/g	Final body weight /g	Change in body weight/g
Control (G1)	193.67^{a} ± 4.84	215.7^{b} ±2.96	282.3^{b} ±1.45	66.7^{a} ±2.40
Control (G2)	194.33^{a}± 4.25	258.3^{a} ±2.60	298.7^{a}±1.87	40.3^{b} ±4.25
0% Flaxseeds or Beetroot	192.00^{a}± 8.89	258.0^{a}±1.15	289.0^{b} ±2.08	31.0^{b}±2.64
15% Flaxseeds (G4)	193.33^{a}± 9.53	257.3^{a}±1.45	249.7^{c} ±2.60	-7.7^{c}±3.71
30% Beetroot (G5)	192.00 ^{a}± 5.69	256.3^{a}±1.86	215.7^{e} ±1.45	-40.7^{d}±1.33
15% Flaxseeds +30% Beetroot (G6)	192.67^{a} ± 7.88	258.7^{a}±0.88	228.0^{d}±4.93	-30.7^{d}±4.09
$p \leq$	-	-	***	***

Each statistic is the average of three replicates. SEM: Standard Error of means. (a, b, c, and d): means within the same column differ significantly at $p \leq 0.05$ when accompanied by a different superscript. *** $p \leq 0.001$.

The result of the group fed on cracker sample containing beetroot or flaxseeds or both beetroot and flaxseeds may be due to increasing contents of protein, fiber, total phenol and flavonoid that can improve weight increase as found by Tettamanzi *et al.* (2021) who observed that the diet rich in protein is more efficient lowering nsulin resistance and in enhancing glycemic variability in obese women with pre-diabetes. Also, the result of flaxseeds harmony with that of Naik *et al.* (2018); Akkuş *et al.* (2023) and Musazadeh *et al.* (2024) who stated that incorporating foods with flaxseeds that are rich in soluble fiber that has glycemic control, increased satiety, reduced hunger. So, it promises as an anti-obesity.

Relative organ weight of obese anemic rats feeding on cracker samples:

The data in Table (7) outlined that there is a significant difference between all groups in relative weight but there are significant increase in the relative weight of the heart and liver in compared to the negative control group. On the other hand, there are significant increase in relative kidney, spleen, lung and heart weight compared to the positive control group. This result might be due to the magnet weight of rats as found in Table (6). Moreover, the results outlined that there are no significant differences between all groups fed on cracker samples in relative weight of heart but there are significant differences between these groups and control groups. However, there is a significant difference in the relative weight of liver and kidney between groups fed on 15% flaxseed +30% beetroot and other groups.

Moreover, the results of the effect of flaxseed are similar to those of Alzahrani (2022) who found variation in the lung, liver, heart, spleen and kidney, weight of normal rats group and hypercholesterolemia are significantly reduced as compared to the group fed on at 20% and 25% flaxseeds oil, respectively.

Table 7. Relative organs weight of obese anemic rats feeding on cracker samples

Parameters / Samples	Heart (%)	Liver (%)	Lung (%)	Spleen (%)	Kidney (%)
Control (G1)	0.40^{ab} ± 0.02	2.58^{b} ± 0.08	0.59^{b} ± 0.03	0.55^{b} ± 0.01	0.19^{c}± 0.003
Control (G2)	0.32^{b} ± 0.03	2.67^{b} ± 0.01	0.84^{a}± 0.10	0.54^{b} ± 0.03	0.19^{c} ± 0.009
0% Flaxseeds or Beetroot	0.40^{a} ± 0.04	2.68^{b} ± 1.22	0.84^{a}± 0.04	0.64^{a}± 0.04	0.22^{c} ± 0.01
15% Flaxseeds (G4)	0.43^{a} ± 0.01	2.80^{b} ± 0.13	0.86^{a} ± 0.05	0.69^{a}± 0.04	0.28^{ab} ± 0.02
30% Beetroot (G5)	0.43^{a} ± 0.01	2.81^{b} ± 0.19	0.82^{a} ± 0.04	0.66^{a}± 0.03	0.30^{ab} ± 0.01
15% Flaxseeds +30% Beetroot (G6)	0.44^{a} ± 0.03	3.31^{a} ± 0.21	0.87^{a}± 0.05	0.73^{a}± 0.009	0.32^{a} ± 0.007
$p \leq$	*	*	**	**	*

Each statistic is the average of three replicates. SEM: Standard Error of means. (a, b, c, and d): means within the same column differ significantly at $p \leq 0.05$ when accompanied by a different superscript. * $p \leq 0.05$; ** $p \leq 0.01$.

Lipid profile of obese anemic rats feeding on cracker samples:

Table (8) shows the effect of feeding on crackers enriched with beetroot and flaxseed on glucose and serum lipid profile, meanwhile the results recorded that the positive control group has the highest significant increase in serum glucose, cholesterol, LDL, VLDL, triglyceride and the lowest HDL compared to other groups. This result is due to this group having the highest hyperlipidemic compared to other groups. So, this group has the highest cardiovascular risk factors. On the other hand, the result of the group feeding on control crackers might be due to the cracker sample containing chickpea and thyme. Chickpeas contain a high content of protein and fiber that cause a decrease in glucose which causes a decrease in lipid profile, this result is in agreement with that of Ebrahim (2018) who showed that there is a significant decrease in diabetic rats' blood glucose levels when eating balady bread contains chickpea. Also, Hernández-Ruiz *et al.* (2025) found that chickpea consumption, caused reduced postprandial glucose levels and caused a reduction in the lipid profile and appetite that influence the release of intestinal hormones or anorexigenic. Correspondingly, Sobhy et al. (2020) found that powder and essential oil of thyme caused a reduction of glucose and lipid profile and a reduction of histopathological and liver abnormalities in obese rats.

The same Table (8) showed that the rats group that fed on crackers containing 15% flaxseeds has the same influence as the rats group that fed on crackers containing 30% beetroot on levels of glucose but it has more influence on lipid profile than that of the group fed on 30% beetroot. Moreover, the group fed on (15% flaxseed +30% beetroot) has the lowest serum glucose, cholesterol, LDL, VLDL, triglyceride and the highest HDL so, it has the lowest cardiovascular risk factors compared to other rat groups. This outcome may be due to these cracker samples containing the highest contents of protein, fiber, minerals and phytochemicals compared to other crackers as shown in Tables (3, 4 and 5). So, this group has the highest reduction in weight and glucose hence, it has the highest reduction in lipid profile. Moreover, all group rats are fed on cracker samples haven't risk of heart.All these results are in agreement with those of McRae (2017) and Pezzali *et al.* (2021) who found that dietary fibers' can bind bile acids which can reduce total cholesterol and LDL-c levels. Additionally, Khan (2016) and Witkowska *et al.* (2017) reported the benefits of eaten more polyphenols within meals, because it was negatively related to cardiovascular disease due to their antioxidant, antiatherosclerotic, and anti-coagulant effects. The result of the effect of flaxseeds is may be due to it contain a high protein, fiber and and ash thus, flaxseed have low glycemic index that can improve insulin resistance index, lipid profile, this result is in agrement with that of Nowak & Jeziorek (2023) and Firdous & Jorge (2024) they reported that flaxseeds contain a high content of protein and its major components are glutelins and globulins. It contains bioactive peptides that can lower cardiovascular risk factors.

Table 8. Lipid profile of obese anemic rats feeding on cracker samples

Parameters / Samples	Glucose (mg/dl)	Cholesterol (mg/dl)	Triglyceride (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)	LDL/HDL-c (mg/dl)
Control (G1)	106.83^{b} ±0.37	115.13^{bc} ±10.65	95.90^{bc} ±6.66	37.67^{a} ±1.81	58.29^{bc} ±7.54	19.18^{bc} ±1.33	1.55^{bc} ±1.3
Control (G2)	121.10^{a}± 3.66	147.97^{a} ±2.08	118.30^{a} ±3.54	32.67^{b} ±1.45	91.64^{a} ±1.26	23.66^{a} ±0.71	2.81^{a} ±0.8
0% Flaxseeds or Beetroot	106.60^{b} ±2.20	127.75^{ab} ±11.49	109.43^{ab} ±9.72	36.00^{ab} ±0.77	69.87^{b} ±10.05	21.89^{ab} ±1.94	1.94^{ab} ±1.8
15% Flaxseeds (G4)	100.20^{c}± 0.90	93.90^{ac} ±8.18	76.48^{cd} ±8.45	36.48^{ab} ±1.11	42.13^{cd} ±7.06	15.30^{cd} ±1.69	1.15^{cd} ±1.3
30% Beetroot (G5)	100.23^{c}± 1.62	81.66^{d} ±2.77	77.08^{cd} ±4.49	37.34^{a} ±1.00	28.90^{d} ±3.00	15.42^{cd} ±0.90	0.77^{d} ±0.8
15% Flaxseeds +30% Beetroot (G6)	93.35^{d}± 0.15	75.50^{d} ±2.26	65.30^{d} ±1.54	37.93^{a} ±1.41	24.51^{d} ±3.00	13.06^{d} ±0.31	0.65^{d} ±0.2
p ≤	***	***	***	-	***	***	***

Each statistic is the average of three replicates. SEM: Standard Error of means. (a, b, c, and d): means within the same column differ significantly at $p \leq 0.05$ when accompanied by a different superscript. *** $p \leq 0.001$.

Also, soluble and insoluble fiber improve fasting glucose, insulin resistance index, lipid profile and lower blood pressure. Flaxseed contains calcium, magnesium, phosphorous, and potassium, which are vital in the lessening risk of stroke and heart attack. Furthermore, Akkuş *et al.* (2023); Nowak & Jeziorek (2023) and Musazadeh *et al.* (2024) reported that incorporating foods or permanent feeding on flaxseeds can enhance lipid profile and reduced blood pressure, fasting glucose, and insulin resistance index. The result of beetroot is conformed with that of Płatosz *et al.* (2020); Azizah *et al.* (2022) and Li *et al.* (2022) who reported that vegetable such as red beetroot contains a high amount of fiber and phytochemicals as carotenoids, anthocyanins, betalains and flavonoid which prevent the activity of forming enzyme of cholesterol and avoid lipid oxidation, anti-inflammatory, glycemic and antidiabetic control effects. Besides, Rohman *et al.* (2024) found that beetroot juice and extract led to a significant decrease in triglyceride and cholesterol levels.

Liver function of obese anemic rats feeding on cracker samples

The data in Table(9) revealed the influence of crackers enriched with flaxseeds and beetroot on liver function, the result showed that there is a significant increase in serum ALT, AST and ALP enzymes of the positive control group compared to the negative control group, and other groups fed on cracker samples. This result may be due to alterations in metabolism such as the administration of toxins, hepatitis and liver cirrhosis leading to an increase in serum ALT, AST, and ALP levels. This result agrees with that of Sobhy *et al.* (2020). The result of decreasing serum liver enzymes may be due to decreasing in lipid profile as shown in Table (8) as a result to increase contents of phytochemicals and flavonoids as shown in Table (5), this contents caused reaction to oxidative damage in the pathogenesis of numerous illnesses, the result of group fed on control cracker sample contain chickpea and thyme is agree with that of Sobhy et al. (2020) who found that the consumption of thyme powder and essential oil can help reduce the liver and histopathological problems linked to obesity.

In the same Table, the result of the group fed on crackers containing flaxseed is harmonised with that of Ume Salma *et al.* (2019) who found that hepatotoxicity can be decreased by using flaxseeds or its protein into meal compositions. As well, Albasher *et al.* (2019) who demonstrated that red beetroot reduces oxidative stress, inflammation, and hepatotoxicity to prevent liver damage. Moreover, the result of the group fed on cracker sample containing flaxseeds and beetroot is agreeement with that of Elgazzar (2022) discovered that rat groups consumed a diet replaced with beetroot and a blend of beetroot and germination flaxseeds at various doses caused reduction the levels of serum AST and ALT.

The kidney function of obese anemic rats feeding on cracker samples:

The results in Table (10) presented that there a significant increase in serum urea and uric acid levels of all obese anaemic rat's groups compared to the negative control group. Nevertheless, rats feeding on crackers enriched with beetroot or flaxseed have a significant decrease in serum urea and uric acid levels compared to the positive control group.

This outcome is in harmony with that of Al Obaidi & Rzoqi (2023) and Armağan & Yeşilot (2023). Moreover, as a result of feeding rats on cracker samples enriched with beetroot or flaxseed and both beetroot and flaxseed the levels of serum urea, uric acid and creatinine are increased.

Table 9. Liver function of obese anemic rats feeding on cracker samples

Parameters / Samples	ALT (u/ml)	ASTn (u/ml)	ALP (u/ml)
Control (G1)	$83.0^{b}\pm3.60$	$74.33^{b}\pm4.41$	$114.33^{c}\pm4.33$
Control (G2)	$105.67^{a}\pm2.85$	$110.0^{a}\pm2.0$	$142.67^{a}\pm4.33$
0% Flaxseeds or Beetroot	$52.67^{cd}\pm3.17$	$74.67^{b}\pm8.1$	$134.67^{ab}\pm1.33$
15% Flaxseeds (G4)	$48.33^{d}\pm2.96$	$43.0^{d}\pm1.51$	$125.33^{b}\pm1.67$
30% Beetroot (G5)	$59.67^{c}\pm3.18$	$57.00^{c}\pm2.89$	$111.50^{c}\pm2.50$
15% Flaxseeds +30% Beetroot (G6)	$47.50^{d}\pm0.50$	$51.00^{cd}\pm1.00$	$109.67^{c}\pm1.76$
$p \leq$	****	****	****

Each statistic is the average of three replicates. SEM: Standard Error of means. (a, b, c, and d): means within the same column differ significantly at $p \leq 0.05$ when accompanied by a different superscript. *** $p \leq 0.001$.

Table 10. Kidney function of obese anemic rats feeding on cracker samples

Parameters / Samples	Urea (mmol/L)	Creatinine (mg/dl)	Uric acid (mg/dl)
Control (G1)	$19.03^{c}\pm2.14$	$0.75^{a}\pm.03$	$4.35^{c}\pm0.45$
Control (G2)	$26.85^{a}\pm2.35$	$0.85^{a}\pm0.03$	$5.97^{a}\pm0.29$
0% Flaxseed or Beetroot	$25.80^{ab}\pm1.20$	$0.83^{a}\pm0.05$	$5.55^{ab}\pm1.15$
15% Flaxseed (G4)	$25.50^{ab}\pm2.40$	$0.80^{a}\pm0.06$	$5.53^{ab}\pm0.15$
30% Beetroot (G5)	$25.66^{a}\pm2.08$	$0.82^{a}\pm0.05$	$5.47^{b}\pm0.52$
15% Flaxseed +30% Beetroot (G6)	$24.25^{b}\pm0.65$	$0.75^{a}\pm0.05$	$5.05^{cb}\pm0.52$
$p \leq$	*	-	*

Each statistic is the average of three replicates. SEM: Standard Error of means. (a, b, c, and d): means within the same column differ significantly at $p \leq 0.05$ when accompanied by a different superscript. * $p \leq 0.05$.

However, the group was fed on a crackers sample containing (15% flaxseed +30% beetroot) which has the lowest levels of serum urea, uric acid and creatinine compared to other groups. The result of the group was fed on control crackers sample might be due to cracker containing thyme and chickpea, this result agrees with that of Sobhy et al. (2020) who stated that thyme powder and essential oil decreased insulin resistance by promoting insulin's absorption of glucose, and they also changed glycoprotein levels in plasma, hepatic tissues, and renal tissues in mice with diabetes caused by feeding on HFD. Also, the result of the group was fed crackers sample containing beetroot is in harmony with that of Al Obaidi and Rzoqi (2023) who stated that beetroot juice led to an improvement in kidney functions compared to the control group. Also, Elaby & Ali (2018) and Abdo et al. (2021) reported beetroot caused significantly ameliorated serum urea, uric acid and creatinine levels in compared to the anemic control group. Similarly, Haq et al. (2019) observed that drinks made with beetroot minimize the negative impacts of gentamicin-induced nephritic stress.

In the same Table, the positive effect of beetroot on kidney function may be due to beetroot and flaxseeds content of bioactive compounds. Moreover, the result of group was fed on crackers containing flaxseeds is agreemet with that of Hussien et al. (2020) and Draganescu et al. (2021) who found that consumption of a flaxseeds diet reduced urea, creatinine and uric acid levels compared to the control group rats. Also, Armağan and Yeşilot (2023) found there are no significant alteration in levels of creatinine in compared to the control group. Furthermore, there are an increase but not significant in serum uric acid level in all rats group fed on a high overdose diet of flaxseeds. Also, Al-Harbi et al. (2024) observed that treatment with beetroot extract enhanced oxidative stress and inflammatory marker levels in the kidneys.

The result of beetroot is harmony with that of Haq *et al.* (2019) who reported that beetroot contains betanin have counteracted the harmful effects of renal toxicity caused by paraquat by increasing antioxidant enzymes and decreasing lipid peroxidation and inflammatory indicators. Also, Hussien *et al.* (2020) reported that flaxseeds rich with α-linolenic acid has essential anti-inflammatory properties, also enhanced in renal tissues and subtotally nephrectomized rats fed on flaxseeds.

Hematological parameters of obese anemic rats feeding on cracker samples:

The obtained data in Table (11) revealed the hematological parameters of obese anemic rats feeding on the cracker samples. The result showed that there are decrease in blood cell counts (RBC), white blood cell counts (WBC), hematocrit (Hct%), mean corpuscular volume (MCV) and mean corpuscular Hb concentration (MCHC) of the positive control group compared to these of the negative control group. Similarly, group was fed on crackers sample was enriched with beetroot, flaxseeds and (beetroot and flaxseeds) enhanced levels of plasma Hb, RBC, WBC, MCV and MCHC, this result may be due to high phenolic and flavonoid active compounds that act as antioxidants have an immunostimulatory effect and can increase erythropoiesis in the bone marrow. The result of the group fed on control crackers may be due to crackers contain thyme leaves which dose as a source of nonheme iron, this result is an agreement with that of Yossef et al. (2024) who reported that feeding anemic rats with thyme leaves as a source of nonheme iron led to a significant increase in Hb, HT, MCV and RBC counts compared with the positive control group. Correspondingly, the result of the group was fed on a crackers sample contained beetroot, due to beetroot has high contents of iron, this is agreed with that of Risnawati et al. (2021) who described that beetroot's iron concentration that helps to treat anemia because it is vital for the human body to carry oxygen to red blood cells. Also, Hikmawanti et al. (2021) estimated that fed male rats beetroot for 21 days, caused a significant increase in haemoglobin, MCV, MCH, MCHC, leukocytes, and platelets compared to the normal group.

Table 11. Hematological parameters of obese anemic rats feeding on cracker samples

Parameters / Samples	Hb g/dL	HCT(PCV%)	RBC(M/μL)	WBC (M/μL)	MCV (Fl)	MCHC(g/Dl)
Control (G1)	$13.63^{b}\pm0.29$	$25.63^{b}\pm0.75$	$5.92^{b}\pm0.41$	$9.82^{a}\pm0.53$	$52.0^{a}\pm0.59$	$53.40^{a}\pm1.25$
Control (G2)	$11.33^{c}\pm0.37$	$25.40^{b}\pm0.83$	$4.57^{c}\pm0.23$	$6.47^{b}\pm0.20$	$48.33^{b}\pm0.22$	$38.77^{d}\pm0.85$
0% Flaxseeds or Beetroot (G3)	$13.23^{b}\pm0.61$	$32.17^{a}\pm1.27$	$5.97^{b}\pm0.22$	$8.01^{ab}\pm0.96$	$52.57^{a}\pm0.17$	$44.73^{c}\pm0.78$
15% Flaxseeds (G4)	$14.2^{ab}\pm0.24$	$32.43^{a}\pm0.26$	$6.18^{ab}\pm0.15$	$8.59^{a}\pm0.65$	$52.83^{a}\pm1.07$	$43.83^{c}\pm0.38$
30% Beetroot (G5)	$15.26^{a}\pm0.20$	$34.63^{a}\pm2.1$	$6.72^{ab}\pm0.62$	$8.60^{a}\pm0.33$	$52.30^{a}\pm1.29$	$43.83^{c}\pm2.13$
15% Flaxseeds +30% Beetroot (G6)	$15.30^{a}\pm0.34$	$34.5^{a}\pm1.87$	$7.33^{a}\pm0.53$	$9.76^{a}\pm0.35$	$52.23^{a}\pm1.57$	$48.93^{b}\pm1.24$
$p \leq$	***	***	**	**	*	***

Each statistic is the average of three replicates. SEM: Standard Error of means. (a, b, c, and d): means within the same column differ significantly at $p \leq 0.05$ when accompanied by a different superscript. * $p \leq 0.05$; ** $p \leq 0.01$;*** $p \leq 0.001$.

Moreover, the result of the group fed on crackers contain flaxseed is agreed with that of Orisakwe *et al.* (2020) and Fayyaz *et al.* (2023) who reported that phenolic compounds and flavonoids present in flaxseed serves as an iron chelator and antioxidant without any side effects. Also, Harby (2023) reported that flaxseed oil and powder can improve RBC, WBC, and platelet of obese diabetes male albino rats induced so, flaxseed can reverse hematological abnormalities in T2-DM rats and could be effective in preventing diabetes complications such as anemia.

CONCLUSION

Flaxseeds and beetroot have high nutritional value and healthy benefits. Therefore, it can be enhanced bakery with a combination of flaxseed and beetroot to produce appealing and healthful baked goods that can be used to cure or prevent anemia and obesity, as well as to improve glucose levels, liver and kidney function, and avoid diseases associated with these conditions.

REFERENCES

A.A.C.C. 2000. American Association of Cereal Chemists. Approved Methods. Ed. St. Paul. Minnesota, USA.

A.O.A.C. 1995. Official Methods of the Association of Official Analytical Chemists. 16th Ed. Published by the Association of Official Analytical Chemists. Washington, D.C, USA.

Abcam, 2019. HDL and LDL/VLDL Cholesterol Assay Kit (Colorimetric/ Fluorometric), Version 11 Last updated 14 June www.abcam.cn.

Abdo, E.M., O.E. Shaltout, S. El-Sohaimy, A.E.M. Abdalla and A.M. Zeitoun. 2021. Effect of functional beetroot pomace biscuit on phenylhydrazine induced anemia in albino rats: hematological and blood biochemical analysis. J. Funct. Foods 78, 104385.

Abdrabou, E.A.A. and D.M.E. Mostafa. 2024. Quality properties of pasta fortification with legume flour and mallow (*malva parviflora* L.) leaves powder. Alex. Sci. Exch. J. 45: 489-500.

Akkuş, Ö.Ö., Y. Özdemir, Ç. Özbek, B. Öncel and B.Y. Nane. 2023. Does flaxseed and chia use affect postprandial glucose, insulin and subjective saturation response in healthy individuals? Effect of chia and flaxseed on glycemic control and satiety. J. Surg. Med. 7: 434-440.

Al Obaidi, A.T.I.T. and Q.A. Rzoqi. 2023. Effect of high-fat diet on the kidneys of albino rats and the protective role of beetroot juice compared with orlistat. Ann. Rom. Soc. Cell Biol. 27: 120-137.

Albasher, G., R. Almeer, F.O. Al-Otibi, N. Al-Kubaisi and A.M. Mahmoud. 2019. Ameliorative effect of *Beta vulgaris* root extract on chlorpyrifos-induced oxidative stress, inflammation and liver injury in rats. Biomol. 9, 261.

Al-Harbi, L.N., G.M. Alshammari, G. Shamlan, M.A. Binobead, S.A. AlSedairy, D.M. Al-Nouri, S. Arzoo and M.A. Yahya. 2024. Nephroprotective and anti-diabetic potential of *Beta vulgaris* L. root (Beetroot) methanolic extract in a rat model of type 2 diabetes mellitus. Med. 60, 394.

Al-Hassawi, F., J. Al-Ghanim, M. Al-Foudari, A.A. Al-Othman and J.S. Sidhu. 2023. Effects of flaxseed on the nutritional and sensory qualities of pan and Arabic flat breads. Foods Raw Mater. 11: 272-281.

Allain, C. 1974. Cholesterol enzymatic colorimetric method. J. Clin. Chem. 2, 470.

Al-Saikhan, M.S., L.R. Howard and J.C. Miller Jr. 1995. Antioxidant activity and total phenolics in different genotypes of potato (*Solanum tuberosum* L.). J. Food Sci. 60: 341-343.

Alshehry, G., A. Abdelazez, H. Abdelmotaal and W. Abdel-Aleem. 2021. Investigating antioxidant and antibacterial activity of functional cookies enriched with beetroot during storage. Czech J. Food Sci. 39: 479-486.

Alzahrani, M.S.H. 2022. The effect of different levels of flaxseed oil on biochemical changes in hypercholesterolemic rats. Arch. Pharm. Pract. 13: 88-93.

Amnah, M. 2013. Nutritional, sensory and biological study of biscuits fortified with red beetroots. Life Sci. J. 10: 1579-1584.

Armağan, İ. and Ş. Yeşilot. 2023. Excessive use of flaxseed may pose a threat to kidney tissue: an experimental study. Med. J. Süleyman Demirel Univ. 30: 89-96.

Aune, D. 2019. Plant foods, antioxidant biomarkers, and the risk of cardiovascular disease, cancer, and mortality: a review of the evidence. Adv. Nutr. 10: S404-S421.

Azizah, R.N., A. Emelda, I. Asmaliani, I. Ahmad and M. Fawwaz. 2022. Total phenolic, flavonoids, and carotenoids content and anti-obesity activity of purslane herb (*Portulaca oleracea* L.) ethanol extract. Pharmacogn. J. 14: 8-13.

Bhavana, K.B., A.N. Babu, J. Lakshmi, B. Deepthi and G. Kavya. 2021. A review on pharmacological properties and laboratory outcomes of flaxseed diet (*Linum usitatissimum*). Int. J. Pharm. Sci. Rev. Res. 70: 100-105.

Carroll, J.J., N. Smith and A.L. Babson. 1970. A colorimetric serum glucose determination using hexokinase and glucose-6-phosphate dehydrogenase. Biochem. Med. 4: 171-180.

Castelli, T. and Y. Levitar. 1977. Atherogenic, index Curr Presc p39.

Ceclu, L. and O.V. Nistor. 2020. Red beetroot: composition and health effects—a review. J. Nutr. Med. Diet Care 6: 1-9.

Chapman, D.G., R. Castillo and J.A. Campbell. 1959. Evaluation of protein in foods: 1. A method for the determination of protein efficiency ratios. Can. J. Biochem. Physiol. 37: 679-686.

Cho, J., S.J. Bing, A. Kim, N.H. Lee, S.H. Byeon, G.O. Kim and Y. Jee. 2017. Beetroot (*Beta vulgaris*) rescues mice from γ-ray irradiation by accelerating hematopoiesis and curtailing immunosuppression. Pharm. Biol. 55: 306-316.

Draganescu, D., C. Andritoiu, D. Hritcu, G. Dodi and M.I. Popa. 2021. Flaxseed lignans and polyphenols enhanced activity in streptozotocin-induced diabetic rats. Biol. 10, 43.

Ebrahim, Y.M. 2018. Effect of balady and imported chickpea on blood glucose and lipid profile of diabetes rats. Res. J. Spec. Educ. 297-312.

Elaby, S.M. and J.B. Ali. 2018. The anti-anemic effect of dried beet green in phenylhydrazine treated rats. Arch. Pharm. Sci. Ain Shams Univ. 2: 54-69.

Elbouny, H., B. Ouahzizi, E.D.T. Bouhlali, K. Sellam and C. Alem. 2022. Pharmacological, biological and phytochemical aspects of Thymus munbyanus Boiss. & Reut.: A review. Plant Sci. Today 9: 399-404.

Elgazzar, H.H. 2022. Evaluation of feeding barley and flaxseed germinated with beetroot powder on heart disorders in rats. Bull. National Nutr. Inst. Arab Republic Egypt 60: 32-54.

Elshehy, H., N. Agamy and H. Ismail. 2018. Effect of fortification of biscuits with flaxseed on omega 3 and calcium content of the products. J. High Inst. Public Health 48: 58-66.

Evstigneeva, T., N. Iakovchenko, N. Kuzmicheva and N. Skvortsova. 2020. Applying beetroot as food ingredient in ice-cream production. Agron. Res. 18: 1662–1672.

Fayyaz, T., M.I. Qadeer, M. Irfan, F. Amjad, T. Fatima and S. Husnain. 2023. Effect of flaxseed intervention on iron overload and its complications in thalassemia major patients. Nutr. Food Sci. 53: 1268-1278.

Firdous, S. and A. Jorge. 2024. Exploring the therapeutic potential of flaxseed oil: insights from pre-clinical and clinical research. World J. Adv. Res. Rev. 23: 214–227.

Fossati, P., L. Prencipe and G. Berti. 1980. Use of 3,5-dichloro-2-hydroxybenzenesulfonic acid/4-aminophenazone chromogenic system in direct enzymic assay of uric acid in serum and urine. Clin. Chem. 26: 227-231.

Hammoudi Halat, D., M. Krayem, S. Khaled and S. Younes. 2022. A focused insight into thyme: biological, chemical, and therapeutic properties of an indigenous Mediterranean herb. Nutr. 14, 2104.

Haq, I.U., M.S. Butt, M.A. Randhawa and M. Shahid. 2019. Nephroprotective effects of red beetroot-based beverages against gentamicin-induced renal stress. Med. Biochem. Res. 43, e12873.

Harby, M.M. 2023. Effect of flaxseed different forms on hematological alteration in Streptozotocin induced diabetic rats. Delta J. Sci. 47: 1-14.

Hernández-Ruiz, R.G., X.C. Olivares-Ochoa, Y. Salinas-Varela, D. Guajardo-Espinoza, L.G. Roldán-Flores, E.A. Rivera-Leon and A. López-Quintero. 2025. Phenolic compounds and anthocyanins in legumes and their impact on inflammation, oxidative stress, and metabolism: comprehensive review. Mol. 30, 174.

Hikmawanti, N.P.E., L.P. Dwita and D.A. Zahra. 2021. Beetroot extracts as haematopoietic agents on rats. Indones. J. Pharm. 32: 175-178.

Hussien, Z.G., R.A. Azize and A.T. Al-Mousawi. 2020. The effect of flaxseed (*Linum Usitatissimum* L) consumption in biochemical parameters of rats. Int. J. Pharm. Res. 12: 3759-3764.

Jackson, S.E., C.H. Llewellyn and L. Smith. 2020. The obesity epidemic–Nature via nurture: a narrative review of high-income countries. SAGE Open Med. 8, 2050312120918265.

Katalinic, V., M. Milos, T. Kulisic and M. Jukic. 2006. Screening of 70 medicinal plant extracts for antioxidant capacity and total phenols. Food Chem. 94: 550-557.

Kaur, P., R. Waghmare, V. Kumar, P. Rasane, S. Kaur and Y. Gat. 2018. Recent advances in utilization of flaxseed as potential source for value addition. Ocl-Oilseeds Fats Crops Lipids 25, A304.

Khan, M.I. 2016. Plant betalains: safety, antioxidant activity, clinical efficacy, and bioavailability. Compr. Rev. Food Sci. Food Saf. 15: 316-330.

Klin, Z. 1972. Colorimetric test for L-(-glutamyl transferase Chem Klin. Biochem.10, 182

Kobylińska, M., K. Antosik, A. Decyk and K. Kurowska. 2022. Malnutrition in obesity: is it possible?. Obes. Facts 15: 19-25.

Kovarovič, J., J. Bystrická, J. Tomáš and M. Lenková. 2017. The influence of variety on the content of bioactive compounds in beetroot (*Beta vulgaris* L.). Potravinarstvo Slovak J. Food Sci. 11: 106-112.

Lee, R. and D. Nieman. 1996. Nutritional assessment. 2nd Edition, Mosby Missouri, USA.

Li, Z., J. Tian, Z. Cheng, W. Teng, W. Zhang, Y. Bao, Y. Wang, B. Song, Y. Chen and B. Li. 2022. Hypoglycemic bioactivity of anthocyanins: a review on proposed targets and potential signaling pathways. Crit. Rev. Food Sci. Nutr. 63: 7878-7895.

Marco, G.J. 1968. A rapid method for evaluation of antioxidants. J. Am. Oil Chem. Soc. 45: 594-598.

Masih, D., N. Singh and A. Singh. 2019. Red beetroot: a source of natural colourant and antioxidants: a review. J. Pharmacogn. Phytochem. 8: 162-166.

McRae, M.P. 2017. Dietary fiber is beneficial for the prevention of cardiovascular disease: an umbrella review of meta-analyses. J. Chiropr. Med. 16: 289-299.

Mitrevski, J., N.Đ. Pantelić, M.S. Dodevska, J.S. Kojić, J.J. Vulić, S. Zlatanović, S. Gorjanović, J. Laličić-Petronijević, S. Marjanović and V.V. Antić. 2023. Effect of beetroot powder incorporation on functional properties and shelf life of biscuits. Foods 12, 322.

Moreau, R., D. Tshikudi Malu, M. Dumais, E. Dalko, V. Gaudreault, H. Roméro, C. Martineau, O. Kevorkova, J.S. Dardon, E.L. Dodd and D.S. Bohle. 2012. Alterations in bone and erythropoiesis in hemolytic anemia: comparative study in bled, phenylhydrazine-treated and Plasmodium-infected mice. PLoS ONE 7, e46101.

Motlagh, H.A., E. Aalipanah, M. Mazidi and S. Faghih. 2021. Effect of flaxseed consumption on central obesity, serum lipids, and adiponectin level in overweight or obese women: a randomised controlled clinical trial. Int. J. Clin. Pract. 75, e14592.

Mudgil, P., F.F. Ajayi, A. Alkaabi, M. Alsubousi, B.P. Singh and S. Maqsood. 2023. Flaxseed-and chia seed-derived protein hydrolysates exhibiting enhanced in vitro antidiabetic, anti-obesity, and antioxidant properties. Front. Sustain. Food Syst. 7, 1223884.

Musazadeh, V., M. Abolghasemian, Z. Kavyani, A.H. Moridpour, A. Nazari and A.H. Faghfouri. 2024. The effects of flaxseed (*Linum usitatissimum*) supplementation on anthropometric indices: an updated systematic review and meta-analysis of randomized clinical trials. Complement. Ther. Med. 84, 103066.

Naik, H.S., C.H. Srilatha, K. Sujatha, B. Sreedevi and T.N.V. Prasad. 2018. Supplementation of whole grain flaxseeds (*Linum usitatissimum*) along with high cholesterol diet and its effect on hyperlipidemia and initiated atherosclerosis in Wistar albino male rats. Vet. World 11, 1433.

Nassef, S.L., H.H. Hafez and A.M. Aly. 2023. Maximizing the use of flaxseed in the production of vegan bakery products free of gluten, eggs, milk and low carbohydrates. Assiut J. Agri. Sci. 54: 102-115.

Noreen, S., T. Tufail, H.B. Ul Ain and C.G. Awuchi. 2023. Pharmacological, nutraceutical, and nutritional properties of flaxseed (*Linum usitatissimum*): an insight into its functionality and disease mitigation. Food Sci. Nutr. 11: 6820-6829.

Noreen, S., T. Tufail, Z. Khalid, A.U. Khan and Y.S. Pane. 2024. Health benefit of flaxseed (*Linum usitatissimum*): a mini review. Food Res. 8: 107-116.

Nowak, W. and M. Jeziorek. 2023. The role of flaxseed in improving human health. Healthcare 11, 395.

Nurhanan, A.R., D.T.W. Xin and L. Tham. 2021. Physicochemical properties and sensory evaluation of green and red spinach crackers. IOP Conf. Ser. Earth Environ. Sci. 756, 012079.

Orisakwe, O.E., C.N. Amadi and C. Frazzoli. 2020. Management of iron overload in resource poor nations: a systematic review of phlebotomy and natural chelators. J. Toxicol. 2020, 4084538.

Pezzali, J.G., A.K. Shoveller and J. Ellis. 2021. Examining the effects of diet composition, soluble fiber, and species on total fecal excretion of bile acids: a meta-analysis. Front. Vet. Sci. 8, 748803.

Platosz, N., T. Sawicki and W. Wiczkowski. 2020. Profile of phenolic acids and flavonoids of red beet and its fermentation products. Does long-term consumption of fermented beetroot juice affect phenolics profile in human blood plasma and urine?. Pol. J. Food Nutr. Sci. 70: 55–65.

Pourabedin, M., A. Aarabi and S. Rahbaran. 2017. Effect of flaxseed flour on rheological properties, staling and total phenol of Iranian toast. J. Cereal Sci. 76: 173-178.

Risnawati, I., I. Indanah and S. Sukesih. 2021. Efektivitas pemberian jus buah bit terhadap kadar hemoglobin ibu hamil dengan anemia di puskesmas tayu I. Indonesia J. Kebidanan 5: 36-41.

Rohman, Y., A. Nurudhin and L.O. Wardhani. 2024. Beetroot (*Beta vulgaris* L.) reduces cholesterol and triglyceride in dyslipidemic male rats sprague–dawley model. J. Gizi Indonesia (Indonesian J. Nutr.) 12: 80-87.

Saad, R.A. and H.M. Qutob. 2022. The relationship between anemia and obesity. Expert Rev. Hematol. 15: 911-926.

Sakhare, K.S., A.R. Sawate, R.B. Kshirsagar and A.T. Taur. 2019. Studies on physical and chemical composition of beetroot (*Beta vulgaris* L.). Int. J. Chem. Stud. 7: 283-285.

Sherwin, J.E. 1984. Liver function. In:kaplan LA, PESCE AJ, eds. Clinical chemistry, theory,analysis, and correlation. St louis:Mosby, 1984:420- 438.

Singleton, V.L. and J.A. Rossi. 1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am. J. Enol. Vitic. 16: 144-158.

Sinha, P. and D. Masih. 2014. Development and quality evaluation of extruded product of rice flour incorporated with beetroot (*Beta vulgaris*) pomace and pulse powder. Int. J. Sci. Res. 3: 148-150.

Sobhy, H.M., N.H.M. Hassanen and M.A.I. Ahmed. 2020. Hepatoprotective activities of thyme (*Thymus vulgaris* L.) in rats suffering from obesity. Egypt. J. Chem. 63: 5087-5101.

SPSS. 2008. Statistical Package for Social Sciences Program. Version 17 for Windows, SPSS Inc., Chicago.

Sundarrao, K., J. Tinkerame, C. Kaluwin, K. Singh and T. Matsuoka. 1991. Lipid content, fatty acid, and mineral composition of mud crabs (*Scylla serrata*) from Papua New Guinea. J. Food Compost. Anal. 4: 276-280.

Tang, Z.X., L.E. Shi, X.M. Wang, G.W. Dai, L.A. Cheng, Z.X. Wan, H. He, Q. Wu, Y.B. Wang, X.Y. Jin and R.F. Ying. 2020. Whole flaxseed-based products and their health benefits. Food Sci. Technol. Res. 26: 561-578.

Tettamanzi, F., V. Bagnardi, P. Louca, A. Nogal, G.S. Monti, S.P. Mambrini, E. Lucchetti, S. Maestrini, S. Mazza, A. Rodriguez-Mateos and M. Scacchi. 2021. A high protein diet is more effective in improving insulin resistance and glycemic variability compared to a Mediterranean diet—a cross-over controlled inpatient dietary study. Nutr. 13, 4380.

Tietz, N.W. 2006. Clinical guide to laboratory test, 4th Ed:316-321.

Tirgar, M., P. Silcock, A. Carne and E.J. Birch. 2017. Effect of extraction method on functional properties of flaxseed protein concentrates. Food Chem. 215: 417-424.

Tran, T.N., A. Athanassiou, A. Basit and I.S. Bayer. 2017. Starch-based bio-elastomers functionalized with red beetroot natural antioxidant. Food Chem. 216: 324-333.

Ume Salma, N., M. Serva Peddha and J.L. Aswathanarayana Setty. 2019. Ameliorative effect of flaxseed (*Linum usitatissimum*) and its protein on ethanol-induced hepatotoxicity in Wistar rats. J. Food Biochem. 43, e13047.

Viveky, N., L. Thorpe, J. Alcorn, T. Hadjistavropoulos and S. Whiting. 2015. Safety evaluation of flaxseed lignan supplementation in older adults residing in long-term care homes. J. Nurs. Home Res. Sci. 1: 84-88.

Witkowska, A.M., A. Waśkiewicz, M.E. Zujko, D. Szcześniewska, A. Pająk, U. Stepaniak and W. Drygas. 2017. Dietary polyphenol intake, but not the dietary total antioxidant capacity, is inversely related to cardiovascular disease in postmenopausal Polish women: results of WOBASZ and WOBASZ II studies. Oxid. Med. Cell. Longev. 2017, 5982809.

Yossef, H.E.E., R.R.R. Abde hameid, N.A. Khali and A.A. Khder. 2024. Efficiency of using thyme (*Thymus vulgaris*) for treating anemia caused by iron deficiency in rats. J. Sci. Spec. Educ. 20: 383-394.

Young D.S. 1990. Effect of drugs on clinical laboratory test, 4th Ed:3-609.

Zhishen, J., T. Mengcheng and W. Jianming. 1999. The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. Food Chem. 64: 555-559.

الملخص العربي

تأثير التغذية على المقرمشات المعززة بمسحوق البنجر وبذور الكتان على فئران التجارب المصابة بالسمنة والأنيميا المستحدثة بفنيل الهيدرازين

إيمان عبد الحميد أحمد عبد ربه، دعاء عمر محمد جودة

تهدف الدراسة الحالية إلى إنتاج مقرمشات مدعمة ببذور الكتان ومسحوق جذور البنجر وخليطهما و دراسة التقييم الحسي والكيميائي والبيولوجي للمقرمشات المدعمة ببذور الكتان ومسحوق جذور البنجر وخليطهما. أجريت الدراسة البيولوجية على الفئران المصابة بالسمنة وفقر الدم وذلك بعد تغذية الفئران على وجبة غذائية عالية الدهون لإصابتها بالسمنة ثم حقنها بالفينيل هيدرازين لاصابه الفئران بفقر الدم و تغذيتها بعد ذلك على المقرمشات المدعمة بنسبة ١٠٠%. أظهر نتائج التقييم الحسي أن جميع المقرمشات مقبولة حسيا. كما تم دراسة التركيب الكيميائي والدراسة البيولوجية على المقرمشات المدعمة و المحتوية على ٠%، و١٥% ، و ٣٠% مسحوق البنجر و(١٥% بذور الكتان + ٣٠% مسحوق البنجر). أظهرت النتائج أن المقرمشات المدعمة ببذور الكتان ومسحوق البنجر وخليطهما كانت مرتفعة في محتواها من الألياف، الرماد، المعادن، المواد الفينوليه، الفلافونويدات ومضادات الأكسدة. كما وجد أن تغذية الفئران المصابة بالسمنة وفقر الدم على المقرمشات المحتوية على ٠%، و١٥% من بذور الكتان، و٣٠% من مسحون جذور البنجر، و خليط (١٥% بذور الكتان + ٣٠% مسحون البنجر) أدت إلى حدوث انخفاض ملحوظ في وزن الفئران، ومؤشرات دهون ، وجلوكوز الدم، وإنزيمات الكبد، وذلك بالمقارنة بمجموعة الفئران المصابة الموجبه. كما وجد إن مجموعة الفئران المغداة على المقرمشات المحتوية على خليط (١٥% بذور الكتان + ٣٠% مسحوق البنجر) كان لها أفضل النتائج بالمقارنة بمجموعات الفئران الأخرى المغداة على المقرمشات. وترجع هذه النتيجة ان كلا من مسحوق جذر البنجر وبذور الكتان يحتوى على المعادن والفيتامينات والألياف والفلافونويد والمواد الفعالة كيمياويا التي تعزز الوظائف البيولوجية للفئران المصابه. لذا، يمكن إثراء المخبوزات بخليط من بذور الكتان و مسحوق جذور البنجر وذلك للحصول على مخبوزات مقبولة حسيا وصحية يمكن استخدامها ايضا لعلاج أو الوقاية من السمنة و الانيميا، وتحسين مستويات السكر ووظائف الكلى و الكبد و الحماية من الامراض المتصلة بهما.

الكلمات المفتاحية: بذور الكتان، البنجر، السمنة، الأنيميا، فنيل الهيدرازين.