The Effect of Moringa Leaves Powder on Hypercholesterolemic Male Rats and the Possibility of Adding to some Vegetable Recipes

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العنوان: كلية التربية النوعية . جامعة المنيا . جمهورية مصر العربية

تأثير مسحوق أوراق المورينجا على ذكور الفئران المصابة بارتفاع الكوليسترول ومدى إمكانية إضافته لبعض أصناف الخضروات

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الملخص

يهدف البحث الحالي إلى دراسة تأثير مسحوق أوراق المورينجا على ذكور الفئران المصابة بارتفاع مستوي الكوليسترول في الدم ومدى إمكانية إضافته لبعض أصناف للخضروات(البازلاء بالطماطم، السبانخ المكمورة، مسقعة الباذنجان ، الملوخية والقلقاس بالخضرة) بنسب 5% ، 10% و 15% . ولهذا الغرض تم تقسيم 35 فأر من ذكورالألبينو إلي مجموعتين رئيستين ، المجموعة الرئيسبة الأولي وعددهم 7 فئران تم تغذيتهم علي الغذاء الأساسي فقط، أما المجموعة الرئيسية الثانية 28 فأر فقد تم إصابتهم بالكوليسترول من خلال تغذيتهم على غذاء مرتفع في محتواه من الكوليسترول ، ثم قسمت المجموعة الثانية الرئيسية إلي أربع مجموعات متساوية العدد إحداهما المجموعة الضابطة المصابة ، أما باقي المجموعات فقد أضيف مسحوق أوراق المورينجا إلى غذائها بنسب 5% ، 10% و 15% علي التوالي لمدة 6 أسابيع . وأوضحت النتائج أن تناول مسحوق أوراق المورينجا صاحبه انخفاض معنوى في كل من وزن الجسم المكتسب ،مستوى الكوليسترول الكلي ، الجليسريدات الثلاثيـة ، كوليسترول البروتينات الدهـنية المنخفضة الكثافة ،البروتينات الدهنية المنخفضة جدا في الكثافة، مستوى جلوكوز الدم ووظائف الكبد ، وارتفاع معنوي في كوليسترول البروتينات الدهنية العالية الكثافة وذلك بالمقارنة بالمجموعة الضابطة الموجبة.كماأظهر الفحص الهستوباثولوجى التأثيرات الوقائية لمسحوق أوراق المورنجا على الكبد.هذا وقدلاقت الخضروات المضاف إليها 5% مورينجا درجة استحسان مرتفعة. وتوصي الدراسة بإدخال أوراق المورينجا ضمن أغذية مرضي الكوليسترول.

الكلمات الرئيسية: أوراق المورينجا، دهون الدم، وظائف الكبد، الفحص الهستوباثولوجي، الخواص الحسية.

The Effect of Moringa Leaves Powder on Hypercholesterolemic Male Rats and the Possibility of Adding to some Vegetable Recipes

Abstract

The aim of the current research was to examine the effect of moringa (*Moringa oleifera*) leaves on hypercholesterolemic male rats and the possibility of adding it to some vegetable recipes (peas with tomatoes, shrouded spinach, moussaka eggplant, molokheia, colocasia with greenery). Thirty five male albino rats were divided into two main groups. The first main group (7 rats) was investigated as negative control group fed on basal diet while the second main group (28 rats) were induced with cholesterol through nutrition on a diet high in content of cholesterol, then divided into four equal groups with using one of them as a positive control group, however the other three groups has received moringa leaves powder in their diet at levels of 5%, 10% and 15%, respectively for 6weeks. Results revealed that all hypercholesterolemic rat groups which fed on 5%, 10% and15% moringa leaves powder resulted in decrease in body weight gain. The results also declared that all hypercholesterolemic rat groups which treated with 5%,10% and 15% moringa leaves powder showed significant decrease in the values of serum cholesterol, TG , LDL-c VLDL-c ,blood glucose and liver functions AST, ALT whereas showed a significant increase ($p \leq 0.05$) in the values of serum HDL-c comparing with the control positive. Histopathological studies showed protective effects of moringa leaves on liver .Results also showed high acceptance for vegetable recipes at 5% moringa. The study recommended adding moringa leaves to diet of cholesterol patients.

Keywords: *Moringa oleifera*, Lipid profile, liver functions, histopathological analysis, sensory evaluation.

Introduction

In the past few years, changes in the style of diet have increased the frequency of lifestyle concerning disorders like hyperlipidemia, diabetes and atherosclerosis **(Santoshkumar *et al.*, 2013).** Metabolic disorders particularly dyslipidemia, hypercholesterolemia which are considered as important contributor in cardiovascular disease, including atherosclerosis and atherosclerosis related conditions leading to coronary heart disease and ischemic cerebrovascular disease (**Nelson, 2013).** Moring (*Moringa oleifera*) is an old plant known for different restorative properties indicated in Ayurveda. It has a space with the Moringaceae family. It is usually named as Sainjana in India and Drumstick or Horseradish tree in English **(Srivastava *et al.*,2020).**

Various parts of this plant containing its leaves, roots, seed, fruit, flowers, and unripe pods can be used as cardiac and circulatory stimulants, furthermore they have antihypertensive, cholesterol lowering, antioxidant, anti-diabetic and hepatoprotective properties, explaining the impeccable importance of this species **(Biswas *et al.*, 2012).** Phytochemical analysis of moringa leaves showed high deposition of potassium, phosphorous, calcium, zinc, iron, vitamin A and D, vitamin C and flavonoids. The results revealed that this plant is an important source of protein, amino acid, and amino acids including aspartic acid, glutamic acid, alanine, valine, leucine, isoleucine, histidine, lysine, arginine, phenylalanine, tryptophan, cysteine and methionine **(Mbikay,2012)**.

It is also an excellent source of β -carotene and different phenolics such zeatin, quercetin, β-sitosterol, caffeoylquinic acid and kaempferol and it is rich too in alpha linoleic acid **(Anwar *et al.*,2006)**. Moringa contains 46 antioxidants that help cells to neutralize free radicals. It is traditionally used to alleviate, spasticity, to treat diarrhea, diuretic and incentive in paralytic affliction, epilepsy and lysteria and treat diabetes mellitus **(Babu and Chaudhuri, 2005)**. It was also displayed to have several major anti inflamatory benefits. It has no bad effects correlating with using moringa which means it is a natural safe method for

people to control their blood glucose and other complications correlating with diabetes **(Bey, 2013)**. The leaves are eaten as vegetables in food because they are high in vitamins, antioxidants and macronutrients to improve nutritional deficiencies **(Asare *et al*.,2012)**.In addition, it is be taken fresh, cooked, or stored as a dried powder for many months without any great loss of its nutritional value **(Boonchum *et al*.,2011)**. Therefore, the current study aimed to study the effect of moringa leaves powder on hypercholesterolemic male rats and the possibility of adding it to some vegetable recipes.

Materials and Methods

Materials

1- *Moringa oleifera* leaves

Moringa (*Moringa oleifera*) leaves were purchased dry from local market of herbs in Damietta governorate, Egypt.

2-Vegetables

Spinach, molokheia ,colocasia, peas, tomato, onions were purchased from local market ,Damietta governorate ,Egypt.

3-Chemicals and Kits

Cholesterol was obtained as a pure white crystalline powder, bile salts was obtained as pure yellow powder , vitamins, minerals, cellulose, choline chloride and diagnostic kits were purchased from El-Gomhoria Company for Trading Drugs ,Chemicals and Medical Equipments, Cairo, Egypt.

4- Animals

35 male albino rats (Sprague Dawley strain) weighing 145±5g were obtained from Food Technology Research Institute, Agriculture Research Center, Giza.

Methods

Chemical analysis of moringa leaves

Proximate analysis involving moisture, protein, fat, ash and crude fiber were achieved according to the methods of **AOAC**

(2005). Carbohydrates content was calculated by difference. Antioxidant activity in moringa leaves estimated according to **Burda and Oleszek (2001)**.

Preparation of Moringa leaves powder

Moringa leaves were ground to fine powder in an electric stainless steel mill and sieved through an 80-mesh screen then the powder was stored in plastic container.

Preparing of vegetable recipes

Vegetables recipes (peas with tomatoes, shrouded spinach, moussaka eggplant, molokheia, colocasia with greenery) were prepared according to **Saba, Nargis (1995)**.

Preparation of experimental animals

All rats fed on basal diet for one week, after a period of one week, rats were divided into two main groups. The first main group (7 rats) fed only on basal diet (negative control group) (NC) according to **Reeves *et al.*, (1993)**. The second main group (28 rats) fed for two weeks on basal diet plus cholesterol (1%), bile salt (0.25%) and animal fat (Dhani fat15%) to induce hypercholesterolemia before starting the experiment .After two weeks feeding rats of the second main group was divided into 4 subgroups which were fed for 6 weeks as follows:

Group (1): Control positive group (PC), was fed on positive diet (basal diet plus cholesterol (1%), bile salt (0.25%) and animal fat (15%). (non treated rats).

Group (2): Rats fed on positive control diet +5% moringa leaves powder (MO1).

Group (3): Rats fed on positive control diet+10% moringa leaves powder (MO2).

Group (4): Rats fed on positive control diet +15% moringa leaves powder (MO3).

Table (1): Composition of different experimental diets

Ingredients	Groups				
	Control (-)	hypercholesterolemic rats			
		Control(+)	MO1	MO2	MO3
Protein(casein)	10%	10%	10%	10%	10%
Corn oil	10%	10%	10%	10%	10%
Mineral mixture	4%	4%	4%	4%	4%
Vitamin mixture	1%	1%	1%	1%	1%
Cellulose	5%	5%	5%	5%	5%
Choline chloride	0.2%	0.2%	0.2%	0.2%	0.2%
Methionine	0.3%	0.3%	0.3%	0.3%	0.3%
Cholesterol	-	1%	1%	1%	1%
Bile salts	-	0.25%	0.25%	0.25%	0.25%
Moringa powder	-	-	5%	10%	15%
Animal fat		15%	15%	15%	15%
Corn starch	69.5%	53.25	48.25	43.25	38.25

Blood sampling

At the end of the experimental period before sacrificing, rats were fasted overnight .Blood was collected and centrifuged (3000rpm), serum was separated for analysis .Serum was carefully aspirated, transferred in to clean cuvette tubes and stored frozen at -20◦C for analysis. During the experimental period, the feed intake (FI) was recorded every day and body weight was recorded every week. Body weight gain (BWG (g)) was calculated by following formula :

BWG (g) = final weight (g) - initial weight (g)

Biochemical analysis:

For each group analyses included the following:

For each group analysis included the following : total cholesterol (TC) was calculated according to **Allen (1974).** Serum triglyceride (TG) was done according to **Fossati and Prencipe (1982).** While high density lipoprotein–cholesterol (HDL-c) was measured according to **Lopez (1977)** and low density lipoprotein–cholesterol (LDL-c) calculated according to **Friedwald *et al.*,(1972)**.

LDL-c = TC-[HDL-c + (TG/5)]

VLDL-c = TG/5

GOT (AST) and GPT (ALT) were performed according to **Gella *et al.*,(1985).**Also, determination of serum alkaline phosphates (ALP) has been done according to **Belfield and Goldberg (1971).** Glucose was measured according to **Tietz (1976)**.

Histopathological analysis

Liver tissues were fixed in 100% formalin and established in paraffin wax. Sections of 4-5 microns thickness were made by rotary microtome and were stained with haematoxylin-eosin. Histological observations were done under light microscope **(Carleton, 1979)**.

Sensory properties

Sensory properties of vegetables recipes was evaluated by 12 trained panelists, according to **Sammak (2016)**.

Statistical Analysis

Statistical analysis was performed by using computer of statistical package for social science (SPSS version 11.0). The results are presented as means ±SD. One way analysis of variance (ANOVA) was used to test the differences between groups **(SPSS, 1999)**.

Results and Discussion

Chemical composition contents of moringa leaves

Chemical composition of moringa (*Moringa oleifera*) leaves powder was presented in table (2). The results were determined for moisture, crude protein, total lipids, total carbohydrate, ash , crude fiber, total antioxidant activity, the ratios were 6.92±0.02g, 26.95±0.01g, 2.85±0.05g, 37.19±0.02g, 7.98±0.03g, 18.11±0.01g, 15.97±0.01 µg, respectively.

The present results are in the same line with **Aberra (2011)** and **Dubey *et al.*, (2013)** who declared that moringa leaves powder had high content of protein, ash and fiber. Furthermore, antioxidant activity from leaves of moringa was high because of the increase in the concentration of polyphenolics **(Sreelatha and**

Padma, 2009).Moringa leaves powder contains considerable amount of polyphenolic compounds, benzoic and caffiene were the basal polyphenolic present in MO leaves powder, comparing with other polyphenolic compounds present in moderates concentrations such as Pyrogallol, Protocatechuic, Caffiene, Ferulic, Vanillic and Coumarin **Halaby and Emara, (2015)**.

Table (2):Chemical composition and total antioxidant activity of moringa leaves powder (g / 100g)

Components	value
Moisture (g)	6.92±0.02
Crude protein (g)	26.95±0.01
Total lipids (g)	2.85±0.05
Total carbohydrate (g)	37.19±0.02
Ash (g)	7.98±0.03
Crude fiber (g)	18.11±0.01
Total antioxidant activity (µg)	15.97±0.01

Values are expressed as means ± SD, means of three determinations

Effect of moringa oleifera leaves powder on body weight gain (BWG) and feed Intake (FI) of the experimental rats suffering From hypercholesterolemia

Data presented in table (3) show the mean values of feed intake (g/day for each rat) and body weight gain (g) of hypercholesterolemic groups. The mean values of feed intake increased in the positive control group **(**12.75±0.01) than that of the negative control group (10.95±0.02 g/day). Increasing levels of moringa leaves powder led to gradual increase in feed intake in hypercholesterolemic rats. Hence , there was a significant increase in body weight gain for positive control group (145.8±0.01), as compared to the negative control group (49.6±0.01g).Therefore, body weight gain of all treated hypercholesterolmic groups with moringa leaves powder at levels 5%,10%,15% led to significant increase as compared to the negative control group and significant decrease as compared to the positive control group , these results

are in agreement with **Ghebreselassie *et al*., (2011)** who reported that the rats treated with moringa leaves showed increase in their body weight compared to the negative control group.

Also, these results are in harmonization with **Ara *et al*., (2008)** who declared significant decrease in body weight gain in induced rats treated with moringa leaves comparing with positive group.

On the other hand ,**Shamsia *et al*.,(2015)** demonstrated that moringa leaves powder caused a reduction of body weight compared to saturated milk fat groups.

Table (3):Effect of moringa leaves powder on body weight gain (BWG) and food Intake (FI) of the experimental rats suffering from hypercholesterolemia

Groups	(BWG) (g)	FI/g/day
NC	49.6 ± 0.01^{e}	10.95 ± 0.02^{e}
PC	145.8 ± 0.01^{a}	12.75 ± 0.01^{d}
MO1	134.6 ± 0.01^{b}	13.35 ± 0.02^{c}
MO2	125.4 ± 0.03^{c}	13.9 ± 0.02^{b}
MO3	117.9 ± 0.01^{d}	14.85 ± 0.03^{a}

NC: negative control group, PC: positive control group, MO1 (5% Moringa), MO2 (10%, Moringa), MO3 (15% Moringa).
Means with different letters in the same column are statistically significant at ($P\leq0.05$)

Effect of moringa oleifera leaves powder on serum lipid profile of the experimental rats suffering from hypercholesterolemia

Results in table (4) demonstrate that, rats in the positive control group have higher cholesterol ,triglycerides (TG), low density lipoprotein–cholesterol (LDL-c) and very low density lipoproteins (VLDL-c)levels, whereas have lower HDL level as compared to rats in the negative control group. The results also declared significant decrease ($p\leq0.05$) in cholesterol ,low density lipoprotein–cholesterol (LDL-c) ,triglycerides(TG) and very low density lipoproteins (VLDL-c) between positive control group (PC) and hypercholesterolemic rat groups which fed on positive diet supplemented with different levels of moringa leaves powder (at levels 5%,10%,15%) (MO1,MO2,MO3).Therefore, these

results showed significant increase ($p \leq 0.05$)in high density lipoprotein cholesterol (HDL-c) of MO1,MO2,MO3 compared to control ($_{+}$) group.

In this concern, moringa leaves appears to contain a package of natural antioxidant compounds like vitamin E, C, carotenoids and polyphenols, which deserves further evaluation as potential antioxidant agents. Consumption of feeds containing a variety of compounds with antioxidant activities has greater nutritional importance in managing hyperlipidemia.

The decrease in the total cholesterol level, triglyceride, LDL and an increase in HDL cholesterol levels indicate that moringa leaves has a profound hypolipidemic activity because of their ability to control the mechanisms involved in lipids elimination from the body **(Lewis and Rader , 2005 and Pratik *et al*., 2013)**.

Hence, moringa leaves powder flavonoids play a remarkable role in HDL metabolism. Recently, **Bienvenu *et al*. , (2016)** reported that moringa leaves can increase HDL concentration.

Therefore, **El-Gindy *et al*., (2017)** indicated that supplementation of moringa leaves significantly stimulated and increased HDL cholesterol of rabbits under moderate heat stress.

Flavonoids and saponins present in moringa led to increase high density lipoprotein cholesterol (HDL-C) and reduce low density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein (VLDL) cholesterol in hypercholesterolemic rats. Flavonoids and saponins reduce cholesterol absorption by inhibiting the solubility of cholesterol micellar **(Mehta *et al*., 2003 and Santoscoy *et al*., 2013)**.

In this concern, data of table (3) confirmed by **Pratik *et al*., (2013)** and **Nikkon *et al*., (2003)** who demonstrated that moringa leaves has a profound hypolipidemic activity which is attributed to its ability to control the mechanisms involved in eliminating from the body.

These results also are in the same line with **Toma *et al.*, (2014)** who found the moringa decreases lipid absorption by inhibiting pancreatic cholesterol esterase, pancreatic lipase, cholesterol micellization and bile binding capacity in vitro.

Table (4): Effect of moringa leaves powder on serum lipid profile of the experimental rat groups

Groups	TC (mg/dI)	TG (mg/dI)	HDL-c (mg/dI)	LDL-c (mg/dI)	VLDL-c (mg/dI)
C-	88.50±0.04^{e}	75.20±0.03^{e}	61.20±0.01^{a}	12.26±0.01^{e}	15.04± 0.01^{e}
C+	212.80±0.02^{a}	128.50±0.01^{a}	28.40±0.02^{e}	158.70±0.04^{a}	25.70± 0.02^{a}
M01	189.20±0.06^{b}	111.00±0.01^{b}	41.60±0.01^{d}	125.40±0.03^{b}	22.20±0.02^{b}
M02	160.50±0.03^{c}	104.60±0.02^{c}	53.20±0.04^{c}	86.38±0.01^{c}	20.92±0.01^{c}
M03	148.00±0.08^{d}	98.60±0.02^{d}	58.00±0.01^{b}	70.28±0.02^{d}	19.72±0.01^{d}

NC: negative control group, PC: positive control group, MO1 (5% Moringa), MO2 (10%, Moringa), MO3 (15% Moringa).
Means with different letters in the same column are statistically significant at (P≤0.05)

Effect of moringa oleifera leaves powder on blood glucose (mg/dl) of the experimental rats suffering from hypercholesterolemia

Data in table (5) demonstrated significant decrease (p≤0.05) in serum blood glucose between positive control group (PC) (133.60 ± 0.17 mg/dl) and groups MO1, MO2 , MO3(121.40± 0.03, 103.80 ± 0.18, 89.00 ± 0.20 mg/dl , respectively), where as there were significant differences between groups MO1, MO2 , MO3 in serum glucose concentration. The best result was at MO3 group (hypercholesterolemic rats treated with 15% moringa leaves powder).

In this respect ,these results are in agreement with **Luangpiom *et al.*, (2013)** who reported that moringa leaves contain many powerful antioxidant phytochemicals, like quercetin and kaempferol. Kaempfero proven to have hypoglycemia .In this concern, moringa hypoglycemic activity has been reported to be because of the presence of α-glucosidase and pancreatic amylase enzyme inhibitors (**Abdul karim *et al.*, 2005)**.

Moreover, **Jaiswal *et al*., (2009)** reported that moringa leaves improved glucose level in diabetic rats. It was expected to have some direct effect by increasing tissue glucose utilization by inhibiting hepatic glucose formation or glucose absorption in muscle and adipose tissue.

Table (5): Effect of moringa leaves powder on blood glucose of the experimental rats suffering from hypercholesterolemia

Groups	Glucose (mg/dl)
NC	76.50 ± 0.33^{e}
PC	133.60 ± 0.17^{a}
MO1	121.40 ± 0.03^{b}
MO2	103.80 ± 0.18^{c}
MO3	89.00 ± 0.20^{d}

NC:negative control group, PC: positive control group, MO1 (5% Moringa), MO2 (10%, Moringa), MO3 (15% Moringa).
Means with different letters in the same column are statistically significant at ($P\leq0.05$)

Effect of moringa oleifera leaves powder on liver functions of the experimental rat Suffering from hypercholesterolemia

Results in table (6) demonstrate the effect of different levels of *Moringa oleifera* leaves powder on liver enzymes AST, ALT and ALP in hypercholesterolemic rats .Results revealed that rats in the positive control group showed high level of liver enzymes (74.50 ±0.11, 51.90 ±0.03, 126.81±0.06 U/L, respectively) for AST, ALT and ALP compared to rats in the negative control group (37.96 ±0.01, 27.2 ±0.01, 46.90±0.03 U/L, respectively).

These results declared that all rat groups ingested moringa leaves in the diet declared significant decrease ($p\leq0.05$) in the values of liver enzymes (AST and ALT) comparing with the control positive group.

These results also indicated that there are significant differences between all rat groups ingested moringa leaves powder in the diets MO1, MO2 , MO3 considering liver enzymes AST and ALT .The best results of liver enzymes was at the ratio 15 % moringa leaves powder. Concerning ALP enzyme results declared that there was no significant differences between all rat

groups ingested moringa leaves powder in the diet MO1, MO2 , MO3 in liver enzyme ALP.

These results are in harmonization with **Akinlolu *et al*.,(2014)** who reported that administrations of doses of moringa leaves reduced levels of alanine and aspartate transaminases . Also, It was found that administration mringa doses in the high fat diet treated group successfully reduced these enzymes. It may be attributed to the phytochemical content in moringa leaves and its antioxidant potentials (**Mabrouki *et al*., 2020)**.

On the other hand, alkaline phosphatase is found in all tissues throughout the body, but is specially concentrated in the liver, bile duct, kidney, bone and the placenta. So it is not a specific marker of the liver function(**Ekundina *et al*., 2015)**

In addition , **Terzungwe et al., (2013)** observed no effects of moringa on alkaline phosphatase effect on the health status of the rabbits. Therefore, the effect of ethanol leaves extract of moringa on alkaline phosphatase activity in rats showed no significant effect due to moringa addition. Also, alkaline phosphatase (ALP) is considered an indication that the treatments have no untoward effect on the rats.

Table (6): Effect of moringa leaves powder on liver functions of the experimental rats suffering from hypercholesterolemia

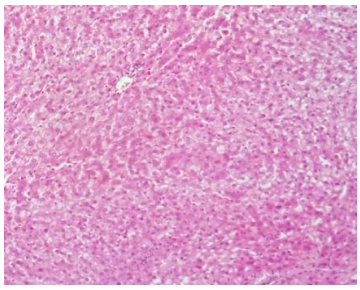
Groups	AST (U/L)	ALT(U/L)	ALP(U/L)
NC	37.96 ±0.01^{e}	27.2 ±0.01^{e}	46.90±0.03^{b}
PC	74.50 ±0.11^{a}	51.90 ±0.03^{a}	126.81±0.06^{a}
MO1	65.58±0.02^{b}	45.24 ±0.02^{b}	126.79 ±0.02^{a}
MO2	52.75±0.03^{c}	39.54±0.03^{c}	126.78±0.03^{a}
MO3	45.25±0.02^{d}	30.80 ±0.02^{d}	126.77± 0.01^{a}

NC: negative control group, PC: positive control group, MO1 (5% Moringa), MO2 (10%, Moringa), MO3 (15% Moringa).

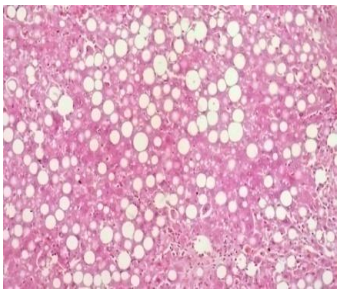
Means with different letters in the same column are statistically significant at (P≤0.05)

Histopathological results

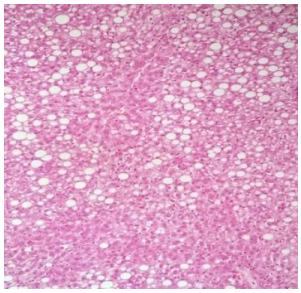
Histopathological checking of liver section of normal rats showed in (Photo A), While (Photo B) positive control group reported severe macrovesicular steatosis > 70%. In this respect, (Photos C, D, E) showing hypercholesterolemic groups treated with 5%,10%,15% moringa leaves indicated gradual improvement of microvesicular steatosis.



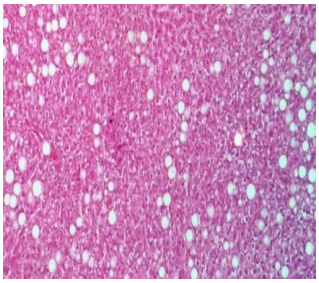
A: Normal liver tissue
(H&E staining – x100)



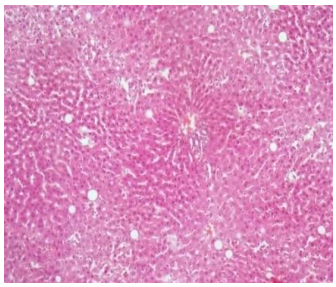
B:Positive control group showed severe macrovesicular steatosis > 70%.
(H&E staining – x100)



C: Rats fed on control positive diet + 5% *Moringa oleifera* leaves powder
declared mild improvement of steatosis with affection of 60 % of hepatocytes
(H&E staining – x100)



E: Rats fed on control positive diet + 10% *Moringa oleifera* leaves powder
declared moderate improvement of steatosis with affection of 35 % of hepatocytes
(H&E staining – x100)



D: Rats fed on control positive diet + 15% *Moringa oleifera* leaves powder
declared marked improvement of steatosis with affection of 15 % of hepatocytes
(H&E staining – x100)

Effect of adding moringa oleifera leaves powder on sensory evaluation of vegetables recipes

Data in tables (7-11) demonstrated the effect of adding moringa leaves powder with different levels 5%, 10% and 15% on the sensory properties of the prepared vegetables recipes (peas with tomatoes, shrouded spinach, moussaka eggplant, molokheia ,colocasia with greenery respectively). Results showed the mean values for color, aroma, taste, texture and overall acceptability and total evaluation for the samples. It could be noticed that with the increasing ratio of moringa leaves powder scores for color, aroma, taste, texture and overall acceptability decreased. On the other hand, results showed high acceptance for vegetable recipes supplemented with 5% moringa leaves powder for all terms of sensory evaluations and the total scores were 91.75±3.49, 93.50±0.52, 83.25±2.59, 93.25±3.04 and 77.31±2.14 for (peas with tomatoes, shrouded spinach, moussaka eggplant, molokheia , colocasia with greenery respectively).

In addition to that, moringa leaves only or in combination with spinach, melon etc. can be used as ingredient in recipes and some researchers reported that up to 30% moringa leaves can be used in traditional dishes with adding some spices (**Babayeju *et al*., 2014).** Moreover, various researches have concluded that moringa should be used as functional ingredient in food products (**Sahay *et al*., 2017)**.

In this respect adding moringa leaves powder at level 10% gave acceptable results in shrouded spinach , molokheia and the total scores were (80.33±1.77 and 85.83±3.13) while all vegetable recipes supplemented with 15% moringa leaves powder showed lower results for color, aroma, taste, texture and overall acceptability and the total scores were 44.00±0.73, 62.75±1.35, 47.25±1.28, 65.00±1.65 and 23.50±2.61 for (peas with tomatoes, shrouded spinach, moussaka eggplant, molokheia , colocasia with greenery respectively).In this concern (**Arise *et al*., 2014)**

declared that adding moringa leaves powder cause minimal changes in colour of fortified products. Also, (**Sengev *et al*., 2013)** demonstrated that increasing levels of moringa leaves powder reduced the acceptability of products.

Table (7): Effect of adding moringa leaves powder on peas with tomato

Properties / Treatments	Color (20 scores)	Aroma (20 scores)	Taste (20 scores)	Texture (20 scores)	Overall Acceptability (20 scores)	Total (100 scores)
Control	20.00±0.00^{a}	20.00±0.00^{a}	19.66±0.49^{a}	20.00±0.00^{a}	20.00±0.00^{a}	99.66±0.49^{a}
Moringa5%	18.25±0.86^{b}	18.25±0.86^{b}	18.25±1.54^{b}	18.00±1.27^{b}	19.00±0.73^{b}	91.75±3.49^{b}
Moringa10%	14.00±2.44^{c}	15.75±0.86^{c}	11.50±1.73^{c}	13.25±0.86^{c}	11.25±1.35^{c}	65.75±3.72^{c}
Moringa15%	9.25±0.86^{d}	9.75±0.86^{d}	8.75±1.35^{d}	9.00±0.73^{d}	7.25±0.86^{d}	44.00±0.73^{d}

Values are expressed as mean ± SD. Means with different letters in the same column are statistically significant at (P≤0.05)

Table (8): Effect of adding moringa leaves powder on shrouded Spinach

Properties / Treatments	Color (20 scores)	Aroma (20 scores)	Taste (20 scores)	Texture (20 scores)	Overall Acceptability (20 scores)	Total (100 scores)
Control	20.00±0.00^{a}	20.00±0.00^{a}	20.00±0.00^{a}	20.00±0.00^{a}	20.00±0.00^{a}	100.00±0.00^{a}
Moringa5%	19.50±0.52^{a}	19.50±0.52^{a}	17.50±0.52^{b}	19.50±0.52^{a}	17.50±0.52^{b}	93.50±0.52^{b}
Moringa10%	16.66±1.30^{b}	16.00±0.85^{b}	15.00±0.85^{c}	17.33±0.49^{b}	15.33±0.49^{c}	80.33±1.77^{c}
Moringa15%	13.75±0.86^{c}	12.75±0.86^{c}	10.50±1.16^{d}	14.00±0.73^{c}	11.75±0.45^{d}	62.75±1.35^{d}

Values are expressed as mean ± SD. Means with different letters in the same column are statistically significant at (P≤0.05)

Table (9) Effect of adding moringa leaves powder on moussaka eggplant

Properties / Treatments	Color (20 scores)	Aroma (20 scores)	Taste (20 scores)	Texture (20 scores)	Overall Acceptability (20 scores)	Total (100 scores)
Control	19.75±0.45 ^{a}	19.83± 0.38^{a}	19.83±0.38^{a}	19.91±0.28^{a}	20.00±0.00^{a}	99.33±1.15^{a}
Moringa5%	12.75±1.71^{b}	18.33±0.49^{b}	18.58±0.51^{b}	18.83±0.38^{b}	14.75±0.45^{b}	83.25±2.59^{b}
Moringa10%	9.83±0.38^{c}	16.50±1.56^{c}	14.75±1.86^{c}	14.50±0.79^{c}	11.25±1.35^{c}	66.83±5.06^{c}
Moringa15%	6.50±0.52^{d}	12.25±0.45^{d}	9.91±0.79^{d}	11.08±1.24^{d}	7.50±1.16^{d}	47.25±1.28^{d}

Values are expressed as mean ± SD. Means with different letters in the same column are statistically significant at (P≤0.05)

Table (10): Effect of adding moringa leaves powder on molokheia

Properties / Treatments	Color (20 scores)	Aroma (20 scores)	Taste (20 scores)	Texture (20 scores)	Overall Acceptability (20 scores)	Total (100 scores)
Control	20.00±0.00^{a}	20.00±0.00^{a}	20.00±0.00^{a}	20.00±0.00^{a}	20.00±0.00^{a}	100±0.00^{a}
Moringa5%	18.75±0.86^{b}	20.00±0.00^{a}	17.75±0.86^{b}	20.00±0.00^{a}	16.75±1.86^{b}	93.25±3.04^{b}
Moringa10%	17.83±1.33^{c}	17.00±1.04^{b}	16.50±0.52^{c}	19.00±0.00^{b}	15.50±0.52^{c}	85.83±3.13^{c}
Moringa15%	16.25±0.45^{d}	14.25±0.45^{c}	9.50±0.52^{d}	15.50±0.52^{c}	9.50±0.52^{d}	65.00±1.65^{d}

Values are expressed as mean ± SD. Means with different letters in the same column are statistically significant at (P≤0.05)

Table (11): Effect of adding moringa leaves powder on colocasia with greenery

Properties / Treatments	Color (20 scores)	Aroma (20 scores)	Taste (20 scores)	Texture (20 scores)	Overall Acceptability (20 scores)	Total (100 scores)
Control	19.75±0.45^{a}	20.00±0.00^{a}	19.83±0.38^{a}	20.00±0.00^{a}	20.00±0.00^{a}	99.58±0.51^{a}
Moringa5%	16.33±1.30^{b}	16.33±1.30^{b}	12.66±1.77^{b}	16.66±1.30^{b}	15.33±1.30^{b}	77.31±2.14^{b}
Moringa10%	9.25±0.86^{c}	9.75±0.45^{c}	8.50±0.52^{c}	10.25±0.45^{c}	8.50±0.52^{c}	46.25±1.13^{c}
Moringa15%	4.25±0.86^{d}	5.75±0.86^{d}	4.00±0.73^{d}	5.50±0.52^{d}	4.00±0.73^{d}	23.50±2.61^{d}

Values are expressed as mean ± SD. Means with different letters in the same column are statistically significant at (P≤0.05)

Conclusion

The results of the current research declared that moringa leaves possesses anti hypercholesterolemic effect. It also exercises hepatoprotection because of phytochemicals present in the leaves. moringa leaves can be add to vegetables recipes at level 5% because of its high nutritional value and increasing levels of moringa leaves powder reduced the acceptability of products.

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