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Comparative Study of White, Brown and Black RiceEffects on Hypercholesterolemic Rat

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Abstract:

This study was carried out to compare white,brown,blackrice, their mixture and biscuits effects on hypercholesterolemic rats.Thirty-fivemale mature albino rats weighing 150-160g per each, were used in this study and divided into 7 equal groups, the first group was kept as a control -ve group, while the other groups were fed on hypercholes -terolemic diet for 3 weeks to induce hypercholesterolemia.The tested plant powdertheir mixtureand biscuitwere given to the rats as a percent of 5 % from the Basel diet for 28 days. At the end of the experiment, serumtotal cholesterol(TC), Triglycerides(TG), High density lipoprotein (HDL-c), GOT, GPT, ALP, urea, creatinine, uric acid were determined. Also,low density lipoprotein(LDL-c), verylow-density lipoprotein (VLDL-c), and (A.I) were calculated .Also, heart was exemminedHis -topathologicaly.The results indicated that tested plants significantly ($P \leq 0.05$) decreased serum TC, TG, LDL, VLDL and increased HDL and A.I.Moreover, the tested seeds improved liver and kidney functionsand prevent some of the adverse histopathological changes in liver. The obtained findingshypothesized that tested plant parts containing several compounds which are able to improve the adverse effects and inhibited hypercholesterolemia.So,the data recommended to takewhite,brown, blackrice by a moderate amount in our diets.

Keywords:T.C, T.G,HDL-c, LDL-c, liver and kidney functions, hypercholesterolemic rats, histopathological examination.

Introduction

Hyperlipidemia is a medical condition characterized by excess of fatty substances such as lipids, cholesterol and triglycerides in the blood.Fatty substances travel in the blood attached to proteins to remain dissolved while in circulation, so hyperlipidemia may be called hyperlipoproteinemia **(Haddad*et al.*, 2013).**The leading cause of morbidity andmortality in many countriesin the world is still cardiovascular disease (CVD), in spite ofremarkable improvements in its prevention, diagnosis and therapy. Hypercholesterolemia is caused by increased concentrations of low-density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein cholesterol (VLDL-C). The increase in VLDL caused the increase in triglycerides (TGs). High TG and greater LDL-C are predictors to increase CVD risk. High-density lipoprotein cholesterol (HDL-C) concentrations provide the opposite relationship,with increasedblood concentrations of HDL-C predicting reduced risk. To lower serum LDL-C levels by making dietary changes is the well-established way to reduce the risk of developing CVD. In addition to reduce saturated fat and cholesterol intake, and increasing cis-unsaturated fat intake, the importance of other dietary approaches, such as increasing the intake of water-soluble dietary fibers has become increasingly recognized **(Tanay *et al*., 2012).**Black rice contains many vitamins and minerals, including iron, vitamin A and vitamin B, which are beneficial for overall health and the prevention of heart disease. These marked health benefits have been attributed to the antioxidant properties of anthocyanin. Anthocyanins are linked with better heart health, cancer prevention, relieving inflammation, and increasing memory. This makes it a stellar addition to the diet in place of other rice **(Kushwaha,2016).** Anthocyanins are naturally occurring plant pigments that belong to the flavonoid family and are widely used for their antioxidant and pharmacological properties. Reactive free radicals have been postulated to contribute the development of chronic inflammatory proliferative diseases (CIPDs), particularly arteriosclerosis and cancer by causing oxidative damage to essential enzymes, cells and tissues. The anthocyanins in rice act as antioxidants, which can inhibit inflammation throughout the body, act as anticancer agents, promote blood circulation, slow damage and aging of tissues, reduce cholesterol and blood sugar levels affect pituitary gland function, inhibit gastric acid secretion and inhibit platelet aggregation **(Wipada and Kanlaya, 2015)**

Materials and methods

Plant materials: White, brown and black rice are obtained from the Ministry of Agriculture (black rice in Horticulture Research station, Sakha, Garbia governorate.

Rats and diets: Male albino rats weighing 150-160g per each were purchased from Medical Insects Research Institute, Cairo, Egypt. Cholesterol and **other Chemicals**basal diet constituents were obtained from El-Gomhoria Company for trading Drug Chemicals and Medicals, Cairo, Egypt.

Basal diet: The basal diet was prepared according to the following : protein (10%), corn oil (10%), vitamin mixture (1%), mineral mixture (4%), choline chloride(0.2%), methionine (0.3%), cellulose (5%), and the remained is corn starch (69.5%) according to **Campbell,(1963)**. The vitamin mixture component was recommended by **Hegested*et al.*, (1941)**, while the salt mixture was formulated according to**Drury and Wallington,(1980).** Cholesterol containing diet was prepared by adding 1.5% cholesterol to the basal diet according to **Hegsted *et al.*, (1941)**

Experimental Design:

Thirty five male albino rats were housed in healthy condition (21-23ºC) and fed on basal diet for one week before starting the experiment for acclimatization .After this, rats were divided into two main groups, the first group (5 rats) fed on basal diet as a negative control (ve-) and the other main group (30 rats) was fed on 1.5% cholesterol for 3 weeks to induce hypercholesterolemia, then classified into six sub groups as follow:

Sub group (2):Control positive group(+ve), hypercholesterolemic rats fed on basal diet.

Sub group (3): Hypercholesterolemic rats fed on basal diet+5%white rice powder.

Sub group (4): Hypercholesterolemic rats fed on basal diet+5%brown rice powder.

Sub group (5):Hypercholesterolemic rats fed on basal diet+5% Black rice powder.

Sub group (6):Hypercholesterolemic rats fed on basal diet 5% mixture of white, brown and black rice powder.
Sub group (7): Hypercholesterolemic rats fed on biscuits made from the three kinds of rice powder 5%.
At the end of the experimental (4 weeks), rats were fasted for 12-h then scarificed. Blood samples were collected from the portal vein into dry clean centrifuge tubes for serum separation, blood samples centrifuged for 10 minutes at 3000 rpm to separate the serum according to **Drury and Wallington, (1980).**Liver of sacrificed rats were kept in 10% formalin solution till processed for histopathological examination.

Serum lipid profile assay

Cholesterol, TG, H.D.L-c, L.D.L-c and V.L.D.L-c were determined according to **Allain *et al*., (1974)**, **Fassati and Prencipe, (1982)**, **Lopez, (1977)**and **Lee and Nieman, (1996),**respectively**.**Low density lipoprotein cholesterol and very low-density lipoprotein cholesterol were calculated according to the following equation:
LDL-Cholesterol = Total cholesterol-(HDL-c + TG/5)
VLDL-c = TG/5**.**
Atherogenic index (AI) was calculated as (LDL+VLDL/HDL) according to**(Kikuchi *et al.*, 1998).**

Liver functions assay:

Glotamic oxalic transaminase (GOT), Glotamic pyrofic transaminase (GPT) and alkaline phosphatase (ALP) were determined according to the methods described by **Bergmeyer and Harder, (1986),Kachmar and Moss, (1976)and Varley *et al*., (1980),**respectively.

Kidney functions assay

Urea, Creatininee and uric acid were determined according to the methods of**Patton and Crouch (1977), Henry (1974),** and**Schultz, (1984**),respectively.

Histopathological Examination:

Small specimens from liver was collected from all experimental groups, fixed in 10% neutral buffered formalin, dehydrated in ascending concentration of ethanol (70, 80, and 90%), cleared in xylene and embedded in paraffin. Sections of (4 - 6) μm thickness were prepared and stained with Hematoxylin and Eosin according to **Bancroft *et al.*,(1996).**

Statistical Analysis:

Data were expressed as mean ± standard deviation. In order to compare the groups. analysis of variance (ANOVA) test was used. Values at ($P \leq 0.05$) were considered to be statistically significant according to **SAS, (2006).**

Results and Discussion

Effectof white, brown, black rice, their mixture and biscuitson serum total cholesterol and triglycerides (mg\dl) of hypercholesterolemic rats

Serum TC and TG in normal and hypercholesterolemic rats fed on diets with or withoutwhite, brown, black rice,their mixtureand biscuitswere recorded in table (1).Rats fed on high cholesterol diet (control +ve) had a significant increase in serum concentration of T.C and T.G which recorded 195± 2 and 180 ± 2mg/dl, respectively compared to control (–ve) group which recorded 131± 1and 90 ± 1mg/dl, respectively. Rats fed on high cholesterol diets with white, brown, black riceand their mixture hadsignificant decreases in serum concentration of TC and TG. as compared to the positive control group. The best serum TCand TGresults were recorded for groups (5 and 6) (mixture 5%) and (biscuits 5%) .These results in the same line carried out by**Wang *et al.*, (2006)**,**Soheir *et al.*, (2016) and Thanuja and Parimalavalli, (2018),**they indicated thatanimals (Wistar male rats) fed with black rice showed lower levels of T.C.Also,data agree with**Jocelem *et al.*,(2010)**and**Soheir *et al.*,(2016)**as they found that black rice feeding of hypercholesteraemic rats reduced the TG.

Table (1). Serum total cholesterol and triglycerides (mg\dl) of hypercholesterolemic rats fed on white,brown,black rice and their mixture

Groups / Variobles	TC(mg/dl)	% change of positive control	LSD ($p\leq0.05$)	TG(mg/dl)	% change of positive control	LSD ($p\leq0.05$)
Control (-)	$131^{d} \pm 1$	-32.82	1.787	$90^{d} \pm 1$	-50	0.965
Control (+)	$195^{a} \pm 2$	-		$180^{a} \pm 2$	-	
White Rice 5%	$186.02^{b} \pm 0.505$	-4.61		$120^{b} \pm 0.5$	-33.33	
Brown Rice 5%	$153^{c} \pm 1.305$	-21.53		$110^{c} \pm 0.4$	-38.89	
Black Rice 5%	$120^{e} \pm 1$	-38.46		$70^{f} \pm 1$	-61.11	
Mixture 5%	$110^{g} \pm 0.5$	-43.89		$58^{g} \pm 0.6$	-67.77	
Biscuits 5%	$114.889^{f} \pm 0.994$	-41.08		$80^{e} \pm 0.7$	-55.56	

Values denote arithmetic means & standard deviation of the mean. Means with different letter(a,b,c,d.etc,) in the same column differ significantly at ($p\leq0.05$) ,using ANOVA test, while those with similar letter are non-significantly different

Effect of white, brown, black , their mixture and biscuiltson serum HDL-c, LDL-c, and VLDL-c (mg\dl) of hypercholesterolemic rats

Data in table (2) indicate that rats fed on high-cholesterol diet had observed reduction in serum level of HDL-c (18 ± 0.5 mg/dl) when compared withrats fed on basal diet (40 ± 1 mg/dl).Rats fed on white, brown, black rice and their mixtureshowedhigher values in serum level of HDL-c as compared to the positive control group.With regard to serum levels of VLDL-c and LDL-c, results revealed that positive control group had observed increases in serum LDL-c and VLDL-c (141 ± 0.5 and 36.01 ± 0.395mg/dl), respectively comparing with negative control group (73 ± 0.4and 18 ± 0.21mg/dl). Rats fed on high cholesterol diets with white, brown, black riceand their mixture had significant decreases in serum concentration of VLDL-c and LDL-c as compared to the positive control group. The best serum HDL, LDL, and VLDL were recorded for group 6 (mixture 5%).**Murata *et al.*, (2007)**used experimental diets with rice for Japanese people 20% black rice from the diet and found a significant decline in levels of blood cholesterol.However**, Lee *et al.*, (2007)** observed an increase in HDL-C levels in rats that received germinated black rice. This trend was also found by **Jocelem *et al.*,(2010)** and**Soheir *et al* ,(2016)**they found that the serum HDL-C levels were significantly increased when rats received 20% black rice from the diet anddecreased serum LDL-c levels .The reduction of the VLDL levels was also observed by **Nan *et al.*, (2008)** they found that rats feed a diet rich in black rice bran oil showed a significant decrease in cholesterol and VLDL-C concentrations.Also, in the same line of **Lobo *et al.*, (2010)**they reported thatblack rice helps to increase high-density lipoprotein (HDL) cholesterol. In present work, however the mixture diet was the best (tables (1&2).This indicated a synergistic action different types of rice considering serum lipids fractions

Table (2). Serum HDL-c, LDL-c and VLDL-c (mg\dl) of hypercholesterolemic ratsfed on white, brown, black and mixture rice

Groups / Variables	HDL-c (mg/dl)	%change of positive control	LSD (p≤0.05)	LDL-c (mg/dl)	%change of positive control	LSD (p≤0.05)	VLDL (mg/dl)	%change of positive control	LSD (p≤0.05)
Control (-)	$40^d \pm 1$	122	0.904	$73^d \pm 0.4$	-48.22	0.257	18d ± 0.21	-50.01	**0.194**
Control (+)	$18^g \pm 0.5$	-		$141^a \pm 0.5$	-		36.01a ± 0.395	-	
White Rice 5%	$29^f \pm 0.3$	61.11		$133^b \pm 0.3$	-5.67		24b ± 0.3	-33.35	
Brown Rice 5%	$38^e \pm 1$	111.11		$93^c \pm 0.5$	-34.04		22c ± 0.2	-38.90	
Black Rice 5%	$43^c \pm 0.3$	138.88		$62.97^e \pm 0.276$	-55.34		14f ± 0.295	-61.12	
Mixture 5%	$46^a \pm 0.51$	155.55		$52^f \pm 0.4$	-63.12		12g ± 0.5	-66.69	
Biscuits 5%	$44^b \pm 0.31$	144.44		$55^g \pm 0.7$	-60.99		16e ± 0.4	-55.56	

Values denote arithmetic means I standard deviation of the mean. Means with different letter(a,b,c,d.etc,) in the same column differ significantly at (p≤0.05) ,using ANOVA test, while those with similar letter are non-significantly different

Effect of white, brown, black and mixture riceon atherogeric index (AI) (mg\dl) of hypercholesterolemic rats

Data in table (3) revealed that rats fed on high-cholesterol diet hadhigher value of atherogeric index (9.823± 0.099) when compared with negative control group (2.28 ± 0.02). Groups treated withwhite, brown, black rice and their mixtureshowed lower values in AI index as compared to positive control group. The best AI (LDL+VLDL/HDL) index was recorded for group 6 (mixture 5%).

Table (3). Atherogeric Index (mg\dl) of hypercholesterolemic rats fed on white, brown, black, mixture rice and biscuits

Groups / Variobles	A.I	%change of positive control	LSD (p≤0.05)
Control (-)	$2.28^{d} \pm 0.02$	-77.60	
Control (+)	$9.823^{a} \pm 0.099$	-	
White Rice 5%	$5.41^{b} \pm 0.02$	-44.93	0.0658
Brown Rice 5%	$3.031^{c} \pm 0.013$	-69.14	
Black Rice 5%	$1.79^{d} \pm 0.01$	-81.78	
Mixture 5%	$1.39^{g} \pm 0.03$	-85.85	
Biscuits 5%	$1.61^{f} \pm 0.01$	-83.61	

Values denote arithmetic means I standard deviation of the mean. Means with different letter(a,b,c,d.etc,) in the same column differ significantly at (p≤0.05) ,using ANOVA test, while those with similar letter are non-significantly different

Effect of white, brown, black and mixture riceon serum GOT, GPT, and ALP (u\l) of hypercholesterolemic rats

Data in table (4) showed that control negative group was significantly lower in serum level of GOT which was 139.04 ± 0.941u/lwhen compared with control positive group266.92 ± 1.891 u/l. Rats treated withwhite, brown, black rice and their mixtureshowedlower values in serum level of GOT as compared to the positive control group. With regard to serum levels of GPT and ALP, results revealed that positive control group had observed an increase in serum GPT and ALP which were193.893 ± 1.613 and 321.89 ± 0.5u/l, respectively comparing with negative control group (97.079 ± 1.666 and 309 ± 0.401u/l). Groups which treated with white, brown, black rice and their mixturedecreased serum levels of GPT and ALP as compared to positivegroup. The best serum GOT, GPT, and ALP were recorded for groups5 and 6 (5% black rice) and (5% mixture).This trend was also fonudby **Soheir *et al.*, (2016),** they found that feeding mice on black rice decreased sernm AST or GOT levels.Similarly, **Jang *et al.*, (2015),** found that feeding rats on black rice decreased levels of serum asparate amine transaminase (AST) or (GOT) and decreased levels of serum alanine transaminase (ALT)or (GPT).The data of above mention tables are in agreement with that obtained by **Jang *et al.*, (2012),** they indicated that the rats fed on black rice decreased levels of serum alkaline phosphatase (ALP) enzyme. For serum(GOT) , (GPT) synergistic action was not found .Never theless biscuits with rice were useful for the rats health, based of liver enzymes levels.

Table (4). Serum GOT, GPT, and ALP (U/L) of hypercholesterolemic rats fed on white, brown, black, mixture rice and biscuits

Groups / Variables	GOT	%change of positive control	LSD (p≤0.05)	GPT	%change of positive control	LSD (p≤0.05)	ALP	%change of positive control	LSD (p≤0.05)
Control (-)	139.04^{f} ± 0.941	-47.91		97.079^{g} ± 1.666	-49.93		309^{g} ± 0.401	-4.0	
Control (+)	266.92^{a} ± 1.891	-		193.893^{a} ± 1.613	-		321.89^{a} ± 0.5	-	
White Rice 5%	249.99^{b} ± 1.55	-6.43	**2.471**	169^{b} ± 1.44	-12.84	**2.785**	320.76^{a} ± 0.463	-0.35	**1.435**
Brown Rice 5%	211.24^{d} ± 1.154	-20.86		162^{c} ± 1.89	-16.45		318^{b} ± 1	-1.21	
Black Rice 5%	169.29^{e} ± 1.4	-36.57		121.616^{f} ± 0.907	-37.28		268.176^{e} ± 0.957	-16.69	
Mixture 5%	194.246^{d} ± 1.05	-27.22		127.233^{e} ± 0.775	-34.48		268.17^{d} ± 0.957	-16.68	
Biscuits 5%	196.63^{d} ± 0.709	-26.33		146.583^{d} ± 1.507	-24.40		286.04^{d} ± 0.94	-11.13	

Values denote arithmetic means I standard deviation of the mean. Means with different letter(a,b,c,d.etc,) in the same column differ significantly at (p≤0.05) ,using ANOVAtest, while those with similar letter are non-significantly different

Effect of white, brown, black, mixture rice and biscuits on serum urea, creatinine, and uric acid (mg\dl) of hypercholesterolemic rats

Data in table (5) indicated that control negative group was significantly lower in serum levels of urea, creatinine, and uric acidwhich were 30 ± 1, 0.64 ± 0.09, and 1.91 ± .085 mg/dl, respectively when compared with control positive group which were 58 ± 0.8, 1.24 ± 0.02, and 3.71 ± 0.1 mg/dl, respectively. Rats treated with white, brown, black rice, their mixtureandbiscuitsshowed significantly lower values in serum levels of urea, creatinine, and uric acid compared to the positive control group. The best serum urea, creatinine, and uric acid were recorded for group 5 (black rice 5%) considering when uric acid, while the best group was the 6 group for creatinine. Similarly trends were given by **Missoun*et al.*, (2010)** they found also that the black rice reduced levels of serum urea.This trend was also found by **Soheir *et al.*, (2016)** they found that the black rice reduced levels of serum urea,creatinine, and uric acid.

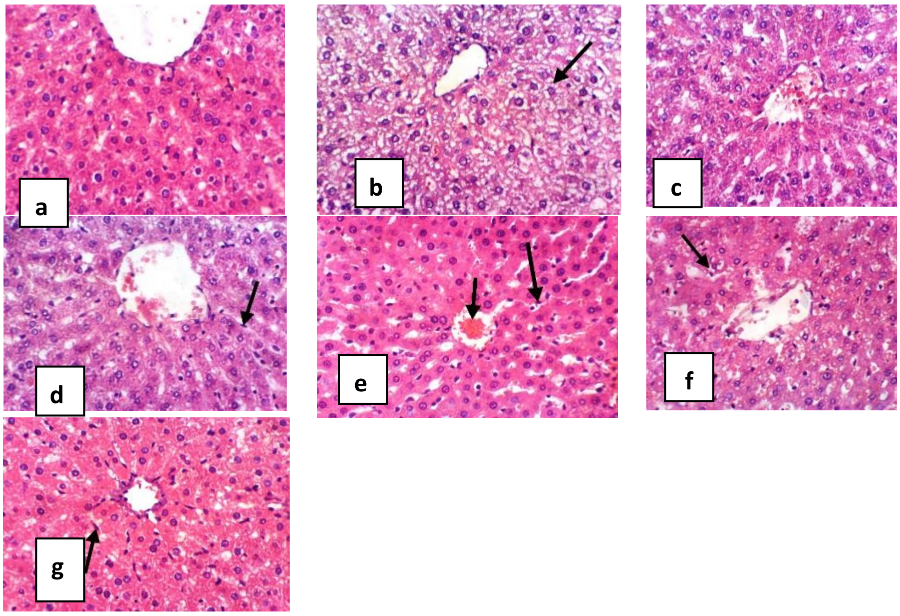
Table (5). Serum urea, creatinine, and uric acid (mg\dl) of hypercholesterolemic rats fed on white, brown, black and mixture rice

Groups / Variables	Urea	% change of positive control	LSD (p≤0.05)	Creatinine	% change of positive control	LSD (p≤0.05)	Uric Acid	% change of positive control	
Control (-)	30[e] ± 1	-48.28	1.161	0.64[c] ± 0.09	-48.38	0.208	1.91[e] ± .085	-48.51	1.161
Control (+)	58[a] ± 0.8	-		1.24[a] ± 0.02	-		3.71[a] ± 0.100	-	
White Rice 5%	49.01[b] ± 0.495	-15.5		1.041[b] ± 0.011	-16.04		3.5[b] ± 0.04	-5.39	
Brown Rice 5%	33.156[c] ± 1.01	-42.83		0.541[d] ± 0.019	-56.37		2.597[c] ± 0.024	-30	
Black Rice 5%	31[de] ± 0.195	-46.55		0.295[e] ± 0.012	-76.21		1.906[e] ± 0.040	-48.63	
Mixture 5%	32.02[cd] ± 0.2	-44.79		0.212[f] ± 0.009	-82.90		2.03 [d] ± 0.167	-45.28	
Biscuits 5%	32[cd] ± 0.495	-44.82		0.23[f] ± 0.019	-81.45		2.066 [d] ± 0.085	-44.31	

Values denote arithmetic means I standard deviation of the mean. Means with different letter(a,b,c,d.etc,) in the same column differ significantly at (p≤0.05) ,using ANOVAA test, while those with similar letter are non-significantly different

Histopathological examination of Liver

Liver of rats from group 1(negative control group) revealed the normal histological structure of hepatic lobule (Photos 1-a). On the other hand, liver of rats from group 2 hypercholesterolemic rats (positive group) showed cytoplasmic vacuolization of hepatocytes (Photo1-b). Meanwhile, liver of rats from group 3 hypercholesterolemic rats treated with white rice) revealed no histopathological changes (Photo 1-c) except congestion of central vein .Moreover, slight congestion of hepatic sinusoids and slight Kupffer cells activation were noticed in liver from group 4 (hypercholesterolemic rats fed on brown rice) (Photos D). Examined sections from group 5(hypercholesterolemic rats fed on black rice) showed congestion of central vein and hepatic sinusoids as well as slight Kupffer cells activation (Photo e). However, liver from group 6 (hypercholesterolemic rats fed on mixture) revealed slight cytoplasmic vacuolization of hepatocytes (Photo f). Moreover, liver from group 7(hypercholesterolemic rats hypercholesterolemic rats fed on biscuit) showed only slight Kupffer cells activation (Photo g).These results in the same line with **Bosello *et al*., (1984).; Rumessen*et al., (1990)*, and Nawras (2009)** they revealed that the soluble fibers in*rice*decreased the absorption of lipids in the proximal intestine and increased the absorption in the mid-intestine, which might alter the size and composition of lipoproteins secreted by the intestine, so it protect the organs from bad changes in hypercholesterolemic induced rats.It seemspossible that restoring the original structure needs more time of feeding.



Photo(1): Effect of tested rice diets on histopathological changes of liver of hypercholesterolemic rats. (a) a normal (control diet); b control diet often inducing by hypercholesterolemia. (c,d,f and g) fed on diet containing rice diets 5% for 28 day after inductionof hypercholesterolemia; (H&E, X 400).

Conclusion

The selected rice in the present study were effective in protecting rats against hypercholesterolemia. These results supported our hypothesis that tested rice contained several important compounds such as fibers, minerals, polyphenols, flavonoids and carotenoids which are able to inhibit hypercholesterolemic process. Therefore, data recommended the selectedrice by a moderate amount to be included in our daily diets.

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دراسة مقارنة للأرز الأبيض والبني والأسودعلي الفئران المصابةبارتفاع الكوليسترول بالدم

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الملخص العربى:
أجريت هذه الدراسه للمقارنة بين أنواع الأرز الأبيض والبني والأسود ومخلوطها والبسكويتبنسبة 5%علي الفئران المصابة بالكوليسترول .لذلك تم استخدام 35 فأر من ذكور فئران الألبينو والتى تزن 150±160 جم تم تقسيمها بالتساوى الى 7مجموعات ، أحداهم استخدمت كمجموعه ضابطه سالبه، بينما باقى المجموعات المختبرة (30) فأر قد تم تغذيتهم على الوجبة المرتفعة الكوليسترول لمدة ثلاثة أسابيع لاحداث ارتفاع فى الكوليسترول للفئران . ثم تم اضافة مساحيق الارز والبسكويت محل الدراسه الى الوجبه الأساسيه للفئران بنسبة 5% وذلك لمدة 28 يوم . وفى نهاية التجربه تم عمل التحاليل التاليه: تقدير الكوليستيرول الكلى، الجليسريدات الثلاثيه ، الليبوبروتينات مرتفعة الكثافه ، الليبوبروتينات منخفضة الكثافه ، الليبوبروتينات المنخفضه جدا فى الكثافه و معامل تصلب الشرايين. كما تم أيضا تقدير كل من وظائف الكبد والكلى وعمل فحص هيستوباثولوجى للكبد. وقد أوضحت النتائج المتحصل عليها وجود انخفاض معنوى ($p\leq0.05$) فى مستويات دهون الدم ووظائف الكبد والكلى ، بينما لوحظ وجود ارتفاع معنوى($p\leq0.05$) فى مستوى الليبوبروتينات المرتفعة الكثافه ومعامل تصلب الشرايين ، كما أيدتنتائج الفحص الهيستوباثولوجى للكبد ما تم التحصل عليه من التحاليل البيوكيميائيه. ويرجع هذا التحسن الى احتواء مساحيق الارز محل الدراسه على العديد من المكونات الحيويه الفعاله التى تحسن من صورة دهون الدم ووظائف الكبد والكلى ، ولذلك نوصى بالاهتمام باستخدام هذه المكونات بكميات معتدله فى وجباتنا اليوميه .

الكلمات المفتاحية : الكوليسترول الكلى، الجلسرىدات الثلاثيه، الليبوبروتينات مرتفعة الكثافه، الليبوبروتينات منخفضة الكثافه، وظائف الكبد والكلى، الفئران المصابه بارتفاع الكوليستيرول و الفحوصات الهيستوباثولوجيه.