

**-BIOEFFECT OF SEMI-PURIFIES UNSABONIFIABLE COMPONENTS OF RICE BRAN OIL ON PLASMA LIPID LEVELS IN MODERATELY HYPERCHOLESTOLEMIC RATS**

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**ABSTRACT**

Number of studies on humans and animals showed lowering effect of rice bran oil (RBO) as well as other vegetable oils in plasma cholesterol levels. The aim of this study was undertaken to compare this effect of two concentrations (1%) and (2%) of Egyptian-RBO active compounds on hypercholesterolemia in rats. Four groups of six rats were used, the first group was fed on basal diet (control), while the second group was fed on basal diet plus 1% cholesterol. Groups 3 and 4 were fed basal diet +1 % cholesterol + RBO active compounds (1 and 2 % respectively). Non significant differences were noticed in the mean values of body weights, organs weights and relative organs weights (organ wt/body wt) between different experimental groups. The results obtained showed no significant changes in transaminase (AST & ALT) activities between different treated groups. No significant effect was observed in plasma urea and creatinine or hemoglobin in different treated groups compared to control group. On the other hand total cholesterol and low density lipoprotein cholesterol data showed a significant increase in hypercholesterolemic groups (50 % and 168 %) compared to control group. Supplementation with rice bran active compounds in groups 4 decreased its level compared to cholesterol group 2. The data obtained revealed that triacylglycerol was significantly decreased due to supplementation with rice bran oil of groups 3 (by 27. 64 %) and 4 (by 15.07%) compared to hypercholesterolemia in rats of group 2.

**Conclusion:** Rice bran oil active compounds seem to be a very promising phytochemical alternative to classic lipid-lowering agents.

**Keywords:** Rice bran oil, Hypercholesterolemia, Plasma lipids

**INTRODUCTION**

Hypercholesterolemia is an established major risk factor for coronary heart disease. Lifestyle modification is the preferable form of treatment for most types of hyperlipidemia [National Cholesterol Education Program 1993]. The most potent drugs that are currently used to lower elevated (LDL-C) levels are the 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase inhibitors (statins) [Gould et al., 1995; Law et al., 2003]. Because of patient reluctance to be treated with chemically derived drugs, especially for primary

prevention which may contribute to the above discrepancy, there is a need for effective, safe and ideally naturally derived drugs. A number of studies in humans and animals have shown that rice bran oil (RBO) is as effective as other vegetable oils in lowering plasma cholesterol levels [Lichtenstein *et al.*, 1994]. In some cases, RBO lowered plasma cholesterol more effectively than other commonly used vegetable oils rich in linoleic acid [Rukmini & Raghuram, 1991], this effect can be attributed to the occurrence of specific components in RBO,  $\gamma$ -oryzanol and perhaps tocotrienols [Nicolosi *et al.*, 1991; Rukmini & Raghuram 1991; Juliano & Cossu., 2005]. The amount of linoleic acid in RBO is rather moderate among the vegetable oils (~ 40 % of total fatty acids), but is still considered a rich source of this acid [Edwards & Radcliff., 1994].

## MATERIALS AND METHODS

### **Extraction of crude oil:**

To extract crude rice bran oil, 100 g of rice bran was extracted with 1 L of n-hexane on a horizontal shaker for 12 hours at 300 oscillations per minute and filtered through fiberglass filter paper. After repeating the extraction procedure, extracts were combined, and n-hexane was evaporated under vacuum at 30 °C [Ha *et al.*, 2005].

### **Semi purification of bioactive component ( $\gamma$ -oryzanol) using low-pressure Silica column. :**

A glass column (2.5 cm x 25 cm) packed with 20 g of silica (grade 60) (Merck Company) was used to remove the triglycerides and other lipids. Initially, the crude oil was solubilized in 50 ml of the solvent (hexane/ethyl acetate = 9:1) for flushing through the column. Then 50 ml of solvent (hexane/ethyl acetate = 7:3) was allowed to flow through the column, and the eluant was collected. The column was then washed with 50 ml of hexane/ethyl acetate (1:1), and the semipurified bioactive components were obtained after the solvent was evaporated [Xu & Godber., 1999].

### **Animals and diets:**

Basal diet was provided in accordance with AIN-93 formulation [Reeves *et al.*, 1993], as shown in Table 1. Forty eight male albino rats with an average body weight  $82 \pm 4$  g were used in this study individual housed in stainless steel cages. The rats were fed basal diet for one week; water was allowed ad-libitum. The rats were divided into 4 groups, 8 rats for each group.

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<b>Cases</b>	120	<b>Group (1)</b>	<b>Group (2)</b>	<b>Group (3)</b>	<b>Group (4)</b>
<b>PAGE</b>	8592				

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*J. Agric. Sci. Mansoura Univ., 33 (12): 8591 - 8598, 2008***Experiment I:**

The first group was fed on basal diet (control) .The second group was fed on basal diet +1 % cholesterol. Group 3 and 4 were fed on basal diet +1 % cholesterol + semi purification of active compounds of rice bran oil (1 and 2 g /100 diet, respectively). After 6 weeks the animals were fasted overnight, blood samples were withdrawn by a fine capillary glass tube from the orbital plexus vein. The blood was collected in heparin containing tubes and which were centrifuged at 3000 rpm for 15 min. and stored at -20°C until analysis.

The plasma enzyme activities of aspartate trans aminas (AST) and alanine trans aminase (ALT) were determined according to the method of: Reitman & Frankel [1957]. Plasma urea was determined by the method of Patton & Grouch [1977]. Plasma total cholesterol, triglycerides, HDL-C and LDL-C were determined using the respectively enzymatic methods: Allain *et al.* [1974], Fossati &Prencipe [1982], Arcol [1989], and Sharf *et al.* [1985]. Creatinine was determined according to the methods of Bartles *et al.* [1972]. Blood hemoglobin was measured using the method of Wintrobe [1956].

**Table 1: Composition of the diets (g/kg diet). Reeves *et al.*, 1993**

Vitamin	50	50	50	50	Salt mixture	100	100	100	100	Sucrose	
					Corn	10	10	10	10	mix	
										oil	

Rice bran active compound  
compound

**Statistical analysis:**

Results were expressed using student's t test according to Statistical Graphic System Version 1.0. Values are statistically significant if the p <

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## RESU

The body weight gain, relative organs weight (liver, lung) and relative organs weight (kidney, heart) were shown in Table 2. Non significant changes in relative weight of body weight, organs weight and relative organs weight were observed among the different experimental groups. Table 3 shows the activities of transaminases (SGOT, SGPT, ALT) in plasma of male albino rats treated with the different experimental treatments. No significant changes in transaminases activities were observed in all treated groups. No significant changes in total creatinine and creatinine kinase in the different treated groups were observed. Table 4 illustrates the total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C). The Total cholesterol (TC) and LDL-C (group 4) showed significant increase (150 % and 168 %) compared to control group. HDL-C was lowered from 3.3 mg/dl in control group to 2.5 mg/dl in group 4. It also improves the risk of cardiovascular diseases commonly used as an index of atherosclerosis.

Significant increase in TC/HDL-C ratio (total cholesterol /HDL-C) was observed in group 4 (compared to control group) and significant decrease was observed in group 2 (compared to hypercholesterolemia group). The TC/HDL-C was lowered from 3.9 in control group to 3.1 in group 2. It also improves the risk of cardiovascular diseases commonly used as an index of atherosclerosis.

**Table 2: Initial, terminal body weight and relative organs weight among different treatment groups**

Group	Group (1)	Group (2)	Group (3)	Group (4)
Initial weight (g)	200	200	200	200
Final weight(g)	200	200	200	200
Gain(g)	0	0	0	0
(g)				
weight %				
(g)				

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<b>weight %</b>
(g) 1.61±0.12 1.31±0.50 1.33
<b>weight %</b>
weight % 0.88±0.04 0.
(g) 1.27±0.14 1.17±0.06 0.9
<b>weight %</b>
weight % 0.690.06 0.70±.04

The results show that supplementation (levels 1 and 2) for 45 days induced in rats by a cholesterol-rich diet diminished the increase in plasma triglycerides and moreover level of HDL-C was in accordance with those of Ge

**Table 3: Plasma, liver, different treatment groups**

Group	Group (1)	Group 2	Group 3
SE	Hemoglobin g/dl	15.20	15.20
Unit/L	22.63±5.80	31.20±3.1	31.20±3.1
81	43.75±6.54	40.59±5.27	40.59±5.27
	1.57±3.99	39.46±3.23	39.46±3.23
0.41	(p<0.05)		Creatinine

Rice bran oil and its main constituents, alcohols, phytosterols, tocotrienols and tocopherols have the ability to improve the plasma lipid profile in primates and human, reducing the total cholesterol concentration and increasing HDL-C [Cicero & Gaddi 2001]. Yet rice bran oil typically contains approximately equal amounts of

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Rajhuram, 1991]. Previous studies have shown that saturated fatty acids on total rice bran oil lowers cholesterol [Rajhuram, 1991]. Sugano & Tsuji (1997) suggests that rice bran oil may reduce cholesterol by its unsaponifiable components [Sugano & Tsuji 1997; Wilcock et al., 1997]. In recent years, researchers have begun to focus on the compounds in rice bran oil. A major triterpene alcohol, tocopherol, in rice bran oil is  $\gamma$ -oryzanol, a triterpenoid saponin (Tsuji 1997). Major components in rice bran oil include campesterol and  $\beta$ -sitosterol. When the plant sterols from rice bran oil were provided at 2.1% g/d to rats, plasma LDL cholesterol decreased by 5% and LDL size increased (Wilcock et al., 2000). The investigators postulated that the increase in LDL size was due to the presence of other 4-dismethylsterols, such as cycloartenol. The cycloartenol structure is more similar to the structure of campesterol and  $\beta$ -sitosterol than to the 4-dimethylsterols, and it may be responsible for the inhibition of cholesterol absorption.

<b>Vitamin</b>	50	50	50	50	<b>Salt mixture</b>	100	100	100	100	<b>Sucrose</b>
Corn					Corn	10	10	10	10	mix
										oil
										Rice bran active compound
										compound

#### **Statistical analysis:**

Results were expressed as mean  $\pm$  S.E.M. using Student's t test according to the Statistical Graphic System (SGS). The differences were statistically significant if the p value was less than 0.05.

#### **RESULTS**

The body weight gain, relative organs weight (liver, heart, lung) and relative organs weight of the liver, heart, lung and kidney are shown in Table 2. Non significant differences between the groups were observed.

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of body weight, organs weight and serum biochemistry in experimental groups. Table 1 shows the effect of compound 4 on ALT in plasma of male albino rats. No significant changes in transaminases were observed in all treated groups. No significant increase in serum creatinine in the different treated groups was observed. Table 2 illustrates the total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), TC /HDL-C. The Total cholesterol (TC) in group 4 showed significant increase (140 %) compared to control (100 %) and 168 %) compared to compound 2. Compound 4 also increases active compounds in both groups. It also decreases the total cholesterol group 2. Thus, compound 4 (group 4), induces significant increase in TC (42.10 %) in plasma, compared to control.

Significant increase in active compounds (compared to control) and significant decrease was observed in TC/HDL-C ratio. TC /HDL-C was lowered from 3.33 in control to 2.44 in group 4. It also improves the risk factors of CVDs which are commonly used as an index of cardiovascular risk.

**Table 2: Initial, terminal body weight and relative gain among different treatment groups**

Group	Initial weight (g)	Terminal weight(g)	Gain(g)	(g)
Control	200	200	0	0
Group 1	200	210	10	50
Group 2	200	215	15	75
Group 3	200	220	20	100
Group 4	200	230	30	150

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(g)	weight %
(g)	weight %
(g) 1.61±0.12	1.31±0.50 1.33
weight %	0.88±0.04 0.
(g) 1.27±0.14	1.17±0.06 0.9
weight %	0.690.06 0.70±0.04

The results show that supplementation (levels 1 and 2) for 45 days induced in rats by a cholesterol diet diminished the increase in plasma moreover level of HDL-C was in accordance with those of Geer et al.

**Table 3: Plasma, liver, different treatment groups**

Group	Group	(1)	Group	SE	Hemoglobin	g/dl	15.20
				Unit/L	22.63±5.80	31.20±3.1	
81	43.75±6.54	40.59±5.27	5				
	1.57±3.99	39.46±3.23	Creat				
0.41	(p<0.05)						

Rice bran oil and its main components, alcohols, phytosterols, tocotrienols, ability to improve the plasma lipoproteins in primates and human, reduced triglyceride concentration and increasing HDL-C [Cicero & Gaddi 2001].

Yet rice bran oil typically contains approximately equal amounts of saturated and unsaturated fatty acids [Rajhuram, 1991]. Previous studies have shown that rice bran oil lowers cholesterol levels in animals [Sugano & Tsuji 1997; Wilson et al.

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inhibiting cholesterol absorpti

Vitamin	50	50	50	50	Salt mixture	100	100	100	100	ucrose
Corn						10	10	10	10	mix oil Rice bran active compound compound

**Statistical analysis:**

Results were expressed  
using student's t test acco  
Statistical Graphic System \  
statistically significant if the p

**RESU**

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The body weight gain, lung) and relative organs were shown in Table 2. Non significant changes in the body weight, organs weight and experimental groups. Table 3 shows the activity of ALT in plasma of male albino rats of the different experimental groups. There were no significant changes in transaminase activity in all treated groups. No significant changes in serum creatinine in the different treated groups. Table 4 illustrates the total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), TC /HDL-C. The Total cholesterol showed significant increase (161 % and 168 %) compared to control group. The active compounds in both groups of hypercholesterolemia (group 2). Thus, compound (group 4), induced a significant decrease (42.10 %) in plasma, compared to control group.

Significant increase in the total cholesterol (active compounds) compared to control group. A significant decrease was observed in the TC/HDL-C ratio compared to hypercholesterolemia group. The TC /HDL-C was lowered from 3.42 to 2.44. It also improves the risk factor of hypercholesterolemia commonly used as an index of cardiovascular disease.

**Table 2: Initial, terminal body weight and relative organs weight among different treatment groups**

Group	Initial weight (g)	Terminal weight(g)	Gain(g)	(g)	(g)	weight %	(g)	weight %	(g)	weight %	(g)	weight %
Control	1.61±0.12	1.31±0.50	1.31±0.50	0.88±0.04	0.88±0.04	0.55	1.61±0.12	1.31±0.50	1.31±0.50	0.88±0.04	0.88±0.04	0.55

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**(g)  
weight %**

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**Table 3: Plasma, liver, different treatment Group**

Rice bran oil and alcohols, phytosterols, tocotrienols ability to improve the plasma primates and human, reduced concentration and increasing [Cicero & Gaddi 2001].

Yet rice bran oil type approximately equal amount [Rajhuram, 1991]. Previous saturated fatty acids on total bran oil lowers cholesterol

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suggests thaT rice bran oil [Sugano & Tsuji 1997; Wilso] by its unsaponifiable compo begun to focus on the com triterpene alcohols, tocopher compound is  $\gamma$ -oryzanol, a Tsuji 1997). Major!compone and 24-methylene cycloart campesterol and  $\beta$ -sitosterol. When the plant sterols f and"provided at 2.1\$g/d to m decreased by 5% and LDL 2000). The investigators pos and other 4-dsmethylsterols dimethylsterols, such as cyc sitosterol structure is more s dimethylsterols, and it may b inhibiting cholesterol absorpt

Vitamin	50	50	50	50	Salt mixture	100	100	100	100	crose
Corn	10	10	10	10	mix	oil	Rice bran active compound compound			

#### Statistical analysis:

Results were express using student's t test acco Statistical Graphic System \ statistically significant if the p

## RESU

The body weight gain, lung) and relative organs w shown in Table 2. Non sign of body weight, organs weig experimental groups. Table : ALT) in plasma of male alb

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of the different experiments significant changes in transaminases were observed in all treated groups. No significant changes in serum creatinine in the different treated groups were observed. Figure 1 illustrates the total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C) and triglycerides (TG). The Total cholesterol (TC) and LDL-C showed significant increases (150 % and 168 %) compared to control group. The HDL-C and TG showed active compounds in both groups. Thus, the administration of compound 4 (group 2) induced a significant increase in HDL-C (42.10 %) in plasma, compared to control group.

Significant increase in TG and HDL-C (active compounds) compared to control group. A significant decrease was observed in TC and LDL-C compared to hypercholesterolemia group. The TG and HDL-C were lowered from 3.42 ± 0.10 mmol/L and 1.06 ± 0.04 mmol/L respectively. It also improves the risk factors of cardiovascular diseases commonly used as an index of cardiovascular risk.

**Table 2: Initial, terminal body weight and gain among different treatment groups**

Group	Initial weight (g)	Terminal weight(g)	Gain(g)	(g)
	(g)			weight %
Control	100	100	0	0
Group 1	100	115	15	15
Group 2	100	115	15	15
Group 3	100	115	15	15
Group 4	100	115	15	15

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(g)			
weight	%	0.46±0.04	0.4
(g)		1.61±0.12	1.31±0.50
weight	%	0.88±0.04	0.1
(g)		1.27±0.14	1.17±0.06
weight %		0.690.06	0.70±.04

The results show that supplementation (levels 1 and 2) for 45 days induced in rats by a cholesterol diet diminished the increase in plasma moreover level of HDL-C was in accordance with those of Geer et al.

**Table 3: Plasma, liver, different treatment groups.**

Group	Group	(1)	Group
SE	Hemoglobin	g/dl	15.20
Unit/L	22.63±5.80	31.20±3.1	
81	43.75±6.54	40.59±5.27	5
	1.57±3.99	39.46±3.23	Creat
0.41	(p<0.05)		

Rice bran oil and its main components, triterpenes, tocopherols, phytosterols, alcohols, phytosterols, tocopherols, ability to improve the plasma lipid profile in primates and human, reducing triglyceride concentration and increasing HDL-C [Cicero & Gaddi 2001]. Yet rice bran oil typically contains approximately equal amounts of saturated and unsaturated fatty acids on total oil weight. Rajhuram, 1991]. Previous studies have shown that rice bran oil lowers cholesterol levels in animals and suggests that rice bran oil may be effective in humans by its unsaponifiable components [Sugano & Tsuji 1997; Wilcockson et al., 1998]. It has begun to focus on the components of rice bran oil, triterpene alcohols, tocopherols, and phytosterols.

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compound is  $\gamma$ -oryzanol, a Tsuji 1997). Major!compone and 24-methylene cycloartenesterol and  $\beta$ -sitosterol. When the plant sterols f and"provided at 2.1\$g/d to m decreased by 5% and LDL 2000). The investigators pos and other 4-dsmethylsterols dimethylsterols, such as cyc sitosterol structure is more s dimethylsterols, and it may b inhibiting cholesterol absorpt

Vitamin	50	50	50	50	Salt mixture	100	100	100	100	rose Corn	10	10	10	10	mix oil Rice bran active compound compound
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#### Statistical analysis:

Results were expressed using student's t test according to Statistical Graphic System V. The results were statistically significant if the p < 0.05.

## RESULTS

The body weight gain, liver, lung) and relative organs w

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shown in Table 2. Non significant changes of body weight, organs weight and experimental groups. Table 3 shows ALT in plasma of male albino rats of the different experimental groups. No significant changes in transaminase in the treated groups. No significant changes in serum creatinine in the different treated groups. Figure 1 illustrates the total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C), TC /HDL-C. The Total cholesterol showed significant increase (140% and 168 %) compared to control group. Active compounds in both groups reduced the total cholesterol group 2. Thus, compound 4 ( group 4), induced a reduction in total cholesterol (42.10 %) in plasma, compared to control.

Significant increase active compounds) compared significant decrease was observed compared to hypercholesterolemia. HDL-C was lowered from 3.4 to 4.4. It also improves the risk commonly used as an index.

**Table 2: Initial, terminal bo**  
**among different t**

**Group**  
**weight (g)**  
**weight(g)**  
**Gain(g)**  
**(g)**  
  
**(g)**  
**weight %**  
**(g)**  
**weight**      **%**  $0.46 \pm 0.04$   $0.4$   
**(g)**  $1.61 \pm 0.12$   $1.31 \pm 0.50$   $1.3$   
**weight**      **%**  $0.88 \pm 0.04$   $0$   
**(g)**  $1.27 \pm 0.14$   $1.17 \pm 0.06$   $0.9$   
**weight %**  $0.690.06$   $0.70 \pm 0.04$

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Yet rice bran oil type approximately equal amount [Rajhuram, 1991]. Previous studies saturated fatty acids on total bran oil lowers cholesterol suggests that rice bran oil may be its unsaponifiable compo

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[Sugano & Tsuji 1997; Wilson et al. 1997] have begun to focus on the compounds. A triterpene alcohol, tocopherol, a compound is  $\gamma$ -oryzanol, a compound isolated from rice bran (Tsuji 1997). Major components include  $\alpha$ -oryzanol and 24-methylene cycloartane-type sterols, campesterol and  $\beta$ -sitosterol. When the plant sterols fraction was added to rat diet and provided at 2.1% g/d to normal rats, plasma cholesterol decreased by 5% and LDL cholesterol decreased by 10% (Wilson et al. 2000). The investigators postulated that the plant sterols and other 4-dismethylsterols, such as cycloartenol, may inhibit cholesterol absorption.

**Vitamin**    50 50 50 50   **Salt mixture**    100 100 100 100   **ose**  
                             Corn                  10 10 10 10   **mix**  
                             oil  
                             Rice bran active compound  
                             compound

## **Statistical analysis:**

Results were expressed using student's t test according to Statistical Graphic System. The results were statistically significant if the p < 0.05.

RESU

The body weight gain, lung) and relative organs were shown in Table 2. Non significant of body weight, organs weight experimental groups. Table 3: ALT) in plasma of male albino of the different experimental significant changes in transaminases.

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treated groups. No significant difference was observed in creatinine in the different treated groups. Table 1 illustrates the total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C) and TC /HDL-C. The Total cholesterol (TC) and LDL-C showed significant increase (140 % and 168 %) compared to control group. The HDL-C and active compounds in both groups were significantly lower than those in the hypercholesterolemia group 2. Thus, the administration of compound ( group 4), induced a significant increase in HDL-C (42.10 %) in plasma, compared to control group.

Significant increase was observed in the levels of active compounds (compared to control group). A significant decrease was observed in the levels of TC and LDL-C (compared to hypercholesterolemia group 2). The TC /HDL-C was lowered from 3.36 to 2.26. It also improves the risk factors for CVDs commonly used as an index of cardiovascular risk.

**Table 2: Initial, terminal body weight and gain among different treatment groups**

Group	Initial weight (g)	Terminal weight(g)	Gain(g)	(g)	(g)	weight %	(g)	weight	%	0.46±0.04	0.46±0.04
Control	20.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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(g) 1.61±0.12 1.31±0.50 1.31  
**weight %** 0.88±0.04 0.91  
(g) 1.27±0.14 1.17±0.06 0.91  
**weight %** 0.690.06 0.70±0.04

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Group	Group	(1)	Group
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and 24-methylene cycloartenol, campesterol and  $\beta$ -sitosterol. When the plant sterols fed "provided at 2.1% g/d to rats decreased by 5% and LDL cholesterol (2000). The investigators postulated that the plant sterols and other 4-dismethylsterols, such as cycloartenol, sitosterol and campesterol, have a dimethylsterols, such as cycloartenol, sitosterol structure is more similar to human cholesterol than to plant sterols, and it may be that the plant sterols are inhibiting cholesterol absorption.

<b>Vitamin</b>	50	50	50	50	<b>Salt mixture</b>	100	100	100	100	se
Corn					Corn	10	10	10	10	mix
oil										
Rice bran active compound										
compound										

**Statistical analysis:**

Results were expressed as mean  $\pm$  S.E.M. using student's t test according to the Statistical Graphic System (SGS) software. The differences were statistically significant if the p < 0.05.

**RESULTS**

The body weight gain, relative weight of liver, heart, lung and relative organs weight were measured and shown in Table 2. Non significant differences were observed in the body weight, organs weight and relative organs weight.

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experimental groups. Table 3 shows ALT) in plasma of male albino rats of the different experimental groups. No significant changes in transaminases were observed in the treated groups. No significant increase in serum creatinine in the different treated groups was observed. Figure 1 illustrates the total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C), and TC /HDL-C. The Total cholesterol showed significant increase (140% and 168 %) compared to control group. The active compounds in both groups reduced the total cholesterol group 2. Thus, compound 1 (group 4), induced a reduction of 42.10 % in plasma, compared

Significant increase in active compounds) compared to significant decrease was observed compared to hypercholesterolemia. HDL-C was lowered from 3.4 to 4. It also improves the risk factors commonly used as an index of cardiovascular risk.

**Table 2: Initial, terminal bo**  
**among different t**

**Group**  
**weight (g)**  
**weight(g)**  
**Gain(g)**  
**(g)**  
  
**(g)**  
**weight %**  
**(g)**  
**weight**      **%**     $0.46 \pm 0.04$     0.4  
**(g)**     $1.61 \pm 0.12$      $1.31 \pm 0.50$     1.3  
**weight**      **%**     $0.88 \pm 0.04$     0.  
**(g)**     $1.27 \pm 0.14$      $1.17 \pm 0.06$     0.9  
**weight %**    0.690.06    0.70 $\pm$ .04

The results show that sup

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(levels 1 and 2) for 45 d induced in rats by a cholesterol diminished the increase in plasma moreover level of HDL-C was in accordance with those of Ge

**Table 3: Plasma, liver, different treatment Group**

Rice bran oil and alcohols, phytosterols, tocotrienols ability to improve the plasma primates and human, reduced concentration and increasing [Cicero & Gaddi 2001].

Yet rice bran oil type approximately equal amount [Rajhuram, 1991]. Previous saturated fatty acids on total bran oil lowers cholesterol suggests that rice bran oil may be by its unsaponifiable components [Sugano & Tsuji 1997; Wilso

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begun to focus on the common triterpene alcohols, tocopherols and compound is  $\gamma$ -oryzanol, a major component of rice bran oil (Tsuiji 1997). Major components of rice bran oil are campesterol and  $\beta$ -sitosterol. When the plant sterols from rice bran oil were provided at 2.1% g/d to mice, plasma cholesterol was decreased by 5% and LDL cholesterol by 10% (Kondo et al. 2000). The investigators postulated that the rice bran oil and other 4-dismethylsterols may inhibit absorption of sitosterol structure is more similar to cholesterol than to campesterol and dimethylsterols, such as cycloartenol. The rice bran oil contains sitosterol structure is more similar to cholesterol than to campesterol and dimethylsterols, and it may be effective in inhibiting cholesterol absorption.

<b>Vitamin</b>	50	50	50	50	<b>Salt mixture</b>	100	100	100	100	e
Corn					Corn	10	10	10	10	mix
oil										
Rice bran active compound										
compound										

#### Statistical analysis:

Results were expressed using student's t test according to Statistical Graphic System (SGS) and considered statistically significant if the p < 0.05.

## RESULTS

The body weight gain, relative weight of liver, heart, lung and relative organs weight were measured and shown in Table 2. Non significant changes in the body weight, organs weight and relative organs weight between all experimental groups. Table 3 shows the serum transaminase activities (ALT and AST) in plasma of male albino rats. No significant changes in transaminase activities were observed in all treated groups. No significant changes in transaminase activities were observed in all treated groups.

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creatinine in the different treatment groups illustrates the total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), TC /HDL-C. The Total cholesterol showed significant increase (140 % and 168 %) compared to control group. active compounds in both groups reduced cholesterol group 2. Thus, compound 4 ( group 4), induced a reduction in plasma cholesterol (42.10 %) in plasma, compared to control.

Significant increase in plasma, compared to hypercholesterolemia, was observed. The level of active compounds) compared to hypercholesterolemia, was lowered from 3.4% to 1.1%.

**Table 2:** Initial, terminal bo  
among different t

**Group**  
**weight (g)**  
**weight(g)**  
**Gain(g)**  
**(g)**  
  
**(g)**  
**weight %**  
**(g)**  
**weight**      **%**     $0.46 \pm 0.04$     0.4  
**(g)**     $1.61 \pm 0.12$      $1.31 \pm 0.50$     1.3  
**weight**      **%**     $0.88 \pm 0.04$     0

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(g)  
weight %

The results show (levels 1 and 2) for 45 d induced in rats by a cholesterol diminished the increase in plasma moreover level of HDL-C was in accordance with those of Geer et al.

**Table 3: Plasma, liver, different treatment Group**

Rice bran oil and alcohols, phytosterols, tocopherols ability to improve the plasma primates and human, reduced concentration and increasing [Cicero & Gaddi 2001].

Yet rice bran oil type approximately equal amount [Rajhuram, 1991]. Previous saturated fatty acids on total bran oil lowers cholesterol suggests that rice bran oil by its unsaponifiable compounds [Sugano & Tsuji 1997; Wilcockson begun to focus on the compound triterpene alcohols, tocopherol compound is  $\gamma$ -oryzanol, a Tsuji 1997). Major components and 24-methylene cycloartane campesterol and  $\beta$ -sitosterol.

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<b>Vitamin</b>	50	50	50	50	<b>Salt mixture</b>	100	100	100	100
	Corn					10	10	10	10

**mix**  
**oil**  
**Rice bran active compound**  
**compound**

When the plant sterols f and "provided at 2.1\$g/d to m decreased by 5% and LDL 2000). The investigators pos and other 4-dsmethylsterols dimethylsterols, such as cyc sitosterol structure is more s dimethylsterols, and it may b inhibiting cholesterol absorpt

**Statistical analysis:**

Results were expressed using student's t test according to Statistical Graphic System V. The differences were statistically significant if the p < 0.05.

**RESULTS**

The body weight gain, relative organs weight (liver, heart, lung) and relative organs weight expressed as a percentage of body weight, organs weight and serum ALT activity in plasma of male albino rats are shown in Table 2. Non significant differences between experimental groups. Table 3 shows the serum ALT (U/L) in plasma of male albino rats.

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of the different experiments significant changes in transaminases in the treated groups. No significant difference was found in creatinine in the different treated groups. Figure 1 illustrates the total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), TC /HDL-C. The Total cholesterol showed significant increase (150 % and 168 %) compared to control group. The active compounds in both groups reduced the total cholesterol group 2. Thus, compound 4 (group 4), induced a reduction of 42.10 % in plasma, compared to control.

Significant increase in active compounds) compared to control. A significant decrease was observed in TC/HDL-C ratio compared to hypercholesterolemia group. TC/HDL-C was lowered from 3.46 to 3.16 mmol/L. 4. It also improves the risk factors of cardiovascular diseases.

**Table 2: Initial, terminal bo  
among different t**

**Group**  
**weight (g)**  
**weight(g)**  
**Gain(g)**  
**(g)**  
  
**(g)**  
**weight %**  
**(g)**  
**weight %** 0.46±0.04 0.4  
**(g)** 1.61±0.12 1.31±0.50 1.3  
**weight %** 0.88±0.04 0.  
**(g)** 1.27±0.14 1.17±0.06 0.9  
**weight %** 0.690.06 0.70±0.04

The results show that superoxide (levels 1 and 2) for 45 days induced in rats by a cholesterol diet.

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diminished the increase in p

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moreover level of HDL-C w

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accordance with those of Ge

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**Table 3: Plasma, liver,**

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different treatment

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**Group**

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alcohols, phytosterols, tocot

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ability to improve the plasm

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primates and human, red

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concentration and increasing

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[Cicero & Gaddi 2001].

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approximately equal amount

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satura ed fatty acids on total

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suggests thaT rice bran oil [

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by its unsaponifiable compo

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[Sugano & Tsuji 1997; Wilso

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begun to focus on the com

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triterpene alcohols, tocophero

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compound is  $\gamma$ -oryzanol, a

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Tsuji 1997). Major!componen

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100	100	Sucrose			
100	100	ucrose			
100	100	crose			
100	100	rose	100		
100	100	ose			
100	100	se			
100	100	e			
100	100	100			
100	100	100			
100	100	100			

	Salt	mixture	50	50	50	Vitamin
mix	10	10	10	10	Corn	
oil	60	60	60	60	Cellulose	40
cholesterol	0	10	10	10	Rice bran	40
compound	0	0	10	20	Starch	40
	590	Total	1000	1000	1000	1000

#### Statistical analysis:

Results were expressed as mean  $\pm$  SD. Statistical significance was calculated using student's t test according to the method of Statgraphics Program Statistical Graphic System Version 2.6 [1987]. Differences were considered statistically significant if the p value < 0.05.

## RESULTS AND DISCUSSION

The body weight gain, organs weight (liver, spleen, kidney, heart and lung) and relative organs weight (organ weight / body weight  $\times$  100) are shown in Table 2. Non significant differences were noticed in the mean value of body weight, organs weight and relative organs weight between different experimental groups. Table 3 illustrates the activities of transaminase (AST & ALT) in plasma of male albino rats in addition to plasma creatinine and urea of the different experimental groups. The results obtained showed no significant changes in transaminase (AST & ALT) activities between different treated groups. No significant effect was observed in plasma urea and creatinine in the different treated groups compared to control group. Table 4 illustrates the total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), triacylglycerols and risk ratio TC /HDL-C. The Total cholesterol and low density lipoprotein cholesterol showed significant increase in hypercholesterolemic rats of group 2 (64.0 % and 168 %) compared to control. The results showed that supplementation of active compound both groups 3 and 4 decreased its level compared with cholesterol group 2. Thus, rats fed diet containing high level of active compound ( group 4), induced decrease in TC (by 14.24 %) and LDL-C (by 42.10 %) in plasma, compared to hypercholesterolaemic rats (group 2).

Significant increase was observed in HDL-C in group 4 (high level of active compounds) compared to group 2 (hypercholesterolaemic rats). Non significant decrease was observed in triacylglycerol of groups 3 and 4 compared to hypercholesterolemic rats of group 2 (table 4). The risk ratio TC /HDL-C was lowered from 3.16 in group (2) to 2.56 and 1.82 in groups 3 and 4. It also improves the risk ratio by decreasing its value; such ratio is commonly used as an index of coronary heart disease.

**Table 2: Initial, terminal body weights (g) and relative organs weight (%) among different treatment groups.**

Group Group (1) Group (2) Group (3) Group (4)  
(Initial weight) (Final weight) (Initial weight) (Final weight)

and 24-methylene cycloartanol. Also it was notable that phytosterols campesterol and  $\beta$ -sitosterol, are found at relatively high amounts in RBO. When the plant sterols from RBO were incorporated into margarine and provided at 2.1 g/d to normolipidemic men and women, total cholesterol decreased by 5% and LDL cholesterol decreased by 9% (Vissers et al. 2000). The investigators postulated that the effect was due to the  $\beta$ -sitosterol and other 4-dsmethylsterols and other 4-desmethylsterols and not to the 4,4-dimethylsterols, such as cycloartenol and 24-methylene cycloartanol. The  $\beta$ -sitosterol structure is more similar to that of cholesterol than is that of the 4,4-dimethylsterols, and it may be more effective than the 4,4-dimethylsterols in inhibiting cholesterol absorption in the small intestine.

## REFERENCES

- Allain C.C., Poon L.S., Chan C.S.G., Richmond W., Fu X.C., Enzymatic determination of total serum cholesterol. Clin. Ciem/, 1974, 20, 470-75.
- Arcol I.S.B®, Sepaòation of high density lipoprotein cnd determination of cholesterol and phospholipids bound to these fraction. Biomerieux, 1989, 15, 121-124.
- Bartjes H., Johmer M., Heierli C., Serum kreatinin bestimmung ohne enteiweissen. Clin. Chim. Acta., 1972, 37, 193-197.
- Berger A., Rein D., Schäfer A., Monnard I., Gremaud G., Lambelet P., Bertoli C., Similar cholesterol-lowering properties of rice bran oil, with varied  $\gamma$ -oryzanol in méldly hypercholesterolemic men. Eur. J. N□tr, 2005†44, 163-173.
- Cicero A.F., Gaddi A., Rice bran oil and gamma-oryzanol in the treatment of hyperlipoproteinaemias and other condyitions. Phytother. Res, 2001, 15, 4, 277-289.
- Edwards M.S., Radcliffe J.D., A coíparison of the effect of rice bran oil and coro oil on lipid status in the rat. Biochem. Qrch, 1994, 10, 87–94.
- Fossetti P., Prencipe L., Serum triglycerides determined calorimetrically with an enzyme that produces hydrogen peroxide. Clin/ Chem., 1982, 28, 2077-2080.
- Gerhardt A.L., Gallo N.B., Full-fat rice bran and oat bran similarly reduce hypercholesterolemia in humans. J. Nutr., 1998, 128, 865–869.
- Gould A.L., Rossouw J.e., Santanello N.C., Hevse J.F., Furberg C.D., Cholesterol reduction yields clinical benefit: a(new look at ond data. Circulation., 1995, 91, 2274-2282.
- Ha T., Han S., Kim S., Kim I., Lee H., Kim H., Bioactive components in rice bran can improve lipid profiles in rats fed a high-cholesterol diet. Nutrition Research., 2005, 25, 597–606.
- Juliano C., Cossu M., Antioxidant activity of gamma-oryzanol: Mechanism of action and its effect on oxidative stability of pharmaceutical oils. Intr. J. Pharm., 2005, 299, 146–154.
- Kerckhoffs D.A.J.M., Brouns F., Hornstra G., Mensink R.P., Effects on the human serum lipoprotein profile of  $\beta$ -glucan, soy protein and isoflavones, plant sterols and stanols, garlic and tocotrienols. J. Nutr., 2002, 132, 2494 –2505.
- Law M.R., Wald N.J., Rudnicka A.R., Quantifying effect of statins on low density lipoprotein cholesterol, ischemic heart disease and stroke: systematic review and meta-analysis. BMJ., 2003, 326, 1423-1429.
- Lichtenstein A.H., Ausman L.M., Carrasco W., Gualtieri L.J., Jenner J.L., Ordovas J.M., Nicolosi R.J., Goldin B.R., Schaefer E.J., Rice bran oil consumption and plasma lipid levels in moderately hypercholesterolemic humans. Arterioscler. Thromb., 1994, 14, 549–556.
- Most M.M., Tulley R., Morales S., Lefevre M., Rice bran oil, not fiber, lowers cholesterol in humans. Am. J. Clin. Nutr., 2005, 81, 64–68.
- National Cholesterol Education Program., Second Report of the Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel II). National Institutes of Health