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Production Performance of Broilers Fed with Crude Rice Bran Oil*

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Abstract: An experiment was conducted to study the inclusion of crude rice bran oil on production performance, carcass characteristics and biochemical parameters for a period of seven weeks with two hundred and sixteen commercial, straight run day-old Vencobb broiler chicks. These chicks were randomly grouped into six treatments with three replicates of twelve chicks each. The treatment groups consisted of 0 percent (T_1), 1 percent (T_2), 2 percent (T_3), 3 percent (T_4), 4 percent (T_5) and 5 percent (T_6) crude rice bran oil included in the broiler diet. The results revealed that there was no significant difference in body weight and body weight gain between treatment groups from first week to end of the experiment period except at second week ($P<0.05$). Similarly, no significant difference was recorded in feed consumption, feed conversion ratio and carcass yields, but in feed conversion ratio significant ($P<0.05$) difference was recorded at second week of age. Livability was 100 percent in all the treatment groups except in T_6 wherein mortality of one bird was observed during seventh week of age. The abdominal fat percentage revealed no significant difference among various treatment groups by inclusion of crude rice bran oil. The breast muscle cholesterol revealed no significant difference between treatment groups. Whereas the mean thigh muscle cholesterol of other treatment group birds was significantly ($P<0.05$) lower than those of control group. The serum total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides level did not differ significantly between treatment groups. The return over feed cost did not differ significantly between treatment groups except at second week of age. Based upon this study, it is concluded that the inclusion of crude rice bran oil up to 3 percent in broiler ration is recommended for better growth and high return over feed cost.

Key words: Broilers, rice bran oil, production performance

Introduction

Poultry industry scenario in India has been in a state of phenomenal and commendable growth for the past three decades. At present, this industry has emerged as the most dynamic and fastest expanding segment in animal husbandry sector with an annual growth rate of 6 percent in 1980s, 11 percent in 1990s and 19 percent in 1997-2002 in broiler chicken production. With an annual production of around 1,440 thousand metric tonnes of broiler meat, India ranks fifth in the world (Poultry International Executive Guide, 2004; Mandal *et al*., 2005).

Rice is the principal cereal for human food in southern states of India and the by-products from its milling are available as important feed resources. Cereal by-products and oil seed residues, usually constituting about 50 percent of poultry diet. Compared to cereals, the usage of oils as sources of energy in broiler feed helps to reduce the cost of production. The production of rice bran oil in southern states of India is 3.5 lakh metric tonnes / annum as edible and 1.3 metric tonnes / annum as inedible (Sea Millennium Hand Book, 2002). Since, the rice bran oil is available locally in the southern poultry belt of India, research on feeding value of rice bran oil in meat type chicken is highly beneficial for further development of poultry industry.

In broilers, dietary inclusion of rice bran oil can result in improved growth rate, higher weight gain and better feed conversion ratio and low cost of feed per kilogram of live weight (Purushothaman *et al*., 2005). Cholesterol lowering properties are present in rice bran oil (Berger *et al*., 2005). Gamma-oryzanol, a phytosteryl ferulate mixture extracted from rice bran oil, has a wide spectrum of biological activities, also it has antioxidant properties (Juliano *et al*., 2005). Several beneficial effects of rice bran oil in broilers can also be obtained by including it in crude form in broiler feed because of its low cost. Hence, the present study was carried out to evaluate the performance of broilers by including crude rice bran oil at different levels in their diet.

Materials and Methods

Two hundred and sixteen commercial, straight run day-old Vencobb broiler chicks belonging to single hatch were purchased from local hatchery, wing banded, weighed and randomly allotted into six treatment groups with three replicates of twelve chicks each. The chicks were reared in broiler cages in a gable roofed, open sided house. All the chicks were provided with uniform floor, feeder and waterer space and were reared under standard management conditions throughout the experimental period of seven weeks.

Experimental diet: The experimental diet was formulated according to the standards prescribed in Bureau of Indian Standards (BIS, 1992). Crude rice bran oil was included in the basal diet and the following experimental groups were formed.

T_1 - Control
T_2 - 1 percent crude rice bran oil
T_3 - 2 percent crude rice bran oil
T_4 - 3 percent crude rice bran oil
T_5 - 4 percent crude rice bran oil
T_6 - 5 percent crude rice bran oil

The broiler starter and finisher diets were fed *ad libitum* to the birds from 1 to 21 and 22 to 49 days of age, respectively. The diets were subjected to proximate analysis as per AOAC (1995). Data on body weight, feed consumption were recorded every week and mortality was recorded at occurrence. From the above data body weight gain, feed efficiency and livability were calculated.

Carcass characteristics: At the end of 49th day of age, one male and one female from each replicate, totally six birds per treatment group were randomly picked up, blood samples were collected for measuring the serum biochemical characteristics and slaughtered as per the method of Arumugam and Panda (1970). The pre-slaughter live weight, New York dressed weight, eviscerated carcass weight, giblets weight, ready-to-cook carcass weight and abdominal fat weight were recorded. Ready-to-cook yield and abdominal fat percentage were calculated on live weight basis. The thigh and breast muscle samples were collected from each carcass and stored at -20^{o}C for estimation of total meat cholesterol.

Muscle cholesterol: The meat samples were chopped and minced with mortar and pestle. The total lipid was extracted from the muscle samples as per the method of Folch *et al.* (1957) and the total meat cholesterol was estimated by one-step method of Wybenga *et al.* (1970).

Serum biochemistry: Blood samples collected from six birds randomly picked up for slaughter from each treatment group were allowed to clot and centrifuged for 20 min at 1500 rpm to separate the sera. The sera samples were stored at -20^{o}C for the analysis of serum total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides.

Statistical analysis: The data collected on various parameters were subjected to statistical analysis as per the methods suggested by Snedecor and Cochran (1989). Angular transformation was applied to percentage wherever needed before carrying out statistical analysis.

Results

Body weight: Statistical analysis revealed no significant difference in body weight of broilers up to 7th week except at second week due to dietary inclusion of crude rice bran oil. The mean body weight of T_2 and T_3 was significantly ($P<0.05$) lower than control group at second week of age.

Feed consumption and feed conversion ratio (FCR): The analysis of data on mean cumulative feed consumption revealed no significant difference between treatment groups from first to seventh week. The cumulative feed consumption was 5479.25, 5437.75, 5437.71, 5352.89, 5339.83 and 5211.83 g in T_3, T_2, T_6, T_1, T_5 and T_4 respectively at seventh week of age.

Statistical analysis of data on feed conversion ratio revealed no significant difference up to seventh week of age except at second week. The mean cumulative feed conversion ratio in T_2 and T_3 was significantly ($P<0.05$) poorer compared to control group at second week of age.

Livability: Livability was 100 percent in all the treatment groups except in T_6 at seventh week of age wherein one mortality was observed during the experimental period.

Carcass characteristics

Carcass yield: The carcass characteristics viz. pre-slaughter, New York dressed, eviscerated weights, ready-to-cook percentage and giblets weight did not differ significantly between the treatment groups by inclusion of crude rice bran oil. The ready-to-cook percentage was numerically higher in T_2 compared to all other treatment groups.

Abdominal fat percentage: Analysis of data on mean abdominal fat percentage revealed no significant difference between treatment groups by inclusion of crude rice bran oil at different levels. The abdominal fat percentage was increased correspondingly to the inclusion level of crude rice bran oil in the diet but it was lower when compared to control group.

Muscle cholesterol: Analysis of variance of data on breast muscle cholesterol level revealed no significant difference between treatment groups. But, thigh muscle cholesterol level differ significantly ($P<0.05$) between the treatment groups. Linear decrease in thigh muscle cholesterol was observed in groups fed with crude rice bran oil from 1 to 5 percent. The mean thigh muscle cholesterol of these groups were significantly ($P<0.05$) lower than control group.

Serum biochemistry

Serum total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides: Analyses of variance of data on serum total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides level revealed no significant difference between treatment groups. All the serum biochemical parameters decreased linearly as the

Table 1: Ingredients and nutrient composition (%DM) of broiler starter ration

Ingredients	T1	T2	T3	T4	T5	T6
Maize	54	52	50	48	46	44
Soya	33	33.5	34	34.5	35	35.5
Fish meal	5	5	5	5	5	5
DORB	5	5.5	6	6.5	7	7.5
Calcite	2	2	2	2	2	2
DCP	1	1	1	1	1	1
Crude rice bran oil	0	1	2	3	4	5
Total	100	100	100	100	100	100
Supplements						
Vitamins AB_2D_3K[1]	0.01	0.01	0.01	0.01	0.01	0.01
B-Complex[2]	0.02	0.02	0.02	0.02	0.02	0.02
Trace minerals[3]	0.1	0.1	0.1	0.1	0.1	0.1
Lysine	0.05	0.05	0.05	0.05	0.05	0.05
Methionine	0.2	0.2	0.2	0.2	0.2	0.2
DOT[4]	0.05	0.05	0.05	0.05	0.05	0.05
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Endox[5]	0.05	0.05	0.05	0.05	0.05	0.05
Toxin binder[6]	0.025	0.025	0.025	0.025	0.025	0.025
Total	0.855	0.855	0.855	0.855	0.855	0.855
Nutrients						
Crude protein	22.61	22.72	22.83	22.94	23.09	23.22
M.E (kcal/kg)*	2817	2835	2853	2871	2876	2888
Crude fibre	4.09	4.13	4.16	4.2	4.34	4.43
Ether extract	2.6	2.53	2.46	2.39	2.29	2.21
Total ash 6.68	6.76	6.84	6.92	7	7.08	
Nitrogen free extract*	64.02	63.86	63.71	63.55	63.28	63.06
Calcium	1.41	1.42	1.43	1.44	1.47	1.49
Total Phosphorus	0.68	0.69	0.69	0.7	0.72	0.73
Lysine*	1.38	1.4	1.41	1.42	1.44	1.46
Methionine*	0.4	0.4	0.4	0.4	0.41	0.4

*Calculated values. [1]One gram of vitamin AB_2D_3K supplement contained 82500 IU of vitamin-A, 50 mg of vitamin-B_2, 12000 IU of vitamin-D_3 and 10 mg of vitamin-K. [2]One gram of B-complex supplement contained 80 mg of vitamin-B_1,16 mg of vitamin-B_6, 80 mcg of vitamin-B_{12}, 80 mg of vitamin-E, 120 mg of niacin, 8 mg of folic acid, 80 mg of calcium pantothenate and 86 mg of calcium. [3]One gram of trace minerals contained 54 mg of manganese, 52 mg of zinc, 20 mg of iron, 2 mg of iodine and 1 mg of cobalt. [4]One gram of DOT contained Dinitro-ortho-toluamide 25 mg w/w. [5]Ethoxyquin, BHT and chelating agents. [6]Hydrated sodium alumino silicate (HSCAS), organic acids, vinylpyrrolidone homopolymer, mannanoligosaccharide (MOS) activated charcoal and lipotropic factors.

inclusion level of crude rice bran oil was increased in the diet. The serum biochemical parameters in all treatment groups were lower compared to control.

Discussion

Body weight: Statistical analysis of data on body weight revealed no significant difference among the treatment groups due to dietary inclusion of crude rice bran oil. However, numerically higher body weight was observed in crude rice bran oil included groups (T_3, T_2 and T_4) at seventh week of age (Deaton *et al.,* 1981; Purushothaman *et al.,* 2005). It was consistent with Fan *et al.* (1995) who reported that growing chickens fed with rice bran oil or maize or blended oil did not significantly affect the body weight gain.

On the contrary, Murugesan (1997) observed a significant ($P<0.05$) increase in weight gain (1352 g) in 2 percent Acidulated Rice bran oil Soapstock (ARS) fed group compared to that of control (1230.84 g) group. Similarly, Purushothaman *et al.* (2000) reported that the body weight gain in starter phase was significantly high in rice bran oil fed group than the control group and 1 percent palm oil fed group, but no significant difference was observed among the treatments in body weight gain in finisher phase.

Feed consumption and feed conversion ratio (FCR): The analysis of data on mean cumulative feed consumption and feed conversion ratio revealed no significant difference between treatment groups. T_3 and T_2 consumed numerically more feed than control group (Dale and Fuller, 1980) and among treatment groups T_4 consumed lower amount of feed. The feed conversion ratio was superior in T_4 compared to all other treatment groups. This finding favourably compared with those earlier reports of Fan *et al.* (1995) who reported that no significant difference in feed conversion ratio in growing chickens fed with rice bran oil or maize oil or blended oil. Similarly, Atteh *et al.* (1983) stated that increasing animal - vegetable blend fat content in broiler diets had no significant effect on feed consumption. Nitsan *et al.* (1997) expressed similar opinion about the inclusion of fat in broiler diet.

On the contrary, Purushothaman *et al.* (2005) stated that

Table 2: Ingredients and nutrient composition (%DM) of broiler finisher ration

Ingredients	T1	T2	T3	T4	T5	T6
Maize	63	61	58	55	52	48
Soya	27	27	27	27	27	27
Fish meal	5	5	5	5	5	6
DORB	2	3	5	7	9	11
Calcite	2	2	2	2	2	2
DCP	1	1	1	1	1	1
Crude rice bran oil	0	1	2	3	4	5
Total	100	100	100	100	100	100
Supplements						
Vitamins AB_2D_3K[1]	0.01	0.01	0.01	0.01	0.01	0.01
B-Complex[2]	0.02	0.02	0.02	0.02	0.02	0.02
Trace minerals[3]	0.1	0.1	0.1	0.1	0.1	0.1
Lysine	0	0	0	0	0	0
Methionine	0.2	0.2	0.2	0.2	0.2	0.2
DOT[4]	0.05	0.05	0.05	0.05	0.05	0.05
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Endox[5]	0.05	0.05	0.05	0.05	0.05	0.05
Toxin binder[6]	0.025	0.025	0.025	0.025	0.025	0.025
Total	0.805	0.805	0.805	0.805	0.805	0.805
Nutrients						
Crude protein	20.33	20.28	20.27	20.26	20.25	20.6
M.E (kcal/kg)*	2904	2904	2922	2925	2927	2919
Crude fibre	3.64	3.72	3.91	4.1	4.29	4.48
Ether extract	2.88	2.81	2.71	2.61	2.51	2.39
Total ash	5.98	6.1	6.36	6.62	6.88	7.25
Nitrogen free extract*	67.17	67.09	66.75	66.41	66.07	65.28
Calcium	1.34	1.36	1.4	1.43	1.47	1.56
Total Phosphorus	0.61	0.62	0.64	0.66	0.68	0.73
Lysine*	1.19	1.2	1.2	1.2	1.2	1.25
Methionine*	0.37	0.37	0.37	0.36	0.36	0.37

*Calculated values. [1]One gram of vitamin AB_2D_3K supplement contained 82500 IU of vitamin-A, 50mg of vitamin-B_2, 12000 IU of vitamin-D_3 and 10mg of vitamin-K. [2]One gram of B-complex supplement contained 80mg of vitamin-B_1,16mg of vitamin-B_6, 80mcg of vitamin-B_{12}, 80mg of vitamin-E, 120mg of niacin, 8mg of folic acid, 80mg of calcium pantothenate and 86mg of calcium. [3]One gram of trace minerals contained 54mg of manganese, 52mg of zinc, 20mg of iron, 2mg of iodine and 1mg of cobalt. [4]One gram of DOT contained Dinitro-ortho-toluamide 25mg w/w. [5]Ethoxyquin, BHT and chelating agents. [6]Hydrated sodium alumino silicate (HSCAS), organic acids, vinylpyrrolidone homopolymer, mannanoligosaccharide (MOS) activated charcoal and lipotropic factors.

during finisher phase (4-6 weeks) the feed consumption in the rice bran oil and tallow fed groups were significantly higher than control group.

Livability: The analysis of data on livability revealed no significant difference between treatment groups. There was only one bird mortality in T_6 at 7th week of age during the entire experimental period which indicated the inclusion of crude rice bran oil in broiler diet up to 5 percent on isocaloric and isonitrogenous basis had no effect on livability. It was consistent with Atteh *et al.* (1983) who observed that supplementation of animal - vegetable blend fat had no effect on mortality at 3 weeks of age in male broilers. Similarly, Vanschoubroek *et al.* (1971) reported that addition of animal fat and vegetable oils (4.5 percent) to the chick ration had no effect on mortality.

Carcass characteristics

Carcass yield: Statistical analysis of data on carcass characteristics revealed no significant difference among treatment groups due to dietary inclusion of crude rice bran oil. Ready-to-cook percentage was numerically high in T_2 compared to all other treatment groups due to low abdominal fat wastage. Eventhough, ready-to-cook percentage was low in T_6, there was no significant difference among treatment groups which was in agreement with the findings of Murugesan (1997) who reported no significant difference in carcass yield, liver fat weight and muscle lipid content by inclusion of Acidulated Rice bran oil Soapstock (ARS) in broiler diet. Similarly, Purushothaman *et al.* (2000) and (2005) reported that no significant difference in dressed weight, liver weight and skin weight among the various groups fed with palm oil, rice bran oil and tallow in broiler diet. Raju *et al.* (2005) also reported that addition of sunflower oil at 30 to 60 g/kg had little or no effect on ready-to-cook yield and fat content of muscle and skin of broilers.

Abdominal fat percentage: The analysis of data on abdominal fat percentage revealed no significant difference among treatment groups due to dietary inclusion of crude rice bran oil. This finding favourably

Table 3: Mean (±S.E.) body weight (g/bird) of broilers fed diet with different levels of crude rice bran oil

Age (weeks)	Inclusion level of crude rice bran oil					
	T1 - 0%	T2 - 1%	T3 - 2%	T4 - 3%	T5 - 4%	T6 - 5%
Hatch weight	49.22±0.69	47.5±0.24	47.75±0.44	48.25±0.73	48.31±0.87	47.59±0.58
I Week	139.92±2.30	127.72±4.80	130.17±1.53	133.92±2.47	133.78±2.52	139.61±2.43
II Week	358.61^{a}±3.00	325.83^{c}±12.08	327.82^{bc}±10.51	351.61^{ab}±1.08	366.03^{a}±9.08	359.05^{a}±5.16
III Week	700.5±10.36	664.11±3.78	624.59±10.74	682.64±13.92	703.89±1.90	703.75±13.94
IV Week	1097.22±17.15	1073.19±5.59	1094.97±9.65	1105.05±22.46	1124.67±19.29	1119.7±20.82
V Week	1528.31±12.44	1513.58±14.19	1536.22±18.24	1529.97±32.21	1539.33±29.57	1516.72±35.88
VI Week	1968.19±18.75	1983.92±23.21	2008.02±26.59	2002.75±48.46	1993.81±22.91	1905.72±79.50
VII Week	2354.03±22.76	2412.91±58.20	2427.74±30.55	2406.78±69.27	2357.78±21.77	2274.22±119.71

Each value is a mean of 36 observations. $^{a-c}$Means within a row with no common superscript differ significantly (P<0.05)

Table 4: Mean (±S.E.) cumulative feed consumption (g/bird) of broilers fed diet with different levels of crude rice bran oil

Age (weeks)	Inclusion level of crude rice bran oil					
	T1 - 0%	T2 - 1%	T3 - 2%	T4 - 3%	T5 - 4%	T6 - 5%
I Week	102.25±5.55	106.78±1.14	98.42±4.03	101.08±4.65	100.92±5.15	100.81±2.51
II Week	428.81±20.05	446.31±1.13	446.44±9.40	432.14±19.49	433.97±14.03	442.47±7.74
III Week	1091.53±10.76	1106.69±18.32	1124.1±20.95	1078.97±20.96	1099.84±21.30	1117.14±9.40
IV Week	1990.92±9.07	2021.53±34.73	2047.4±51.08	1966.94±23.27	2007.5±42.61	2040.25±19.52
V Week	3040.78±26.52	3087.22±46.52	3112.14±64.73	2980.97±27.65	3040.72±65.33	3097.22±38.81
VI Week	4213.22±41.37	4281.22±60.55	4312.2±68.38	4115.25±45.41	4218.17±65.69	4267.94±55.87
VII Week	5352.89±56.28	5437.75±67.07	5479.25±78.24	5211.83±54.74	5339.83±60.89	5437.71±56.94

Each value is a mean of 3 observations

Table 5: Mean (±S.E.) cumulative feed conversion ratio of broilers fed diet with different levels of crude rice bran oil

Age (weeks)	Inclusion level of crude rice bran oil					
	T1 - 0%	T2 - 1%	T3 - 2%	T4 - 3%	T5 - 4%	T6 - 5%
I Week	1.13±0.08	1.34±0.09	1.19±0.03	1.19±0.09	1.19±0.08	1.1±0.05
II Week	1.38^{a}±0.05	1.61^{b}±0.07	1.60^{b}±0.06	1.42^{a}±0.07	1.37^{a}±0.04	1.42^{a}±0.05
III Week	1.67±0.01	1.8±0.04	1.8±0.01	1.7±0.01	1.68±0.03	1.7±0.05
IV Week	1.9±0.04	1.97±0.03	1.95±0.04	1.86±0.02	1.87±0.01	1.9±0.04
V Week	2.06±0.03	2.11±0.02	2.09±0.05	2.01±0.03	2.04±0.01	2.11±0.05
VI Week	2.2±0.04	2.21±0.01	2.2±0.06	2.1±0.03	2.17±0.01	2.31±0.09
VII Week	2.32±0.05	2.3±0.03	2.3±0.06	2.21±0.04	2.31±0.03	2.45±0.14

Each value is a mean of 3 observations. a-c Means within a row with no common superscript differ significantly (P<0.05)

percent had no significant (P>0.05) effect on abdominal compared with earlier reports of Griffiths *et al.* (1977) who observed that the dietary fat levels of 0, 3, 6 and 9 fat pad size in male broiler chickens at 8 weeks of age. Similarly, Alao and Balnave (1985) reported that neither type of fat supplement nor the level of supplementation had any significant influence on carcass fat content of male broilers.

Muscle cholesterol: The analysis of data on breast muscle cholesterol revealed no significant diff erence among treatment groups due to dietary inclusion of crude rice bran oil. But the thigh muscle cholesterol revealed significant (P<0.05) difference among the treatment groups. It was consistent with Ramesh Kumar (2000) who revealed that total cholesterol content of muscle was significantly reduced in groups fed sunflower seed, sunflower oil and rice bran oil when compared to groups fed tallow, palm oil and no fat / oil in broilers.

Breast muscle had lower cholesterol values than thigh muscle, because of its lower fat content. Cholesterol content was significantly influenced by the dietary fatty acid profile in broiler chickens at 49 days of age (Crespo and Esteve-Garcia, 2001).

Serum biochemistry

Serum total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides: Statistical analysis of data on serum biochemical parameters revealed no significant difference among the treatment groups by dietary inclusion of crude rice bran oil. There was proportional decrease in the values of total serum cholesterol when the level of inclusion of crude rice bran oil in the diet was increased from 1 to 5 percent. This finding was consistent with Fan *et al.* (1995) who reported that serum triglycerides and LDL cholesterol are lowered in growing chickens fed with diet containing blended oil (rice bran oil + maize oil).

Similarly, Ramesh Kumar (2000) stated that total

Table 6: Mean (±S.E.) carcass characteristics and biochemical parameters of broilers at 7 weeks of age fed diet with different levels of crude rice bran oil

Carcass characteristics	Inclusion level of crude rice bran oil					
	T1 - 0%	T2 - 1%	T3 - 2%	T4 - 3%	T5 - 4%	T6 - 5%
Pre-slaughter live weight (g)	2354.03±22.76	2412.91±58.20	2427.74±30.55	2406.78±69.27	2357.78±21.77	2274.22±119.71
New York dressed weight (g)	2159.5 ±127.04	2211.33±91.07	2124.5±93.34	2146.33±112.28	2181.67±94.48	2082.67±126.60
Eviscerated carcass weight (g)	1924.17 ±114.31	1959.67±97.62	1874±92.87	1894.17±102.10	1938.67±89.85	1808.33±112.25
Ready-to-cook yield (%)	75.47±0.49	76.32±0.56	74.94 ±0.21	75±0.29	75.32±0.24	72.78±3.08
Giblets (g)						
Gizzard	50.67±2.79	43.67±1.67	44.83±2.18	45±2.89	44.17±2.27	40.67±1.36
Liver	45.5±1.91	42.5±2.19	41.33±2.11	40.5±2.59	42.5±3.45	44.67±1.17
Heart	12.17±0.31	12±0.93	12±0.26	11.17±0.75	12.5±0.99	12.17±0.95
Abdominal fat percentage	0.96 ±0.19	0.58±0.11	0.65±0.13	0.75±0.12	0.86±0.16	0.9±0.07
Breast muscle cholesterol (mg/dl)	86.79±13.49	62.65±12.84	58.29±10.77	54.31±18.39	45.87±9.54	32.27±3.50
Thigh muscle cholesterol (mg/dl)	185.13^{a}±27.61	148.83^{ab}±26.89	127.12^{ab}±4.45	103.78^{b}±32.28	90.99^{b}±30.51	50.22^{c}±2.82
Total cholesterol (mg/dl)	90.96±7.77	90±8.85	84.78±9.63	81.12±5.55	75.83±5.23	74.17±5.97
HDL cholesterol (mg/dl)	25.94±1.97	27.2±1.28	27.27±2.21	27.51±1.34	27.83±0.94	27.83±1.70
LDL cholesterol (mg/dl)	61.84±8.39	61.22±7.15	54.78±9.82	51.51±5.97	46.69±5.54	44.32 ±5.72
Triglycerides (mg/dl)	12.35 ±0.47	12.05±1.03	11.11±1.36	10.85±0.70	10.1±1.81	8.18±0.71

Each value is a mean of 6 observations. a-cMeans within a row with no common superscript differ significantly (P<0.05)

cholesterol contents of serum were significantly reduced and HDL cholesterol contents of serum were significantly increased in groups fed with sunflower seed, sunflower oil and rice bran oil.

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