TÜBİTAK

Turkish Journal of Veterinary and Animal Sciences

http://journals.tubitak.gov.tr/veterinary/

Research Article

Turk J Vet Anim Sci
(2013) 37: 31-37
© TÜBİTAK
doi:10.3906/vet-1106-17

Effects of feeding dry fat and yeast culture on broiler chicken performance

Mutassim Mohamed ABDELRAHMAN*
Department of Animal Production, College of Food and Agriculture Sciences, King Saud University,
P.O. Box 2460, Riyadh 11451, Saudi Arabia

Received: 13.06.2011 • **Accepted:** 30.05.2012 • **Published Online:** 22.01.2013 • **Printed:** 22.02.2013

Abstract: A feeding trial with 400 male broilers (Ross) was conducted to investigate the effect of using dry fat and 2 levels of yeast culture (*Saccharomyces cerevisiae*) on performance, blood glucose, cholesterol, calcium, phosphorus, cobalt, copper, magnesium, manganese, and zinc. One-day-old broilers were distributed among 4 treatments, with 4 replicates and 25 chicks/replicate. The treatments were: diet 1 (basal diet with maize oil, group T1), diet 2 (basal diet with dry fat, group T2), diet 3 (basal diet with dry fat + 2 kg of yeast culture/t diet, group T3), and diet 4 (basal diet with dry fat + 3 kg of yeast culture/t diet, group T4). Measurements included body weight gain, feed intake and conversion, serum parameters, carcass weight, and abdominal fat. The inclusion of dry fat and 3 kg of yeast culture/t improved body weight gain and feed conversion ($P < 0.05$) compared with chicks from groups T2 and T3, but no differences were observed when compared with the control group. The serum cholesterol levels were significantly ($P < 0.05$) reduced by adding the yeast culture when compared with chicks from the control and T2 groups. Furthermore, the abdominal fat percentages were significantly lower in chicks from groups T1, T3, and T4 compared with that of group T2. The Co and Zn concentrations in the liver were significantly reduced ($P < 0.001$ and $P < 0.05$, respectively) by feeding of yeast culture, but no effect was observed for Cu, Mn, and Mg concentrations. In conclusion, the addition of yeast culture (3 kg/t) to diets containing dry fat improves broiler growth performance and positively affects the carcass characteristics by reducing the abdominal fat and blood cholesterol level.

Key words: Yeast culture, broiler, abdominal fat, dry fat, cholesterol

1. Introduction

Much of the world's human population suffers from malnutrition. In Saudi Arabia and many other developing countries, the profit of raising broilers is very marginal because of the high feed costs, poor growth rate, poor feed conversion, and high mortality rate. Saudi Arabia, one of the countries in the Middle East, raises more than 10,000,000 broiler chicks/month. This number is very high because of the competitive price of a unit of white meat compared with dark meat.

Commercial strains of broilers are genetically capable of high rates of rapid growth at maximum feed conversion. This tremendous potential cannot be fully expressed unless the broiler rations are nutritionally adequate and the conditions in the intestinal tract promote the maximum digestion and absorption of nutrients. Unless this genetic potential is fully expressed, broiler producers stand to suffer economic loss. Natural commercial products such as yeast culture and other products may be used to reduce mortality and improve and maximize the genetic potential of broilers regarding feed efficiency and weight gain.

Reports related to improved poultry performance resulting from the addition of yeast culture are limited and inconsistent. Daghir and Abdul-Baki (1) studied the performance of broilers given yeast protein cultured on molasses to replace part of the soybean meal and/or fish meal. They found that the yeast might replace up to one-third of the soybean and all of the fish meal in the broiler rations if the methionine concentrations in all of the treatments were balanced. Plavnik and Scott (2) reported an improvement of leg weakness condition when a complete, practical broiler diet was supplemented with 2.5% and 5.0% brewer's dried yeast. Stanley et al. (3) showed that body weight would increase and the severity of aflatoxins would decrease when broiler chicks were fed diets containing 0.1% *Saccharomyces cerevisiae*. Madriqal et al. (4) reported an improvement of the feed utilization of broilers when fed 50, 100, and 200 g/t of *Saccharomyces cerevisiae* var. *boulardii* from 1 to 49 days of age. Bradley et al. (5) showed that supplemental yeast (*Saccharomyces cerevisiae* var. *boulardii)* at rates of 0.01%, 0.02%, and 0.06% in rations for poultry increased the body weight of chicks without any significant difference in feed consumption at 7, 14, and 21 days of age.

* Correspondence: mutassimm@yahoo.com

Hosseini (6) and Onifade (7) reported an increase in body weight, feed conversion, and carcass weight when yeast culture was added to broiler rations.

Trace minerals are well known to be essential in animal health (immunity) and productivity by playing a vital role in many physiological and biochemical reactions in animals' bodies, mainly as a component of many enzymes. Few studies were conducted to examine the effect of feeding yeast culture on trace mineral metabolism in monogastric and ruminant animals. Bradley and Savage (8) reported a significant increase ($P < 0.05$) in the retention of some minerals (Ca, P, Mn, and K) in turkey chicks when fed live yeast culture (*Saccharomyces cerevisiae*) compared with those fed the control or autoclaved yeast culture.

This study was conducted to evaluate the effect of feeding 2 levels of yeast culture (*Saccharomyces cerevisiae*) with dry fat on the growth performance, dressing percentage, and mineral utilization of broiler chickens.

2. Materials and methods

A total of 400 one-day-old male broilers (Ross) were randomly distributed as a complete randomized block design into 4 equal treatments, each with 4 replicates (25 chicks/replicate). The chicks were reared in an open house in pens providing a floor area of 3 m^2 (2 m × 1.5 m) covered with wood shavings. The treatments were: diet 1, basal diet (corn–soybean–oil meal diet, group T1); diet 2 (corn–soybean–dry fat meal diet, group T2); diet 3 (diet 2 plus 2 kg of Diamond V yeast culture/t diet, group T3); and diet 4 (diet 2 plus 3 kg of Diamond V yeast culture/t diet, group T4). The chemical composition of the dry fat (Feedar) used in this study was: gross energy, 7400–7600 kcal/kg; 95%–97.5% dry matter; 18%–20% ash; and 7.5%–8.5% Ca. Diamond V (Diamond V Mills, Inc., USA) is a dried product composed of yeast (*Saccharomyces cerevisiae*).

All of the rations were formulated by using the BLP88™ computer program for formulating least cost rations. All of the rations in the starter and finisher periods were formulated to be isocaloric and isonitrogenous according to National Research Council (9) recommendations. The chemical composition and nutritive value of the experimental diets are presented in Table 1. The chicks were fed starter rations from 1 to 21 days of age and finisher rations from 22 days of age until the completion of the experiment, at 42 days of age. Live body weight and feed intake were recorded weekly until the 6th week of age and the feed conversion ratio was calculated. Five chicks from each replicate were slaughtered after an overnight fast by severing the jugular vein, allowed to bleed for 120 s, scalded at 54 °C for 2 min in a dunking scalder, picked for 30 s in a rotary drum picker, and eviscerated manually. Blood and liver samples were collected for further analyses. Abdominal fat (surrounding the gizzard, cloaca, and adjacent abdominal muscles) was removed and weighed for calculations. Hot carcass weights were recorded and the dressing percentage was calculated as a percent of the live weight.

Liver samples were dried at 105 °C overnight, ashed by muffle furnace (600 °C/6 h), and prepared for mineral analysis according to the AOAC method (10) using an atomic absorption spectrophotometer. Moreover, blood serum was separated by centrifugation of the blood at 3000 rpm for 15 min. The serum was analyzed for cholesterol and glucose using laboratory kits (Chemelex, Industria, Barcelona, Spain) by spectrophotometer. The blood serum Ca concentration was analyzed using an atomic absorption spectrophotometer with lanthanum chloride and P by spectrophotometer according to the method of the AOAC (10).

Data were analyzed by using SPSS 10.0 (SPSS, Chicago, Illinois, USA). Duncan's multiple range test was used to determine the differences among the treatment means for significant dietary effect (11), with $P < 0.05$ considered statistically significant unless otherwise noted.

3. Results

3.1. Production performance

Table 2 presents the weight gain, feed intake, and feed conversion during the starter, finisher, and overall periods of production. A significant effect of the dietary treatments on weight gain during the starting and finishing stages was observed. Broilers fed dry fat (group T2) showed a significantly ($P = 0.02$) lower overall (0–42 days) weight gain compared with groups T1, T3, and T4. Treatments did not affect ($P > 0.05$) the feed intake during the starting, finishing, and overall periods. A significant effect of the dietary treatment was detected regarding the overall feed conversion ratio ($P = 0.03$). The addition of the yeast culture at a level of 3 g/kg to the feed containing dry fat improved the feed conversion as compared to the nonsupplemented group and the group receiving 2 g/kg diet, whereas no difference was found when compared to the control group.

3.2. Carcass quality and blood parameters

The effects of treatments on carcass quality and blood parameters are shown in Table 3. The dietary treatments did not cause a significant ($P > 0.05$) difference in the carcass dressing percentages among any of the groups, but a significant effect was detected in the abdominal fat percentages. Chicks fed dry fat instead of oil accumulated a significantly higher percentage of abdominal fat when compared with the other groups. Moreover, a significantly ($P = 0.05$) higher concentration of blood serum cholesterol was found in chicks fed dry fat (group T2) compared with the control, T3, and T4 groups. The treatment did not cause any significant ($P > 0.05$) effect on the concentrations of glucose, Ca, and P in the blood serum of all of the groups

Table 1. Composition of the starter and finisher experimental diets containing corn oil or dry fat (Feedar) used in this study.

Ingredient	Starter		Finisher	
	Corn oil	Dry fat	Corn oil	Dry fat
Corn	54.22	54.40	60.38	60.46
Soybean meal	36.70	36.51	30.00	30.00
Corn oil	3.10	-	3.60	-
Dry fat (Feedar)	-	4.00	-	4.50
Fish meal	2.50	2.50	2.50	2.50
Dicalcium phosphate	1.65	1.65	1.55	1.55
Limestone	1.14	0.25	1.20	0.22
Methionine	0.17	0.17	0.14	0.14
Lysine	0.047	0.05	0.14	0.14
Salt	0.30	0.30	0.32	0.32
Vitamins + minerals*	0.10	0.10	0.10	0.10
Choline	0.07	0.07	0.07	0.07
Total	100%	100%	100%	100%
Calculated composition				
Metabolizable energy (kcal/kg)	3000	3000	3100	3100
Crude protein (%)	22.5	22.5	20.0	20.0
Methionine (%)	0.54	0.54	0.48	0.48
Lysine (%)	1.3	1.3	1.2	1.2
Fiber (%)	3.75	3.75	3.5	3.5
Calcium (%)	1	1	0.98	0.98
Available P (%)	0.46	0.46	0.43	0.43
Sodium (%)	0.17	0.17	0.17	0.17

*Vitamin and mineral premix: every 1 g of premix contained vitamin A, 1500 IU; vitamin D_3, 150 IU; vitamin E, 200 µg; vitamin B_1, 200 µg; vitamin B_2, 200 µg; vitamin B_6, 300 µg; vitamin B_{12}, 0.5 µg; vitamin K_3, 200 µg; folic acid, 30 µg; pantothenic acid, 550 µg, nicotinamide, 1 mg; Fe_2SO_4, 550 µg; Mn_2SO_4, 450 µg; Zn_2SO_4, 230 µg; Cu_2SO_4, 56 µg; and Ca_2CO_3, 14 µg.

even though dry fat contains high levels of Ca, but dry fat Ca seems to be highly available and is absorbed efficiently compared with dicalcium phosphate.

3.3. Trace mineral concentrations in the liver

Table 4 shows the trace mineral concentrations in the liver of chickens receiving the different dietary treatments. The dietary treatment caused a significant change in the Co ($P = 0.001$) and Zn ($P = 0.05$) concentrations in liver of the chicks, with significantly lower values for chicks fed yeast culture (Table 4). There was no significant ($P > 0.05$) effect of the treatments on the concentrations of Cu, Mn, and Mg in the liver of the chicks. Moreover, significantly lower Zn concentrations were found in the liver of chicks fed dry fat (group T2) when compared with the control, but this did not significantly differ when compared with the chicks fed the 2 levels of yeast culture.

Table 2. Effect of feeding different levels of yeast culture with dry fat on the performance of broiler chickens.

Measurements	Treatments					
	Control T1[i]	T2[ii]	T3[iii]	T4[iv]	SE	P-value
Weight gain (g)						
1–21 days	652	601	593	646	14.2	>0.05
22–42 days	1440	1340	1400	1450	19.6	>0.05
1–42 days	2140a	2020b	2080a	2145a	19.8	0.02
Feed intake (kg)						
1–21 days	1.55	1.52	1.55	1.56	0.02	>0.05
22–42 days	3.58	3.52	3.50	3.47	0.03	>0.05
1–42 days	5.1	5.02	5.03	5.06	0.03	>0.05
Feed conversion						
1–21 days	2.37	2.47	2.51	2.43	0.03	>0.05
22–42 days	2.47	2.46	2.49	2.38	0.04	>0.05
1–42 days	2.39a	2.47b	2.46b	2.35a	0.02	0.03

[a,b,c]: Means in rows with no common superscript differ significantly.
[i]: Fed corn oil as a source of energy.
[ii]: Fed dry fat instead of corn oil as a source of energy.
[iii]: Fed dry fat with 2 kg yeast culture/t of feed.
[iv]: Fed dry fat with 3 kg yeast culture/t of feed.
SE = Standard error of means.

Table 3. Effect of feeding different levels of yeast culture with dry fat on the carcass parameters of broiler chickens.

Measurements	Treatments					P value
	Control T1[i]	T2[ii]	T3[iii]	T4[iv]	SE	
Dressing percentage*	72.90	72.70	73.70	72.81	0.281	>0.05
Abdominal fat%**	3.25a	3.42b	3.09a	2.98a	0.18	0.03
Blood cholesterol (mg/dL)	182.1a	193.8b	132.9c	139.3c	3.6	0.05
Blood glucose (mg/dL)	381.2	375.1	401.0	391.5	6.1	>0.05
Blood serum Ca (mg/dL)	10.3	11.6	11.3	10.5	0.86	>0.05
Blood serum P (mg/dL)	7.15	6.73	7.34	6.9	0.92	>0.05

[a,b,c]: Means in rows with no common superscript differ significantly.
[i]: Fed corn oil as a source of energy.
[ii]: Fed dry fat instead of corn oil as a source of energy.
[iii]: Fed fat with 2 kg yeast culture/t of feed.
[iv]: Fed fat with 3 kg yeast culture/t of feed.
*Dressing percentage is a prechill carcass taken as a percentage of live weight.
**Abdominal fat is calculated as a percentage of fat pad weight of prechill carcass.
NS = Not significant, SE = standard error of means.

Table 4. Effect of feeding different levels of yeast culture and dry fat on trace mineral concentrations in the liver of broiler chickens.

Measurement	Treatments					P-value
	Control T1[i]	T2[ii]	T3[iii]	T4[iv]	SE	
			Dry weight (µg/g)			
Co	0.543a	0.785b	0.330c	0.149d	0.05	0.0001
Cu	52.85	43.7	61.1	60.1	3.54	>0.05
Mn	41.9	25.9	45.2	36.1	2.7	0.10
Mg	3035.8	2360	2900.1	2658.8	112.9	0.10
Zn	36.4a	25.6b	35.2a	29.2ab	1.64	0.05
			Wet weight (µg/g)			
Co	0.183a	0.213a	0.13b	0.098b	0.04	0.001
Cu	13.22	11.38	15.25	15.42	0.86	>0.05
Mn	10.7	6.7	10.5	9.14	0.64	0.10
Mg	761.5	615.7	730.8	637.6	25.8	>0.05
Zn	9.2a	6.7b	8.94ab	7.52ab	0.39	0.03

[a,b,c]: Means in rows with no common superscript differ significantly.

[i]: Fed corn oil as a source of energy.

[ii]: Fed dry fat instead of oil as a source of energy.

[iii]: Fed fat with 2 kg yeast culture/t of feed.

[iv]: Fed fat with 3 kg yeast culture/t of feed.

WW = Wet weight, DW = dry weight, SE = standard error of means.

4. Discussion

This study was designed to evaluate the effect of feeding 2 levels of yeast culture (*Saccharomyces cerevisiae*) with dry fat on the growth performance, dressing percentage, and mineral utilization of broiler chickens. Broiler chicks that were fed dry fat (group T2) showed a significantly (P = 0.02) lower overall (0–42 days) weight gain compared with groups T1, T3, and T4. These results are not in agreement with the findings of Pesti et al. (12), who reported no significant differences in body weight at 39 days due to the fat sources, although the value for chicks fed corn oil (2.46 ± 0.08 kg) was numerically higher compared to chicks fed dry fat (2.38 ± 0.06 kg). Furthermore, the scientific literature related to feeding yeast culture (*Saccharomyces cerevisiae*) to broiler chickens has been inconsistent in its findings. Zhang et al. (13), Gao et al. (14), Ignacio (15), and Onifade et al. (16) reported that feeding yeast culture to chicks improves the body weight gain and feed conversion ratio. On the other hand, the findings of Madriqal et al. (4) and Karaoglu and Durdag (17) were in disagreement with our findings regarding body weight gain. Onifade et al. (18) reported that yeast culture supplementation in broilers improves the feed conversion but not the growth rate. In contrast, Kanat and Çalışlar (19) found that feeding yeast culture to broilers effectively increased body weight gains without affecting the feed/gain ratio, which was in complete disagreement with our findings in this study. Moreover, Karaoglu and Durdag (17) reported no significant effect of yeast on the average feed consumption (1–49 days) and feed conversion (1–49 days), which was in partial agreement with our findings. In a recent study by Hosseini (6), he reported a significant improvement in weight gain, body weight, and feed consumption throughout the experiment, which was in complete disagreement with most of our findings, except for the total weight gain.

The most crucial concern of the poultry industry is to obtain a higher dressing percentage and consequently increase the edible portion and profit. On the other hand, the consumers are concerned about meat quality in terms of high nutritive value with lower fat content. The high consumption of saturated fatty acids from poultry meat by humans causes an increase in serum cholesterol and, consequently, increases the risk of coronary heart

disease (20). Abdominal fat is highly correlated (0.6 to 0.9) with the total carcass lipids and is used as a main criterion reflecting excessive fat deposition in the broiler carcass (21). Therefore, there is a substantial potential for using yeast culture to reduce fat and improve meat quality.

A significantly ($P = 0.05$) higher concentration of blood serum cholesterol was found in chicks fed dry fat (group T2) compared with the control, T3, and T4 groups. Generally, once dietary fat is absorbed, saturated fatty acids tend to be deposited in the body while unsaturated fatty acids tend to be oxidized to produce energy and heat (22). More unsaturated fatty acids from vegetable oil tend to produce lower energy retention and higher heat production in mice and humans (23,24). Moreover, Shimomura et al. (25) and Takeuchi et al. (26) found a similar response by feeding safflower oil to rats. These findings support our results, which conclude that the feeding of higher saturated fatty acid as dry fat increases the deposition of fat in broiler tissues and the cholesterol level in the blood serum when compared to vegetable oil. However, the chicks from the groups fed the 2 levels of yeast culture showed significantly lower blood serum cholesterol when compared with the control and T1 groups. There was no significant difference between the groups receiving the 2 levels of yeast in terms of the cholesterol concentration in their blood serum. This gives an indication that yeast culture may play an important role in reducing the levels of cholesterol and the accumulation of fat in the broiler tissues by affecting their absorption and metabolism. The mechanisms proposed for the lowering of the blood serum cholesterol level by yeast culture probiotics are numerous. One of the proposed mechanisms includes the enzymatic effect on gallbladder bile salt deconjugating under anaerobic conditions by bile-salt hydrolase of probiotics, which mainly consist of cholesterol. Once deconjugated, bile acid is less soluble and is easily eliminated in the feces. Hence, the cholesterol will be used to synthesize new bile salts in a homeostatic response that results in lowering the serum cholesterol (27). Other researchers reported that probiotics remove cholesterol by binding onto the cellular surface and incorporating in the cellular membrane during growth (28). In general, if the influence is not at the gut level, then it must be due to some basic effect on bird metabolism, which needs more research for a better understanding.

The liver is considered as a storage organ for certain minerals (29), and analysis of liver mineral concentrations is a useful indicator of the mineral status in livestock. Trace minerals are very important elements that are required for basically all biochemical process in an animal's body. Despite their relatively low requirements, severe or marginal deficiencies of these trace minerals can cause substantial economic losses by affecting animal performance and health. Therefore, liver samples were collected, prepared, and analyzed for Cu, Zn, Co, Mg, and Mn, as the dry and wet weight of the liver. According to Puls (30), all of the trace mineral concentrations in the liver and the Ca and P in the blood serum were in the physiological range.

In general, trace mineral bioavailability can be affected by many dietary factors, including feed additive, interaction with dietary nutrients and ingredients, choice of response criteria, choice of standard source, chemical form, and the solubility of the mineral. Bradley and Savage (8) reported a significant increase ($P < 0.05$) in the retention of some minerals (Ca, P, Mn, and K) in turkey chicks when fed live yeast culture compared with the control and autoclaving yeast culture groups. Therefore, the results of this experiment support the general idea that yeast culture somehow plays an important role in increasing the absorption and retention of some minerals by modifying the conditions in the digestive tract of poultry, and consequently reduces the soil contamination through their excreta. On the other hand, the interaction between the minerals, both antagonistic and synergistic, affects the bioavailability of the minerals and their absorption. For example, feeding high Ca levels along with plant protein containing phytates leads to a reduction in the bioavailability of dietary Zn, to the point of severe deficiency of the element (29). Hence, using dry fat may affect the absorption of Zn and Co, since it consists of a high level of Ca (7.5% to 8.5%) and other minerals (ash, 18%–20%), by competing to bind to sites in the small intestinal tract luminal surface of the mucosal cells and proteins (metallothionein and cysteine rich intestinal proteins) and consequently reducing absorption. Unfortunately, there were no publications in the literature discussing the possible interaction between dietary minerals and metabolism for monogastrics.

Dry fat (4 kg/t for starter and 4.5 kg/t for finisher) can be used efficiently as a source of energy instead of vegetable oil in broiler diets without any negative effect on chick performance. In terms of meat quality, the feeding of dry fat increases the abdominal fat percentage and blood cholesterol. On the other hand, adding yeast culture (3 kg/t) to a diet containing dry fat reduces the blood serum cholesterol levels, abdominal fat percentages, and improves the general performance of broiler chicks.

Acknowledgments

This project was supported by the King Saud University, Deanship of Scientific Research, College of Food and Agriculture Sciences, Research Center. Appreciation goes to the staff of the animal production farm for providing proper care and management for this trial.

References

1. Daghir, N.J., Abdul-Baki, T.K.: Yeast protein in broiler rations. Poult. Sci., 1997; 56: 1836–1841.
2. Plavnik, I., Scott, M.L.: Effects of additional vitamins, minerals, or brewer's yeast upon leg weaknesses in broiler chickens. Poult. Sci., 1980; 59: 459–464.
3. Stanley, V.G., Ojo, R., Woldesenbet, S., Hutchinson, D., Kubena, L.F.: The use of *Saccharomyces cerevisiae* to suppress the effects of aflatoxicosis in broiler chicks. Poult. Sci., 1993; 72: 1867–1872.
4. Madriqal, S.A., Watkins, S.E., Adams, M.H., Waldroup, A.L., Waldroup, P.W.: Effect of an active yeast culture on performance of broilers. Poult. Sci., 1993; 72: 87 (abstract).
5. Bradley, G.L, Savage, T.F., Timm, K.I.: The effects of supplementing diets with *Saccharomyces cerevisiae var*. boulardii on male poult performance and ileal morphology. Poult. Sci., 1994; 73: 1766–1770.
6. Hosseini, S.C.: The effect of utilization of different levels of *Saccharomysec cerevisiae* on broiler chicken's performance. Global Veterinaria, 2011; 6(3): 233–236.
7. Onifade, A.A.: Growth performance, carcass characteristics, organs measurements and haematology of broiler chickens fed a high fiber diet supplemented with antibiotics or dried yeast. Nahrung., 1997; 41(6): 370–374.
8. Bradley, G.L., Savage, T.F.: The effect of autoclaving a yeast culture of *Saccharomyces cerevisiae* on turkey poultry performance and the retention of gross energy, and selected minerals. Anim. Feed Sci. Technol., 1995; 55: 1–7.
9. National Research Council: Nutrient Requirements of Poultry. National Academy Press, Washington, DC, USA. 1994.
10. AOAC: Official Methods of Analysis. 15th edn., Association of Official Analytical Chemists, Arlington, VA, USA. 1990.
11. Steel, R.G., Torrie J.H.: Principles and Procedures of Statistics. 2nd edn., McGraw-Hill Inc., New York, NY, USA. 1980.
12. Pesti, G.M., Bakalli, R.I., Qiao, M., Sterling, K.G.: A comparison of eight grades of fat as broiler feed ingredients. Poultry Sci., 2002; 81: 380–390.
13. Zhang, A.W., Lee, W.D., Lee, S.K., Lee, K.W., An, G.H., Song, K.B., Lee, C.H.: Effect of yeast (*Saccharomyces cerevisiae*) cell components on growth performance, meat quality and ileal mucosa development of broiler chicks. Poult. Sci., 2005; 84: 1015–1021.
14. Gao, J., Zhang, H.J., Yu, S.H., Wu, S.G., Yoon, I., Quigley, J., Gao, Y.P. Qi, G.H.: Effects of yeast culture in broiler diets on performance and immunomodulatory functions. Poult. Sci., 2008; 87: 1377–1384.
15. Ignacio, E.D.: Evaluation of the effect of yeast culture on the growth performance of broiler chicks. Poult. Sci., 1995; 74: 196 (abstract).
16. Onifade, A.A., Babatunde, G.M., Afonja, S.A., Ademola, S.G., Adesina, E.A.: The effects of a yeast culture addition to a low-protein diet on the performance and carcass characteristics of broiler chickens. Poult. Sci., 1998; 7: 44 (abstract).
17. Karaoglu, M., Durdag, H.: The influence of dietary probiotic (*Saccharomyces cerevisiae*) supplementation and different slaughter age on the performance, slaughter and carcass properties of broiler. Int. J. Poult. Sci., 2005; 4(5): 309–316
18. Onifade, A.A., Odunsi, A.A., Babatunde, G.M., Olorede, B.R., Muma, E.: Comparison of the supplemental effects of *Saccharomyces cerevisiae* and antibiotics in low-protein and high-fiber diets fed to broiler chicken. Arch. Tierernahr., 1999; 52: 29–39.
19. Kanat, R., Çalışlar, S.: A research on the comparison effect on broiler chickens performance of active dried yeast and inactivated and stabilized probiotic yeast supplemented to the rations in different levels. Poultry Sci., 1996; 75: 123 (abstract).
20. Grundy, S.M., Bilheimer, D., Blackburn, H., Brown, W.V., Ovichs, P.O., Mattson, F., Schonfeld, G., Weidman, W.H.: Rationale of the diet-heart statement of the American Heart Association: report of the nutritional committee. Circulation, 1992; 65: 839–851.
21. Chambers, J.R.: Genetics of growth and meat production in chicks. In: Crawford, R.D., Ed. Poultry Breeding and Genetics. Elsevier, Amsterdam. 1990; 599–643.
22. Beynen, A.C., Katan, K.B.: Why do polyunsaturated fatty acids lower serum cholesterol? Am. J. Clin. Nutr., 1985; 42: 560–563.
23. Mercer, S.W., Trayhurn, P.: Effect of high fat diets on energy balance and thermogenesis in brown adipose tissue of lean and genetically obese ob/ob mice. J. Nutr., 1987; 117: 2147–2153.
24. Jones, P.H., Scheeler, D.A.: Polyunsaturated:saturated ratio of diet fat influences energy substrate utilization in the human. Metabolism, 1988; 37: 145–151.
25. Shimomura, Y., Tamura, T., Suzki, M.: Less body fat accumulation in rats fed a safflower oil diet than in rat fed a beef tallow diet. J. Nutr., 1990; 120: 1291–1296.
26. Takeuchi, H., Tatsuhoro, M., Tokutama, K., Shimomura, Y., Suzuki, M.: Diet induced-thermogenesis is lower in rats fed a lard diet than in those fed high oleic acid safflower oil diet or a linseed oil diet. J. Nutr., 1995; 125: 920–925.
27. Begley, M., Hill, C., Gahan, C.G.M.: Bile salt hydrolase activity in probiotics. Appl. Environ. Microbiol., 2006; 72: 1729–1738.
28. Chiang, Y.R., Ismail, W., Heintz, D., Schaeffer, C., Van Dorsselaer, A., Fuchs, G.: Study of anoxic and oxic cholesterol metabolism by *Sterolibacterium denitrificans*. J. Bacteriol., 2008; 190: 905–914.
29. Underwood, E.J., Suttle, N.F.: The Mineral Nutrition of Livestock. 3rd edn., CAB International, Wallingford, UK. 1999.
30. Puls, R.: Mineral Levels in Animal Health. Sherpa International, Clearbrook, Canada. 1988.