Performance and lipid profiles of native chickens fed diet containing skipjack fish oil as by-product of fish canning factory

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**Abstract:** The study was conducted to determine the use of fish oil as by-product of fish canning factory in diet on the performance and lipid profiles of native chickens. The experiment used 100 native chicken with an average initial body weight of 48.9 gram (sd ± 9.9), was used in this study for 8 weeks experiment. These were arranged by a completely randomized design with 5 treatments, 5 replications and 4 hens in replication each. The diets were: R0 = 100% Based Diet (BD) + 0% Fish Oil (FO); R1 = 98.5% BD + 1.5% FO; R2 = 98% BD + 2% FO; R3 = 97.5% BD + 2.5% FO; R4 = 97% BD + 3% FO. Feed and water were provided ad libitum. Variables were performance parameters and lipid profiles. Results showed that fish oil inclusion in diets were significantly increased feed intake, body weight gain, carcass percentage, liver, breast and thigh weight, and decreased blood cholesterol, carbohydrate and meat cholesterol, and also tended to decrease abdominal fat. However, there were no affected on feed conversion, water, protein, fat and ash of breast meat. It can be concluded that the use of fish oil in diet up to 3% could improved performance parameters of native chickens.

**Keywords:** Fish oil, Lipid profiles, Native chicken, Performance

1. Introduction

Chicken meat is widely consumed by people because of the low and medium of fat content. Unlike other animal fats, around two third of poultry fat are unsaturated fatty acids, and they are belonged to omega-3 (n-3) and omega-6 (n-6) fatty acids. Therefore, to develop the meat products with lower fat content and/or higher levels of unsaturated fatty acids, especially n-3 fatty acids, would be desirable as a strategy to help defer cardiovascular and inflammatory pathologies [1-3].

Dietary supplements such as n-3 PUFA have been tested in an attempt to decrease fat and cholesterol contents of poultry meat [4]. In poultry, it is common that dietary fat has a great influence on fatty acid profiles of poultry meat [5,6]. Polyunsaturated fatty acids (PUFA) intake including n-3 and n-6 fatty acids have beneficial effects on both animal and consumer health. However, as [7] reported that excessive intake of n-6 relative to n-3 fatty acids causes an increase in pathogenesis. Dietary fatty acids would be absorbed by monogastric animals and deposited in their tissues without significant modification [8]. It has been recorded that chickens could modify their lipid profile within a week after replacement of the dietary lipid source [9].
Fish lipids in the diet of animals improves health. Both fish oil and fish meal supply lipids and provide source of EPA and DHA for animals. Fish oil that contains unsaturated fatty acids with long omega-3 chains (LC-n-3 PUFA), ecosapentanoic acid (EPA 20:5n-3) and decosahexanoic acid (DHA 22:6n-3) improves health-related factors in humans and animals [5]. They are used because of their growth-promoting effects, their cheap source of energy, and their vitamin A and D content. The deposition of EPA and DHA in animal products such as meat and eggs provides a valuable source in the human diet [10].

The positive effect of fish oil in broiler diets on the performance has been already demonstrated. Fish oil is one of the available sources used in the diet to provide energy for fowl’s while it’s supplementation has been shown to improve body weight gain, feed conversion ratio and safety in the poultry [11-12]. Numerous studies indicated that dietary fish oil declines the level of total cholesterol, low density lipoprotein and triglycerides [13]. Also, it has been shown that fish oil can modify abdominal fat deposition in broiler chickens [14] stated that fish oil improved lipid profiles, reduced proinflammatory eicosanoid contents by inhibiting phospholipase A2 production in broilers; while zinc reduced the contents of plasma malondialdehyde, phospholipase A2, and then decreased the concentration of prostaglandin E2 of broiler. Laying hens can be fed fish oil because of the beneficial effect on egg production and hatchability.

Skipjack fish industrial waste has potential as an alternative feed source in Indonesia. That is a by-product of making wooden fish and canning fish. North Sulawesi Utara is known as one of the region’s potential skipjack fishing ground in Indonesia. The production of skipjack in Sulawesi Utara in 2010 amounted to 60.168.1 tons/per year, where one ton of wet skipjack waste can produce 250 kg of dry waste with 10 kg moisture content [15], and also it can produce fish oil.

To the rural farmers, indigenous chickens are the most preferred for they are not capital intensive [16]. The chickens have little/no religious or social constraints affecting their production [17]. However, indigenous chickens have poor growth rate, low feed conversion efficiency, and their weight is 2.5 times less when compared with exotic breeds of chicken broilers [18].

Native chicken in Indonesia is believed to be the most qualified sources for healthy eggs and chicken meat among Indonesians [19]. Indonesian peoples prefer to consume products of native chicken rather than those of broiler because of its egg and meat’s taste are better. And, they are believed to contain higher nutritional values which bringing about the selling price is relatively more expensive compared to that of broiler chicken products [20]. [21] Stated that productivity of indigenous chicken breeds may be doubled with improved diets and management conditions. The indigenous chickens have not attained their full production potential due to exposure to risks that influence against their survival and productivity under extensive management conditions.

Improved nutrition is critical for increasing egg and meat production in native chickens in Indonesia [22]. However, there was no information about effect of fish oil of native chickens. The objective of this research was to determine the performance and lipid profiles of native chicken fed fish oil as fish canning by-product in diets.

2. Materials and Methods

2.1. Preparation of Samples
Skipjack fish canning waste is liquid fraction mixed with meat residue of fish canning factory. The wastes were collected and then were heated 10-15 minutes at 95 °C, and filtered for separating the solid fraction (meat residue) and liquid fraction (fish oil). The fish oil which have brown color then used as treatments.

Table 1. Fatty Acid Profiles of Skipjack Fish Oil.

| Fatty Acid             | (mg/100 g) |
|------------------------|------------|
|                        |            |
Caprilic acid (C8:0)     Ud
Capric acid (C10:0)     Ud
Lauric acid (C12:0)     1
Miristic acid (C14:0)   56
Pentadecanoic acid (C15:0) Ud
Palmitic acid (C16:0)   518
Stearic acid (C18:0)    250
Arakhidic acid (C20:0)  11

**Total Saturated Fatty Acid** 836

Mysteoleic acid (C14:1) Ud
Palmitoleic acid (C16:1, n-7) 63
Oleic acid (C18:1, n-9) 170
Linoleic acid (C18:2, n-6) 26
α-Linolenic acid (C18:3, n-3) 13
11-Eicocanoic acid (C20:1, n-9) 14
Arakhidonic acid (C20:4, n-6) Ud
EPA (C20:5, n-3) 84
DHA (C22:6, n-3) 601

**Total Unsaturated Fatty Acid** 971

Omega-3 Fatty Acid 0.69 %
Omega-6 Fatty Acid 0.03 %
Omega-9 Fatty Acid 0.18 %

Ud = Undetected

Results of laboratory analysis of nutrition science department and integrated laboratory technology, IPB.

2.2. Birds, Diets and Experimental Design

The research was subject to one-way completely randomized design, rationing. It was used one hundred native chickens animal experiment. The experiment was applied five treatments and four replications. The birds were divided into five experimental diets and each was divided into four replicate groups of five birds per replication using completely randomized design, thus there were 20 unit experiments. The dietary treatment were formulated using similar feed with 45% yellow corn, 9% rice bran, 12% fish meal, 9% soybean meal, and 25% commercial diet. Fish oil was included in five experimental diets at levels of 0%, 1.5%, 2%, 2.5%, and 3%, respectively, to substitute based diet. Fatty acid profiles of skipjack fish oil were shown in Table 1 and the composition and nutrients of diets were shown in Table 2. Feed and water were provided *ad libitum* and diets were presented in mash form. The study was conducted over a period of 8 weeks. The parameters observed were performance: carcass and abdominal fat percentage, heart, liver, breast, thigh, back and wings weight; blood cholesterol, HDL-cholesterol and LDL-cholesterol; meat cholesterol and meat chemical profiles of chickens.

| Table 2. Composition and Nutrients of the Diets |
|-----------------------------------------------|
| | R0 | R1  | R2  | R3  | R4  |
| Ingredients, % | | | | | |
| Based Diet | 100 | 98.5 | 98  | 97.5 | 97  |
| Fish Oil | 0 | 1.5  | 2   | 2.5  | 3   |
One representative bird from each pen was conventionally sacrificed by cervical dislocation technique, as described in the Report of the AVMA Panel on Euthanasia [23]. This technique consists basically on cutting the carotid artery and the jugular vein along the neck (unilateral cut) [24] and its carcass parameters (ready to cook) including dressing percentage and abdominal fat were determined. Carcass characteristics and internal organs were weighted and abdominal fat pad (including fat surrounding gizzard, bursa of fabricius, cloaca & adjacent muscles) was removed and weighed individually for 4 chicks per treatment. Breast muscles of chickens were removed and were weighed individually. Samples were stored at -20 °C until analysis. Four samples of muscle per treatment were taken from the breast and were used to cholesterol, crude fat, protein and carbohydrate, water and ash determination.

2.3. Chemical Analysis
Dry matter was determined by drying samples at 100 °C for 16 h in a pre-weighed dried crucible in a convection oven. Fat was determined by Soxhlet extraction [25]. Starch was measured using alpha-amylase method [25].

2.4. Statistical Analysis
Data were subjected with one-way analysis of variance, and it was continued to Duncan’s multiple range test [26] at a probably level of 5% when the treatment indicated significant effect. All data are expressed in the form of standard error of mean. The IBM SPSS Statistics 22 software was used for the statistical processing of data.

3. Results and Discussion
The effects of dietary treatments on feed intake, body weight gain, carcass percentage and organ weight data obtained are presented in Table 3. Results showed that feed intake, body weight gain, carcass percentage and organ weight were affected by the treatment diets. Fish oil inclusion in diets were significantly increased the feed intake, body weight gain, carcass percentage, liver, breast and thigh weight, and decreased blood cholesterol, carbohydrate and meat cholesterol, and also tended to decrease abdominal fat. However, there were no significant difference between treatments on feed conversion, water, protein, fat and ash of breast meat. This result is not consistent with the findings [27] who reported that the inclusion of FO in poultry diets had no effect on feed intake.

Table 3. Effect of Fish Oil in Diet on Performance and Meat Chemical Profiles of Native Chickens

| Variables | Treatments | SEM | P value |
|-----------|------------|-----|---------|
| Performances | 0% FO | 1.5% FO | 2% FO | 2.5% FO | 3% FO |          |        |
| Total | 100 | 100 | 100 | 100 | 100 | | |
| Calculated composition: | | | | | | |
| Protein (%) | 20.8 | 20.6 | 20.6 | 20.5 | 20.5 | | |
| Fat (%) | 6.83 | 7.1 | 7.48 | 7.85 | 8.23 | | |
| Crude Fiber (%) | 4.83 | 4.75 | 4.73 | 4.70 | 4.68 | | |
| Ca (%) | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | | |
| P (%) | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | | |
| ME (Kcal/kg) | 2905 | 2959 | 2969 | 2978 | 2988 | | |
That higher breast meat was achieved by including linseed oil as a source of precursor, α-linolenic acid [28]. Several trials have shown that an increase in the oil content of long chain n-3 fatty acid (0.69%) and EPA (3.27%) was shown the total n-3 PUFA and monounsaturated fatty acid increased with increasing levels of FO used in this study was a rich source of DHA (601 mg/100 g) and contained n-3 fatty acid (0.69%) and EPA (84 mg/100 g) (Table 1). That was shown the total n-3 PUFA and monounsaturated fatty acid increased with increasing levels of FO in the diet. Several trials have shown that an increase in the oil content of long chain n-3 PUFA in chicken broiler meat may be achieved by including linseed oil as a source of precursor, α-linolenic acid [28].

In recent year, high growth performance, properties of carcass and meat quality have been beneficial to the broiler production. Especially is on better body composition with higher breast meat yield and lower abdominal fat. According to [29] that the use of fish oil in native chickens up to 7.5% could reduce lipid consumption and increase carcass yield but the result as relatively similar effect to blood profile, feed and energy consumption. Also [30] reported that Thai native chicken has an advantage over broiler in terms of carcass composition and meat quality traits such as high WHC, firm meat texture and high protein as well as low fat content.

The internal organs of Thai native chickens were liver 2.17%, heart 0.44% and dressing percentage 64.54%, that can be the alternative "healthy" meat. [31] reported that chicks fed diets containing 4% fish oil had a significantly lower ether extract in breast, but a higher ether extract concentration in thigh. The present study showed that deposition of broiler abdominal fat could be tend to reduced by

| Fed Intake (g/bird) | 438.4<sup>a</sup> | 480.4<sup>b</sup> | 457.0<sup>b</sup> | 502.4<sup>b</sup> | 514.4<sup>b</sup> | 9.51 * |
| Weight Gain (g/bird) | 1115<sup>a</sup> | 1264<sup>b</sup> | 1202<sup>a</sup> | 1257<sup>b</sup> | 1266<sup>b</sup> | 19.8<sup>1</sup> * |
| Feed Conversion | 2.54 | 2.64 | 2.63 | 2.52 | 2.46 | 0.04 NS |
| Carcass (%) | 72.41<sup>a</sup> | 73.12<sup>a</sup> | 74.74<sup>a</sup> | 76.47<sup>b</sup> | 76.47<sup>b</sup> | 0.52 * |
| Abdominal Fat (%) | 1.46 | 1.02 | 1.32 | 1.09 | 1.02 | 0.67 NS |
| Liver Weight (g) | 28.0<sup>a</sup> | 29.2<sup>a</sup> | 30.2<sup>b</sup> | 32.0<sup>b</sup> | 34.6<sup>c</sup> | 0.90 ** |
| Heart Weight (g) | 7.6 | 8.0 | 8.8 | 8.8 | 8.8 | 0.24 NS |
| Breast Weight (g) | 216.60<sup>a</sup> | 218.48<sup>a</sup> | 221.40<sup>a</sup> | 242.24<sup>b</sup> | 246.40<sup>b</sup> | 3.49 ** |
| Thigh Weight (g) | 237.80<sup>a</sup> | 335.52<sup>b</sup> | 338.84<sup>b</sup> | 341.36<sup>b</sup> | 350.00<sup>c</sup> | 10.7 ** |
| Back Weight (g) | 233.50 | 272.40 | 232.50 | 243.00 | 245.50 | 7.72 NS |
| Wings Weight (g) | 135.00 | 136.32 | 131.86 | 139.00 | 135.50 | 3.27 NS |

Blood:

| Cholesterol (mg/100 g) | 139.4<sup>a</sup> | 139.4<sup>b</sup> | 122.4<sup>a</sup> | 123.4<sup>a</sup> | 120.2<sup>a</sup> | 2.11 * |
| HDL-Cholesterol | 102.8<sup>b</sup> | 99.4<sup>d</sup> | 98.0<sup>b</sup> | 98.2<sup>b</sup> | 93.8<sup>e</sup> | 3.38 * |
| LDL-Cholesterol | 55.4<sup>c</sup> | 57.8<sup>d</sup> | 46.8<sup>e</sup> | 49.0<sup>b</sup> | 43.2<sup>e</sup> | 2.76 * |

Meat:

| Cholesterol (mg/100g) | 39.5<sup>c</sup> | 26.2<sup>b</sup> | 23.1<sup>ab</sup> | 22.4<sup>a</sup> | 25.5<sup>b</sup> | 1.99 ** |
| Water (%) | 73.6 | 73.2 | 74.0 | 73.9 | 74.0 | 0.20 NS |
| Protein (%) | 22.6 | 21.2 | 21.5 | 21.5 | 21.2 | 0.33 NS |
| Fat (%) | 2.23 | 1.84 | 1.83 | 1.85 | 1.68 | 0.15 NS |
| Ash (%) | 1.06 | 1.15 | 1.10 | 1.10 | 1.15 | 0.02 NS |
| Carbohydrate (%) | 0.54<sup>b</sup> | 0.50<sup>b</sup> | 0.34<sup>a</sup> | 0.34<sup>a</sup> | 0.33<sup>c</sup> | 0.07 * |

<sup>a</sup>Means in a row with different superscripts are significantly different at the P-value shown
<sup>1</sup>SEM = pooled standard error of mean (n=4)
<sup>2</sup>Significance level: *P<0.05, **P<0.01, NS = not significant P>0.05

FO = fish oil
supplementing fish oil in the diet. As [32-33] reported that dietary fatty acid could affect abdominal fat deposition and there are several reports on the effects of polyunsaturated fatty acids on abdominal fat pad reduction in broiler chickens. Compared to fast-growing broilers, native chicken breeds and their hybrids show lower weight gain and a smaller proportion of breast muscle in the carcass, but their meat has many quality characteristics valued by modern consumers [34].

These results are in agreement with those reported previously by [35] which showed that the presence of saturated fatty acid in bird meat was dependent on the presence of these fats in the diet, their oxidation rate, and also their synthesis in the liver. [36] showed that the supplementation of feeds with fish oil at 1.5% improved performance of broiler chickens. The supplementation of 3% fish oil in the diet improved the level of n-3 fatty acid and the immune system, and decreased the levels of cholesterol and triglyceride in the plasma of broilers.[37] showed that the lipid content of serum reduced as the levels of dietary PUFA increased. However, in opposite results to our findings, [38] showed that the level of serum cholesterol was not affected noticeably by dietary rich fish oil. The differences between the studies on the lipid content of serum may be attributed to the genetic, sex and dietary factors.

4. Conclusions

Based on these results it can be concluded that the use of fish oil in diet up to 3% could improved performance parameters in native chickens

5. References

[1] Kris-Etherton P M, Harris W S and Appel L J 2002 Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease Circulation 106 2747–2757

[2] Din J N, Newby D E and Flapan A D 2004 Science, medicine, and the future – Omega 3 fatty acids and cardiovascular disease - Fishing for a natural treatment British Med. J. 328 30–

[3] Ruxton et al., 2007 Ruxton C H S, Reed S C, Simpson M J A and Millington K J 2007 The health benefits of omega-3 polyunsaturated fatty acids: a review of the evidence J. Hum. Nutr. Diet 20 275–285

[4] Ayerza et al., 2002 Ayerza R, Coates W and Lauria M 2002 Chia seed (Salvia hispanica L.) as an omega-3 fatty acid source for broilers: influence on fatty acid composition, cholesterol and fat content of white and dark meats, growth performance, and sensory characteristics Poult. Sci. 81 826–837

[5] Crespo N and Esteve-Garcia E 2001 Dietary fatty acid profile modifies abdominal fat deposition in broiler chickens Poult. Sci. 80 71-78

[6] Krejci-Treu et al., 2010 Krejci-Treu T, Straková E, Suchý P and Herzig I 2010 Effect of vegetable oil fortified feeds on the content of fatty acids in breast and thigh muscles in broiler chickens. Acta Vet. Brno. 79 S21-S28

[7] Simopoulos A P 2003 Importance of the ratio of omega-6/omega-3 essential fatty acids: Evolutionary aspects World Rev. Nutr. Diet 92 171-174

[8] Rhee K S, Davidson T L, Cross H R and Ziprin Y A 1990 Characteristics of pork products from swine fed a high monounsaturated fat diet: Part 1. Whole muscle products Meat Sci. 27 329-341

[9] Lopez-Ferrer S, Baucells M D, Barroeta A and Grashorn M A 2000 n-3 Enrichment of chicken meat. 1. Use of very long-chain fatty acids in chicken diets and their influence on meat quality: Fish oil Poult. Sci. 80 741-752
[10] Pike I H 1999 Health benefits from feeding fish oil and fish meal the role of long chain omega-3 polyunsaturated fatty acids in animal feeding *IFOMA* No 28

[11] Alparslan G and Özdogan M 2006 The effects of diet containing fish oil on some blood parameters and the performance values of broilers and cost efficiency *Int. J. of Poult. Sci.* 5 (5) 415–419

[12] Farhoomand P and Checaniazer† S 2009 Effects of graded levels of dietary fish oil on the yield and fatty acid composition of breast meat in broiler chickens *J. App. Poult. Res.* 18 508–513

[13] Crespo N and Esteve-Garcia† E 2003 Polyunsaturated fatty acids reduce insulin and very low density lipoprotein levels in broiler chickens *Poult. Sci.* 82 1134–1139

[14] Liu G, An S, Yuan J, Guo Y, Liu D, Chen H and Huang R 2014 Dietary fish oil and zinc reduced plasma prostaglandin E2 content by inhibiting phospholipase A2 production in broilers *J. Poult. Sci.* 51 66-70

[15] Leke J R, Achmanu, Sjofjan O and Najoan M 2013 Egg internal quality and n-3 fatty acids of native chicken fed on skipjack fish (*Katsuwonus pelamis*. L.) industrial waste containing feed *Int. J. of Poult. Sci.* 12 (8) 484-488

[16] Food and Agriculture Organisation of the United Nations 2003 Poultry keeping [www.fao.org/english/newsroom/new/2003/13200-en.html](http://www.fao.org/english/newsroom/new/2003/13200-en.html).

[17] Swatson H K, Tshovhote J, Nesamvumi E, Ranwedzi N E and Fourie C 2001 Characterization of village free ranging poultry production systems under traditional management conditions in the Vhembe district of the Limpopo Province pp. 1-5

[18] Jaturasitha S, Kayan A and Wicke M 2008 Carcass and meat characteristics between Thai village chickens compared with improved layer breeds and their crossbred Poult. Sci. 51 (3) 283-294

[19] Iriyanti N, Santosa R S and Rachmawati W S 2014 Blood profile and performance of native chicken with functional feed *Int. J. of Poult. Sci.* 13 (11) 645-651

[20] Ma’rifah B, Atmomarsono U and Suthama N 2013 Nitrogen retention and productive performance of crossbred native chicken due to feeding effect of kayambang (*Salvinia molesta*) *Int. J. of Sci. and Engin.* 5 (1) 19-24

[21] Chowdhury S D, Ahmed S and Hamid M A 2006 Improved feeding of desi chicken reared in confinement. *The Bangladesh Vet.* 23 29-35

[22] Henuk Y L and Bailey C A 2014 Husbandry systems for native chickens in Indonesia *Proc. of the 16th AAAP Anim. Sci. Congress* pp 759-762

[23] AVMA 2000 Report of the AVMA Panel of Euthanasia *J. of the American Vet. Med. Assoc.* 218 (5) 669-696

[24] Craig, E.W. and D.L Fletcher and P.A.Papinaho 1999 The effects of antemortem electrical stunning and postmortem electrical stimulation on biochemical and textural properties of broiler breast meat. Poult.Sci., 78;480-494.

[25] AOAC 1990 *Official Methods of Analysis* (Association of Official Analytical Chemists Ed.) Washington DC

[26] Steel R G D and Torrie J H 1994 *Principles and Procedures of Statistics* McGraw-Hill Book Co. Inc. Pub. Ltd. London

[27] Huang Z B, Ackman R G, Ratnayake W M N and Proudfoot F G 1990 Effect of dietary fish oil on n-3 fatty acid levels in chicken eggs and thigh flesh *J. Agric. Food Chem.* 38 743–747

[28] Zelenka J.,A.Jarosovo, D. Schneiderova 2008 Influence of n-3 and n-6 polyunsaturated fatty acids on sensory characteristics of chicken meat. Czech.J.Anim.Sci. 53,299 -305.

[29] Iriyanti N, Santosa R S and Rachmawati W S 2014 Blood profile and performance of native chicken with functional feed *Int. J. of Poult. Sci.* 13 (11) 645-651
[30] Jaturasitha S, Kayan A and Wicke M 2008 Carcass and meat characteristics between Thai village chickens compared with improved layer breeds and their crossbred Poult. Sci. 51 (3) 283-294

[31] Navidshad B 2009 Effects of fish oil on growth performance and carcass characteristics of broiler chicks fed a low-protein diet Int. J. Agric. Biol. 11(5) 635-638

[32] Vila B and Esteve-Garcia E 1996 Studies on acids oil and fatty acids for chickens. I. Influence of age, rate of inclusion and degree of saturation on fat digestibility and metabolisable energy of acid oils Braz. Poult. Sci. 37 105 - 117

[33] Sanz M, Flores A, Pèrez De Ayala P and Lo Pez-Bote C J 1999 Higher lipid accumulation in broilers fed on saturated fats than in those fed on unsaturated fats Braz. Poult. Sci. 40 95-101

[34] Sokolowicz Z, Krawczyk J and Swiatkiewicz S 2016 Quality of poultry meat from native chicken breeds - a review. Annals of Anim. Sci.

[35] Lopez-Ferrer S, Baucells M D, Barroeta A C and Grashorn M A 1999 Omega-3 enrichment of chicken meat using fish oil: Alternative substitution with rapeseed and linseed oils Poult. Sci. 78 356–365

[36] Saleh H, Rahimi S and Karimi Torshizi M A 2009 The effect of diet that contained fish oil on performance, serum parameters, the immune system and the fatty acid composition of meat in broilers Int. J. Vet. Res. 3 (2) 69-75

[37] Celebi and Utlu 2006 Influence of animal and vegetable oil in layer diets on performance and serum lipid profile. Int J Poult Sci. 5-370-373

[38] Alparslan G and Ozdogan M 2006 The effects of diet containing fish oil on some blood parameters and the performance values of broilers and cost efficiency Int. J. of Poult. Sci. 5 (5) 415-419