World Journal of Nutrition and Health, 2016, Vol. 4, No. 1, 5-9
Available online at http://pubs.sciepub.com/jnh/4/1/2

DOI:10.12691/jnh-4-1-2

Comparative Evaluation of Cholesterol Content and Storage Quality of Chicken and Quail Eggs

Adeniyi P.O.[1,*], Obatolu V.A.[1], Farinde E.O.[1]

Product Development Programme, Institute of Agricultural Research and Training, Apata, Ibadan, Nigeria
*Corresponding author: doyinadeniyi@yahoo.com

Abstract In recent times, the consumption of quail egg has become a food fad, with little knowledgeable input, owing to the claim that it is lower in cholesterol than chicken egg, hence, there is need for more scientific basis to certify the preferred consumption of quail egg over chicken egg as a food fad which should be encouraged or a food fallacy that needs to be corrected. This study was therefore designed to determine the storage quality and cholesterol content of chicken and quail eggs during the two commonly used storage methods. Eggs of 53 weeks old chicken (ISA-Brown) and 9 weeks old quail (Japanese Breed) were analyzed for pH, microbial count and cholesterol content on the day of lay and weekly during cold (4°C) and room temperature (27°C) storage for 5 weeks using appropriate analytical kits. Data were analyzed using means, standard deviation and ANOVA. The pH of chicken egg albumin (CA) and chicken egg yolk (CY) at the day of lay (R0) were 7.48 and 5.65 respectively and these significantly increased to 12.31(CA); 9.56 (CY) and 8.94 (CA); 6.85(CY) at 5 weeks' room temperature (R5) and cold (C5) storage respectively. The pH of quail egg albumin (QA) significantly increased from 8.67 at R0 to 12.99 at R5 and 9.83 at C5 while that of quail egg yolk (QY) increased from 5.92 at R0 to 10.00(R5) and 6.86(C5). Both eggs were sterile throughout the experimentation period. At R0, cholesterol content (mg/g) of CA, CY, QA and QY were 22.67, 33.67, 34.33 and 46.83 respectively; at R5 these significantly increased to 62.67(CA), 96.00(CY), 49.33(QA), 68.67(QY) and at C5 the values were 54.17(CA), 78.17(CY), 51.17(QA) and 68.00(QY). The reduced quality of the eggs with storage was not as a result of microbial invasion but of deteriorative reactions within the eggs. Though the cholesterol content of chicken egg was lower than that of quail egg at the day of lay it was significantly higher in chicken egg by the end of the 5 weeks storage period. However, fractionation of the cholesterol into the different types is recommended for a better understanding of the nutritional significance.

Keywords: *chicken egg, quail egg, cholesterol, storage quality*

Cite This Article: Adeniyi P.O., Obatolu V.A., and Farinde E.O., "Comparative Evaluation of Cholesterol Content and Storage Quality of Chicken and Quail Eggs." *World Journal of Nutrition and Health*, vol. 4, no. 1 (2016): 5-9. doi: 10.12691/jnh-4-1-2.

1. Introduction

Cholesterol is from ancient Greek words 'chole' meaning 'bile', 'stereos' meaning 'solid' and '–ol' for 'alcohol'. It is an organic molecule. A sterol or modified steroid which is a lipid molecule that is biosynthesized by all animal cells. Cholesterol is transported in the blood by different carriers. The two major blood cholesterol carriers are LDL (Low Density Lipoprotein) and HDL (High Density Lipoprotein). LDL cholesterol is known as "bad" cholesterol because it delivers blood cholesterol throughout the body, depositing it as plaque in the arterial walls to results to a condition known as atherosclerosis. On the other hand HDL cholesterol is known as the 'good' cholesterol because it transports cholesterol from the body tissues back to the liver which turns it to bile and is excreted via the gastrointestinal tract. Cholesterol is needed for good health, hence, a moderate intake is not harmful but problem arises when the LDL cholesterol levels become elevated and the HDL cholesterol becomes too low. When cholesterol is consumed in excess it elevates total cholesterol to a high level which may result in atherosclerosis, hence, many people always desire to consume less cholesterol in their diet.

Poultry eggs have been identified as a rich dietary source of cholesterol and many have been cautious in its inclusion in their diets. The clamour for low cholesterol diet has drawn the attention of many to the preference of quail eggs over chicken eggs owing to the claim that the former is lower in cholesterol but little attention has been paid to the effect of storage on the cholesterol content of these eggs. The conflicting nature of past scientific findings on the comparison of cholesterol content of both chicken and quail eggs demands the exploration of this concept. Olugbemi et al., [1] reported that the egg yolk of exotic chicken (ISA Brown) was 243.8mg/dl which was higher than that of Japanese quail that was observed to be 80.60mg/dl. Bragagnolo and Rodriquez-Amaya, [2] on the other hand reported that there existed no significant difference in the cholesterol content of Brazilian chicken egg yolk and that of quail eggs. They reported that the cholesterol content of Brazilian chicken egg yolk was 12.0mg/g of yolk while that of quail was 12.1mg/g of the yolk. More still, the cholesterol content of Italian chicken

eggs was observed to be 157 ±3mg/egg which was lower than the previously reported value of 213mg/egg and the cholesterol content did not vary with storage time [3]. In another comparative study of the cholesterol content of domesticated birds (avian species), quail egg yolk was observed to have the least cholesterol content among ostrich, turkey quail, duck and goose. All yolks from the birds, especially that of ostrich, were found to be excellent sources of lecithin [4].

The in depth knowledge of the nutritional significance of cholesterol is needed in order to properly apply this in human nutrition. Cholesterol is c compound of sterol type that is present in most body tissues. It is an important constituent of cell membranes and precursor of other steroid compounds but high concentration of it in the body may predispose the body to atherosclerosis which is the deposition of cholesterol in the arterial vessels. The formular for cholesterol is $C_{27}H_{46}O$ with molar mass 386.65g/mol, melting point of 148^{o}C and boiling point 360^{o}C. The body needs some cholesterol to produce hormones, vitamin D and some components that participate in food digestion. It is of interest to note that the body is capable of producing the cholesterol that it needs, hence, the extra consumed from foods may predispose the body to some ill health states or conditions. As earlier mentioned cholesterol is transported in the blood by HDL (good cholesterol) and LDL (bad cholesterol). The higher the level of LDL cholesterol in the body the greater the chances of developing heart disease [5] and the higher the level of HDL cholesterol in the blood the lower the chance of developing heart disease [6,7]. The LDL-C can be estimated using Friedewald formular below:

$$LDL - C = TC - HDL - C - TG / 5$$

Where TC is Total Cholesterol, TG is Triglyceride.

Atherosclerotic plaque which builds up in the arterial vessels is made up of cholesterol, fat, calcium and other substances present in the blood. It makes the arteries not to be flexible and reduces the available space for blood flow within the arteries. Total cholesterol in the body is made up of LDL cholesterol, HDL cholesterol and Triglycerides. The relationship between these, in overnight fasted state, is expressed in the Friedwald formular above. A TC level of < 200mg/dl is desirable; a value between 200-239 is borderline high while ≥ 240mg/dl is too high. HDL-C level of ≥ 40mg/dl is desirable but if it is < 40 there is need to do the total lipid profile of the blood. LDL-C level of 100mg/dL is optimal, 100mg/dL is near optimal, 130-159mg/dL is borderline high, 160-189 is high while ≥190mg/dL is very high. For triglyceride borderline high is 150-199mg/dL and ≥ 200mg/dL is high. All these values are after a 9 to 12 hour fast. [8]. HDL cholesterol can be likened to arteries vacuum cleaner because it removes plague from the arterial walls, reverse blockages and carry cholesterol back to the liver. The liver then deposits the cholesterol in the bile and it flushes out with bowel movement. This shows that the lower the amount of HDL cholesterol in the body the higher the risk of heart disease. It is therefore pertinent that the foods sources of the different types of cholesterol be known so as to guide individual towards a healthy food choices as far as cardiovascular health is concerned.

Fatty fish such as salmon, tuna, halibut, and mackerel are rich in omega-3-fatty acids which contain a lot of HDL cholesterol. Also tree nuts such as almonds, walnuts, cashew nuts have high levels of HDL cholesterol and are also rich in polyunsaturated fatty acids. Fish oil supplements may also be taken in order to boost the level of HDL cholesterol in the body.

Parameters which are commonly used for evaluating poultry egg quality are : pH, albumen and yolk weight and height [9]; microbial load/count [10]; egg length, egg width, shape index, breaking strength, albumen height., haugh unit and shell thickness [11]. Other parameters include; yolk colour, yolk index, egg shape index, specific gravity and haugh unit [12].

Different possible measures have been applied to reduce the cholesterol content of egg. Feeding of laying chickens with water leaf mucilage (up to 200ml/L of drinking water) was observed to significantly reduce cholesterol content of egg yolk [13]. Consumption of diet containing 0.25% dry ginger and 0.3% garlic for 4 weeks was observed to reduce egg yolk cholesterol by 24.8% in quail egg with a concomitant reduction in serum total cholesterol, triglyceride, LDL, VLDL and liver cholesterol but increased plasma HDL cholesterol significantly [14]. Morestill, supplementation of laying hens diet with Atorvastin (0.03%), Niacin (375ppm) and EDTA (0.5%) was reported to reduce egg yolk cholesterol content by up to 35% in White Leghorn laying hens [15]. Similarly, diet containing 0.04% *Rhodobacter capsulatus* for 60 days resulted in reduced cholesterol content of egg yolk, serum and hepatic cholesterol but increased excreta cholesterol in laying hens [16]. Vidal et al., [17] also reported that feeding of laying hens with diet containing up to 25% cashew nut (Cashew nut meal) was observed to reduce the cholesterol content of egg yolk but increased monounsaturated/ saturated fatty acid ratio of the yolk in chicken eggs. Feeding of Lohmann Brown laying chickens with feed fortified with olive leaf powder (at 3%) was observed to reduce the cholesterol content of the egg yolk by 10% and also increased the intensity of the yellow colour of the yolk but had no effect on feed intake, egg weight and egg yield [18] while garlic (*Allium sativum*) powder in the diet of hens was observed to significantly reduce egg yolk cholesterol but increased serum cholesterol in a dose dependent manner, that is, the higher the garlic in the diet the higher the serum cholesterol [19]. Replacing soybean meal with sunflower seed meal was found to reduce egg yolk cholesterol of Rugao laying hens after 6 weeks [20]. Feeding of 222 HyLine Brown laying hens for 24 weeks on diet containing probiotic Pediococcus acidilactici reduced the egg yolk cholesterol by 10% independent of the dose of the probiotic in the feed. There was also reduction in number of broken eggs and eggs without shell with a concomitant increase in egg weight and egg shell thickness [21]. This suggests that the inclusion of probiotic *Pediococcus acidilactici* in poultry feed has potential commercial applications for improvement in hen performance and egg quality during the laying period [21]. The inclusion of *Cordyceps militaris* waster medium in feed of 22 weeks old Hendrix laying hens for 12 weeks markedly reduced the egg cholesterol with no alteration in egg yolk weight, egg shell weight and thickness as well as egg yolk colour [22]. Cordyceps militaris waster medium is a by-product of the edible

portion of the fruiting body of Cordyceps fungi. However, no change was observed in egg yolk cholesterol, feed intake, egg yield and mass in Lohmann Brown Laying eggs after feeding them with a diet formulated with strawberry leaf powder for 10 weeks [23]. Replacement of soybean meal with low-fiber sunflower meal (Helianthus annus L.) in the feed of ISA Brown layers for 10 weeks reduced serum and egg yolk cholesterol and LDL cholesterol concentration but increased HDL cholesterol level thus suggesting that the replacement of conventional soybean with low fibre sunflower meal may be a feasible alternative in the feed of laying hens to improve egg quality and produce eggs with low cholesterol content [24].

Morestill, increasing the dietary concentration of Gynura procumbens reduced serum and egg yolk cholesterol and triglycerides significantly in Hy-Line Brown layers that were fed with the diets at 2.5, 5.0 and 7.5g/kg diet for 56 days (8 weeks). There was also reduction in excreta total anaerobic bacteria, *Clostridium spp* and *Escherichia coli* thus indicating that dietary supplementation with G. procumbens could reduce egg yolk cholesterol and suppress harmful excreta microflora [25]. Extra virgin olive oil in the diet of laying hens up to 2.5% was reported to lower serum and egg yolk cholesterol level but increased polyunsaturated fatty acid composition of the egg [26]. Supplementation of Bovans white laying hens feed with fish oil at 3.5% for 12 weeks markedly reduced egg yolk cholesterol by 14.5% compared to the negative control with a concomitant 30.5% increase in linolenic fatty acids of the eggs [27]. All these scientific reports only reported the effect of different types of feed formulation on the cholesterol content of the eggs produced but there is scarcity of the influence of storage on the cholesterol content of poultry eggs. This study was therefore designed to compare the cholesterol content and the storage quality of chicken and quail eggs under the two commonly used methods of storage.

2. Materials and Method

2.1. Egg Collection

Seventy two eggs of 9 weeks old Japanese quails and seventy two eggs of 53 weeks old ISA Brown chickens were used for this experiment. The eggs were collected at point of lay and 36 of each were stored at room temperature (27°C) while the remaining 36 eggs were stored at refrigerating temperature (4°C) for 5 weeks. Six eggs were picked from the lot on the day of lay and weekly during storage and analyzed for pH, cholesterol content and microbial load/ count

2.2. pH Measurement

The egg was broken and was carefully separated into yolk and albumen. The pH of each was determined using HANNA pH meter, U.S.A.

2.3. Determination of Cholesterol Content

The cholesterol was measured using a test kit. Randox kit, UK was used to determine cholesterol of the egg albumen and egg yolk separately and the procedure as stipulated by the manufacturer was followed. To 1ml of reagent 10µl of sample was added. This was then incubated for 10 minutes at room temperature (25°C). Color changed from colorless to pink or violet and the optical was read at 546nm. This procedure was repeated for standard and blank using the standard and distilled water respectively in place of the sample. Cholesterol content was then calculated thus:

$$\text{Serum cholesterol} = \frac{\text{Optical density (sample)}}{\text{Optical density (standard)}} \times \text{concentration of standard (mg/dl)}.$$

2.4. Plate Count or microbial count using The Pour Plate Method [28]

One (l) ml of the sample was aseptically dispensed into a sterile petri dish using a sterile pipette. A measured quantity (15 - 20ml) of sterile nutrient agar was added and the two mixed thoroughly by swirling gently. The dish was then incubated at 37°C for 18-24hours. The number of colonies growing in the agar plate was then counted.

For Coliform, MacConkey Agar was used.

For Anaerobes, MRS Agar (MRS = de Manns Rogosa and Sharpe) was used.

For Fungi, Potato Dextrose Agar was used.

For Aerobes, Nutrient Agars was used.

2.5. Statistical Analyses

Results were expressed in mean ± standard deviation and ANOVA (at $p \leq 0.05$) was used to compare mean values.

3. Result and Discussion

3.1. pH of Egg Albumen and Egg Yolk

On the day of lay the pH of both albumen was alkaline (CA-7.48; QA-8.67) while that of yolk was slightly acidic (CY-5.65; QY- 5.92) as expressed in Table 1.

Table 1. Effect of storage on the pH of chicken and quail egg albumen and yolk

	R0	R1	C1	R2	C2	R3	C3	R4	C4	R5	C5
CA	7.48*/0.17	9.37/0.16	7.65*/0.01	10.01*/0.07	8.01*/0.01	11.15/0.03	8.24*/0.01	11.96*/0.02	8.58*/0.04	12.31/0.29	8.94*/0.03
CY	5.65/0.20	6.59/0.07	5.85/0.03	7.64/0.03	6.06/0.05	7.93⁰/0.02	6.15/0.03	8.07⁰/0.03	6.65/0.03	9.56/0.02	6.85/0.03
QA	8.67*/0.34	9.57/0.19	8.96*/0.02	10.64*/0.03	9.03*/0.02	11.86/0.03	9.15*/0.02	12.70*/0.09	9.44*/0.02	12.99/0.61	9.83*/0.04
QY	5.92/0.18	6.45/0.04	5.98/0.02	7.85/0.02	6.18/0.03	8.18⁰/0.03	6.24/0.01	9.26⁰/0.02	6.52/0.02	10.00/0.03	6.86/0.02

*-- data (in column) are significantly different

⁰ -- data (in column) are significantly different

CA – Chicken albumen

CY – Chicken yolk

QA-- Quail albumen

QY – Quail yolk

R0 – pH on the day of lay

R1 --- pH at 1 week room temperature storage

C1 ---pH at 1 week cold storage.

The pH of both the albumen and yolk of the two different types of eggs increased with increase in storage time but the pH of the eggs stored at room temperature was significantly higher than that stored in a refrigerator. The pH values of quail egg albumen and yolk were significantly higher than that of chicken egg throughout the experimentation period except in the chicken yolk and quail yolk at the 5th week cold storage between which there existed no significant difference ($p \leq 0.05$). This result suggests that the higher the pH of these two poultry egg components the lesser the quality because signs of loss of quality such as the changing of the yellow colour of the yolk in quail eggs to black at the 5th week of storage at room temperature was evident. Silversides and Budgell , [29] also observed an increase in the pH as well as whipping volume and a decrease in albumen height with increase in time of storage of eggs (5days to 10 days) from Brown Leghorn hen (ISA Brown) and Babcock hens (commercial white egg layer). There is dearth of past scientific report on the pH of poultry eggs with respect to the storage period, hence, appreciable comparison cannot be made.

3.2. Cholesterol Content

Table 2. Effect of storage on the cholesterol content (mg/g) of chicken and quail eggs

	R0	R1	C1	R2	C2	R3	C3	R4	C4	R5	C5
CA	22.67*/1.21	32.00/1.27	28.17*/1.33	35.17/1.17	29.67*/1.63	37.17*/1.47	31.33*/3.45	57.67*/4.23	46.50/1.87	62.67*/1.63	54.17/3.86
CY	33.67θ/2.34	52.83θ/2.23	48.00/1.79	52.50/1.04	58.50/0.55	56.33θ/1.12	64.00/3.23	84.33θ/2.80	74.33θ/3.32	96.00θ/2.53	78.17θ/3.40
QA	34.33*/1.03	34.83/0.75	34.93*/0.75	38.33/0.52	38.83*/0.75	40.67*/1.97	41.00*/2.10	43.17*/1.83	48.17/1.17	49.33*/2.07	51.17/3.25
QY	46.83θ/0.98	46.83θ/1.47	46.38/1.03	54.17/1.33	57.00/0.89	63.83θ/1.47	63.85/1.57	66.67θ/0.82	67.17θ/1.47	68.67θ/2.85	68.00θ/1.41

*--data (in column) are significantly different
θ --data (in column) are significantly different
CA – Chicken albumen
CY – Chicken yolk
QA-- Quail albumen
QY – Quail yolk
R0 – cholesterol content on the day of lay
R1 --- cholesterol content at 1 week room temperature storage
C1 ---cholesterol content at 1 week cold storage.

On the day of lay the cholesterol content of quail albumen and yolk were significantly higher than that of chicken egg but at the 5th week of storage the cholesterol content of chicken egg was significantly higher than that of quail eggs (Table 2). The cholesterol content of the eggs stored at room temperature significantly increased more than that stored at cold temperature. Though there is disparity in the values obtained the cholesterol content of the yolk on the day of lay as observed in this study is comparable to the report of Aziz et al., [30] who reported that the average cholesterol content in chicken, duck and quail eggs was 7.65±0.28mg/g yolk, 10.36±0.94mg/g yolk and 16.05±0.63mg/g yolk respectively. The cholesterol content in egg of chicken as reported by Sujatha et al., [31] was higher than that observed in this study. They reported that the cholesterol in the egg and the cholesterol /g of the yolk of range reared rural chicken was 180mg/g egg and 13.4mg, that of urban backyard chicken was 187mg/g egg and 13mg which were lower than that of commercial layer eggs which was 207mg/g egg and 14mg. The results observed in this study was also lower compared to the report of Naviglio et al., [3] who observed that the average cholesterol content of eggs in local Italian market was 157± 3 mg/g egg. The variation in all these reports may be a resultant effect of feed, strain of chicken, season etc. On the other hand the cholesterol content of egg sampled in U.S. retail market relatively lower than the values obtained in this study. The average cholesterol content of eggs in U.S. retail markets was 423mg/110g in 2000-2001 while in 2010 it was 372mg/100g [32]. The results of this study was relatively higher than that observed by Bair and Marion, [33] who reported a cholesterol range of 12.77 to 21.99mg/g yolk in avian species, specifically; guinea fowl, chicken, pheasant, quail, turkey, duck, goose and dove. The presumed belief or assumption that egg albumen does not contain cholesterol has made many to neglect this part of poultry eggs as far as cholesterol content is concerned but this study hereby calls the attention of researchers to this concept because egg albumen was observed to contain some cholesterol, though the fractionation of this total cholesterol into the different types is necessary for proper explanation of the nutritional significance.

3.3. Microbial Analyses

The eggs were sterile throughout the experimentation period. This shows the effectiveness of the cuticle layer on unwashed poultry eggs in preventing microbial invasion. This also suggests that the reduction in quality of the eggs with storage, especially in eggs stored at room temperature, was not as a result of microbial invasion but was due to the biochemical reactions within the eggs. This deterioration as evident in the quail egg yolk which has turned black at the 5th week of room temperature storage, yet the eggs were found to be sterile. This contradicts the report of Staji et al., 2012 who observed Salmonella enteritidis as most prevalent in quail egg in Semnan area of Iran [34]. The observation in this study is also in conflict with the result of Katayama et al., [35] who reported the presence of Salmonella enteritidis in the inner content of quail eggs before immersion into a broth containing the microbe.

4. Conclusion and Recommendation

The cholesterol content of chicken egg was lower than that of quail eggs on the day of lay but at 5 weeks of storage that of chicken eggs became higher than this parameter in quail egg. The higher the pH of an egg the lesser the quality. The deterioration that commonly occurs in eggs with time of storage is not as a result of microbial invasion but due to the biochemical reaction within the egg. However, fractionation of the cholesterol content of these eggs is recommended for a deeper understanding of the nutritional significance.

References

[1] Olugbemi T.S., Sule A., Orunmuyi M., Daudu O.M. and Olusola O.O.(2013). Chemical analysis and consumer preference of selected poultry egg types in Zaria, Nigeria. Nigerian Journal of Animal Sciences;15: www.ajol.info/index.php/tjas/article/view/94048.

[2] Bragagnolo N. and Rodriguez-Amaya D.B. (2013). Comparison of the cholesterol content of Brazilian chicken and quail eggs. Journal of Food Composition and Analysis; 16(2): 147-153.

[3] Naviglio D., Gallo M., Le Grottaglie L., Scala C., Ferrara L. and Santini A. (2012). Determination of cholesterol in Italian chicken eggs. Food Chemistry; 132(2):701-708.

[4] Sinanoglou V.J., Strati I.F. and Miniadis-Meimaroglou S. (2011). Lipid, fatty acid and carotenoid content of edible egg yolks from avian species: A comparative study. Food Chemistry; 124(3): 971-977.

[5] Varbo A., Benn M., Tybjaerg-Hansen A. and Nordestgaard B.G. (2013). Elevated remnant cholesterol causes Ischemic heart disease without inflammation. Circulation; 128: 1298-1309.

[6] The BIP Study Group (2000). Secondary Prevention by raising HDL cholesterol and reducing triglyceride in patients with coronary artery disease. The Bezafibrate Infaction Prevention (BIP) Study. Circulation; 102: 21-27.

[7] Burillo E., Martin-Fuentes P., Mateo-Gallego R., Baila-Rueda L., Cenarro A., Ros E. and Civeira F. (2012). Omega-3-fatty acids and HDL. How do they work in the prevention of cardiovascular diseases? Current Vascular Pharmacology; 10(4): 432-441.

[8] US Department of Health and Human Services (2005). National Institutes of Health, National Heart, Lung and Blood Institute (NIH Publication number 05-3290). www.nhlbi.nih.gov/health/resorces/heart.

[9] Scott T.A. and Silversides F.G. (2000). The effect of storage and strain of hen on egg quality. Poultry Science: 79(12): 1725-1729.

[10] De Reu K., Grijspeerdt K., Heyndrickx M., Uyttendaele M. and Herman L. (2005). The use of total aerobic and gram negative flora for quality assurance in the production chain of consumption eggs. Food Control: 16(2): 147-155.

[11] Monira K.N., Salahuddin M. and Miah G. (2003). Effect of breed and holding period on egg quality characteristics of chicken. International Journal of Poultry Science; 2(4): 261-263.

[12] Oke O.E., Ladokun A.O. and Onagbesan O.M. (2014). Quality parameters of eggs from chickens reared in deep litter system with or without access to grass or legume pasture. Livestock Research for Rural Development; 26(11):www.lrrd26/11/oke26201.htm

[13] Sanda M.E. (2015). Evaluation of quality and cholesterol level of eggs of laying hens placed on drinking water fortified with waterleaf (Talinum triangutare) mucilage. American Scientific Research Journal of Engineering, Technology and Sciences; 13(1): www.asrjetsjournal.org.

[14] Singh V., Tyagi P.K., Mandal A.B. and Singh S. (2013). Reducing egg cholesterol through dietary addition of ginger and garlic in quails. Indian Journal of Poultry Science; 48(3): 306-312.

[15] Kumar S., Tyagi P.K.,Prasad Y., Shrivastav A.K., Shrivastava H.P. Mandal A.B., Tyagi P.K., Deo C. and Singh R. (2012). Effect of dietary addition of pharmacological drugs on the production performance and plasma lipid profile and egg cholesterol content of laying hens. Indian Journal of Poultry Science; 47(2): 158-163.

[16] Salma U., Miah A.G., Tsuji H., Schellander K and Sudekum K-H. (2011). Effect of dietary Rhodobacter capsulatus on lipid fractions and egg yolk fatty acid composition in laying hens. Journal of Animal Physiology and Animal Nutrition; 96(6): 1091-1100.

[17] Vidal T.F., Pereira A.L.F., Abreu V.K., Frietas E.D. Neto MAS and Zapata J.F.F. (2013). Egg quality and yolk lipid composition of laying hens fed diets containing cashew nut meal. Food Science and Technology; 33(1).

[18] Cayan H. and Erener G. (2015). Effect of olive leaf (Olea europaea) powder on laying hens performance, egg quality and egg yolk cholesterol levels. Asian-Australas Journal of Animal Science; 28(4): 538-543.

[19] Kaya H. and Macit M. (2012). Effect of inclusion of garlic (Allium sativum) powder at different levels and copper into diets of hens on performance, egg quality traits and yolk cholesterol content. International Journal of Poultry Science; 11(2): 114-119.

[20] Shi S.R., Lu J., Tong H.B., Zou J.M. and Wang K.H. (2012). Effect of graded replacement soybean meal by sunflower seed meal in laying hens diet on hen performance, egg quality, egg fatty acid composition and cholesterol content. Journal of Applied Poultry research; 21(2): 367-374.

[21] Mikulski D., Jankowski J., Naczmanski J., Mikulska M. and Demey V. (2012). Effects of dietary probiotic (Pediococcus acidilactici) supplementation on performance, nutrient digestibility, egg traits, egg yolk cholesterol and fatty acid profile in laying hens. Poultry Science; 91(10): 2691-2700.

[22] Wang C-L, Chiang C-J., Chao Y-P., Yu B. and Lee T-T (2015). Effects of Cordyceps militaris waster medium on production performance, egg traits and egg yolk cholesterol of laying hens. The Journal of Poultry Science.

[23] Duru M. (2013). Effects of dietary strawberry (Fragaviax ananassa Duch.) leaf powder on egg yield, quality and egg yolk cholesterol in laying hens. Journal of Food and Agriculture and Environment; 11(2): 477-480.

[24] Laudadio V., Ceci E., Lastella N.M.B and Tufarelli V. (2014). Dietary high polyphenols extra virgin olive oil is effective in reducing cholesterol content in eggs. Lipids in Health and Disease; 14:5.

[25] Lokhande A., Ingale S.L., Lee S.H., Sen S., Khong C., Chae B.J. and Kwon I.K. (2014). Effects of dietary supplementation with Gynura procumbens Merr. On egg yolk cholesterol, excreta microflora and laying hen performance. British Poultry Science; 55(4): 524-531.

[26] Laudadio V., Ceci E., Lastella N.M.B. and Tufarelli V. (2015). Effect of feeding low-fiber fraction of air-classified sunflower (Helianthus annus L.) meal on laying hen productive performance and egg yolk cholesterol. Poultry Science; 93(11): 2864-2869.

[27] Saleh A.A. (2013). Effects fish oil on the production performances, polyunsaturated fatty acids and cholesterol levels of yolk in hens. Emirates Journal of Food and Agriculture; 25(8): 605-612.

[28] Harrigan W.F and McCance M.E. (1976). Laboratory methods in food and dairy microbiology, Academic Press, London.

[29] Silversides F.G. and Budgell K. (2004). The relationship among measures of egg albumen height, pH and whipping volume. Poultry Science; 83(10): 1619-1623.

[30] Aziz Z., Cyriac S., Beena V. and Philomina P.T. (2012). Comparison of cholesterol content in chicken, duck and quail eggs. Journal of Vet. Animals Science; 43: 64-66.

[31] Sujatha T., Kumar V. and Rajini R.A. (2014). Seasonal variation in egg quality and yolk cholesterol in backyard rearing and cage rearing chicken. South Asian Journal of Life Sciences;2(1): 1-3.

[32] Exler J., Phillips K.M., Patterson K.Y. and Holden J.M.(2013). Cholesterol and vitamin D content of eggs in the U.S. retail market. Journal of Food Composition and Analysis: 29(2): 110-116.

[33] Bair C.W. and Marion W.W. (1978). Yolk cholesterol in eggs from various avian species. Poultry Science; 57(5): 1260-1265

[34] Staji H., Ghazvinian K., Vayeghan A.J., Salimi M and Mahdavi A. (2012). Prevalence of Salmonella spp in the quail egg interior content: A provincial study. Iranian Journal of Veterinary Medicine; 6(3): 191-196.

[35] Katayama ERi, Donato T.C., Silva A.P., Mazola R.P., Garcia E.A., Okamoto A.S. and Andreatti F.R.L. (2013). Salmonella enteritidis in the eggs of Japanese quail fed diets with different calcium and phosphate levels. Revista Brasileira de Cencia Avicola; 15(1).