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Original Research Article

PROXIMATE COMPOSITION AND CHOLESTEROL CONTENT OF EGG OBTAINED FROM VARIOUS BIRD SPECIES.

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Abstract: The proximate composition and cholesterol contents of some egg species were determined. The proximate compositions were determined by the methods of Association of Official Analytical Chemists while cholesterol contents were determined by enzymatic method. Proximate compositions of the various egg species revealed that protein was significantly higher (P≤0.05) in shika brown egg (10.31±0.04) and lower in *Columbia livia* (8.98±0.09). Crude lipid was significantly higher (P≤0.05) in *Anas platyhyncha* (12.73±0.23) and lower in *Corturnix ypsilophora* (10.00±0.40), *Columbia livia* (10.40±0.35) eggs respectively. Moisture was significantly higher (P≤0.05) in *Columbia livia* (76.00±0.50), *Gallus domesticus* (75.50±0.87), *Corturnix ypsilophora* (75.00±1.26) and lower in *Anas platyhyncha* (71.83±0.29), *Numida melleagris* (72.67±0.76) eggs. The carbohydrate composition was significantly higher in *Anas platyhyncha* (5.04±0.04) and lower in *Gallus domesticus* (2.88±1.20) eggs. The result also revealed that cholesterol was significantly higher (P≤0.05) in *Gallus domesticus* egg (796.25±9.09) mg per dl and lower in *Columbia livia* (553.44±12.03), Shika brown (547.28±12.86) and *Numida melleagris* (548.31±23.89) mg per dl. The composition of the avian egg protein and other constituent will continue to provide sources of nutrients for human. In fact, knowledge of the nutrient content from various species of birds will also serve as nutritional guide in food composition table as well as providing valuable information on nutrient intake. The variation in the proximate composition and cholesterol of some avian eggs obtained in this study may serve as a guide of providing useful information on food composition.

Key Words: Poultry; Eggs; Proximate; Cholesterol

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1.0 Introduction

The modern poultry industry emerged in the late nineteenth century in Europe and America as breeders focused on improving meat and egg production. Production and consumption of poultry products increased significantly during World War II when beef and pork were in

limited supply [1]. Eggs are highly versatile food containing many essential nutrients[2]. Eggs provide protein, vitamin A, riboflavin, and other vitamins and minerals[1]. The yolk contains all the fat, saturated fat and cholesterol in an egg. In one large egg, the yolk contains 5 grams total fat, 2 grams saturated fatty acids, 213 milligrams cholesterol, and 60 calories[1]. Most egg lipids are concentrated in the yolk, and consist of lipoproteins, phospholipids, triacylglycerol, and cholesterol. The lipid fraction of the yolk is composed of 8.7g saturated fatty acids, 13.2g monounsaturated fatty acids, 3.4 g polyunsaturated fatty acids and 1.120 mg cholesterol per 100 g of fresh yolk[3]. Cholesterol deposition in the egg yolk can be affected by nutrition[4].

Cholesterol is found naturally within the body in the structure of cell walls. It is also used to produce steroid hormones, vitamin D and to manufacture bile acids which help the digestion and absorption of dietary fat in the gut[5]. Cholesterol is carried around the body in the blood by proteins known as high density (HDL) and low density (LDL) lipoproteins, or 'good' and 'bad' cholesterol respectively. HDL cholesterol is beneficial to the body but LDL cholesterol can cause blood vessels to become narrowed or blocked[6]. High LDL levels can increase the risk of heart attacks, Myocardial Infraction (MI), chest pain (angina), narrowing of the blood vessels (peripheral artery disease) and stroke collectively known as cardiovascular disease (CVD) [7].

Egg yolk has been described as a concentrated source of cholesterol, [8]reported measurements of egg yolk cholesterol have ranged from 195-270mg/egg [9, 10, 11]. The most commonly used bird eggs are those from the chicken[12]. But in real sense there are other poultry birds that produce eggs for human consumption, among these birds are domestic chicken (Gallus domesticus), Exotic chicken (Shika brown), Guinea fowl (Numida melleagris), Quail (Corturnix ypsilophora), Duck (Anas platyhyncha), Pigeon (Columbia livia). The cholesterol and proximate composition (crude fat, crude carbohydrate, crude protein, ash content and moisture content) of the above listed bird eggs varies, this variation may be due to difference in specie, diet or environment[13].

The most commonly used eggs are those from exotic chickens and the demand is often greater than supply, since all species of birds have different genetic background, the egg nutritional composition and cholesterol content may vary significantly as a result of differences in breed, feed, feeding way, growing environment. Therefore, it is imperative to compare the proximate and cholesterol composition of these birds in order to ascertain the level of nutrient composition and the specie that has the lowest cholesterol composition since high serum cholesterol has been associated with cardio vascular diseases.

2.0 Materials and Methods

2.1 Collection and identification of samples:

Exotic chicken Shika brown eggs were purchased from Labana Farm in Aliero, Aliero Local Government, *Columbia livia* eggs, *Gallus domesticus* eggs and *Numida melleagris* eggs were purchased from Jega Market, Jega local government Area of Kebbi State. While *Anas platyhyncha* eggs, and *Corturnix ypsilophora* eggs were purchased from sokoto meat market. All egg species were identified and authenticated at the Department of Animal science, Faculty of Agricultural, Kebbi State University of Science and Technology, Aliero.

2.2 Chemicals/Reagents

Boric acid, Ammonium Hydroxide, Conc. HCl, Petroleum ether, Sodium Hydroxide, Conc. H_2SO_4, were of analytical grade. Cholesterol assay kit was obtained from randox laboratory UK.

2.3 Preparation of egg for analyses

The sample of various egg species were carefully cracked and the contents emptied into a beaker. Egg samples were weighed using electronic balance and recorded. The sample was homogenized and kept in a dry, clean sample bottles and later used for the analysis.

2.4 Proximate composition

Moisture, ash, protein and carbohydrate were determined by the method as described by [14]. Whereas lipid composition was determined by the method as described by [15].

2.5 Cholesterol determination

Cholesterol content was determined by the method as described by [16].

2.6 Statistical Analysis

Data were expressed as the means ±SD of three (3) replicate. Significant differences between the means were determined using one-way analysis of variance (ANOVA) and Duncan multiple range test (DMRT) at 5% confidence limit using a software SPSS VERSION 17.0.

3.0 Results and Discussion

3.1 Proximate composition of *Anas platyhyncha*, Shika brown, *Numida melleagris*, *Gallus domesticus*, *Columbia livia* and *Corturnix ypsilophora* eggs.

The result revealed no significant difference (P≥0.05) in moisture contents between *Columbia livia*, *Corturnix ypsilophora* and *Gallus domesticus* egg. At the same time there was no significant difference (P≥0.05) in the moisture composition between Shika brown, *Gallus domesticus* and *Corturnix ypsilophora* egg. Similarly, no significant difference (P≥0.05) was observed in moisture compositions between *Anas platyhyncha* and *Numida melleagris* egg. However, there was significant difference (P≤0.05) in the moisture compositions between *Columbia livia* and Shika brown, *Numida melleagris*, *Anas platyhyncha* eggs. (Table 1).

The result also revealed no significant difference (P≥0.05) in protein content between *Anas platyhyncha and Corturnix ypsilophora* egg, however, it shows significant difference (P≤0.05) in protein content when compared across all other egg species (Table 1). Similarly, the results revealed significant alterations (P≤0.05) in ash, crude lipids and carbohydrates contents compared across the egg species though, it shows no significant difference (P≥0.05) between some of the egg species (Table 1).

Table 1: Proximate composition (%) of *Anas platyhyncha*, Shika brown, *Numida melleagris*, *Gallus domesticus*, *Columbia livia* and *Corturnix ypsilophora* eggs.

Egg species	Moisture (%)	Ash (%)	Crude protein (%)	Crude lipid (%)	CHO (%)
Anas platyhyncha	71.83±0.29^{c}	1.83±0.29^{abc}	9.56±0.07^{c}	12.73±0.23^{a}	5.04±0.04^{a}
Shika brown	74.50±0.50^{b}	1.33±0.58^{a}	10.13±0.04^{a}	10.73±0.31^{cd}	3.31±0.73^{ab}
Numida melleagris	72.67±0.76^{c}	1.17±0.29^{ab}	9.75±0.06^{b}	11.13±0.12^{bc}	5.28±0.69^{a}
Gallus domesticus	75.50±0.87^{ab}	0.67±0.29^{bc}	9.42±0.10^{d}	11.53±0.50^{b}	2.88±1.20^{b}
Columbia livia	76.00 ±0.50^{a}	0.50±0.00^{c}	8.98±0.09^{e}	10.40±0.35^{de}	4.12±0.63^{ab}
Corturnix ypsilophora	75.00±1.26^{ab}	1.00±0.00^{abc}	9.60±0.08^{c}	10.00±0 .40^{e}	4.40±0.84^{ab}

Values were presented in Mean ± Standard deviation of 3 replicates.

$^{a-e}$ Test values with different superscript along the columns are significantly different at P≤0.05

3.2 Cholesterol contents of *Anas platyhyncha*, Shika brown, *Numida melleagris*, *Gallus domesticus*, *Columbia livia* and *Corturnix ypsilophora* eggs.

significant difference (P≥0.05) in cholesterol content between some of the egg species when compared across (Table 2).

The result revealed significant difference (P≤0.05) in cholesterol content between *Gallus domesticus* egg when compared with all other egg species. However, there was no

Table 2: Cholesterol Contents of *Anas platyhyncha*, Shika brown, *Numida melleagris*, *Gallus domesticus*, *Columbia livia* and *Corturnix ypsilophora* eggs.

Egg species	Cholesterol (mg/dl)
Anas platyhyncha	747.32±14.55[b]
Shika brown	547.28±12.86[d]
Numida melleagris	548.31±23.89[d]
Gallus domesticus	796.25±9.09[a]
Columbia livia	553.44±12.03[d]
Corturnix ypsilophora	691.81±14.07[c]

Values were presented in Mean ± Standard deviation of 3 replicates.

[a-d] Test values with different superscript along the columns are significantly different at P≤0.05

3.3 Discussion

3.3.1 Proximate Composition

The moisture content of a given sample simply refers to the water content of that sample. The amount of water in a food varies from low amount in dry food to high amount in high moisture foods[17]. Fresh eggs were used in this analysis, thus it contains a higher amount of moisture. The level of moisture was found to be significantly lower in *Anas platyhyncha* egg (Table 1) compared to other species of bird eggs. [18] stated that moisture contents of foods above 15% will favour microbial activities which will result to food spoilage. Thus, since the moisture contents of all the egg species exceed 15% this signifies that all the eggs cannot be store for a longer period. The moisture content of Duck (Table 1) was in range with the value recorded by[19]. The moisture content of *Corturnix ypsilophora* in this recent work (Table 1) was higher compared to the work of[20] who recorded a value of 70.60%. Pigeon egg however has the highest moisture content which is an indication that the egg cannot be store for a longer period of time because there are possibilities of bacteria growth which result in food spoilage.

Proteins are essential components of living cell; they are polymers of amino acids and are nutrients needed by the human body for growth and maintenance of body cells. The result observed (Table 1) indicates that all the species of eggs can serve as a good source of protein. Protein content was higher in Shika brown egg, this may be due to the fact that their feed is well fortified with protein, laying birds requires adequate protein to maximize egg production. This protein content of Shika brown was lower compared to the value (12.14%) reported by [21]. Egg provides means through which the protein need of the populace can be met. Egg has various uses and contains many essential nutrients as it supports life during embryonic growth and one of the nutritious and complete food known to man[22]. The protein composition of *Corturnix ypsilophora* and *Numida melleagris* obtained in this work is in agreement with the values reported by[2]. The crude protein recorded in this recent work for *Anas platyhyncha*, *Gallus domesticus*, Shika brown, *Numida melleagris*, and *Columbia livia* egg is in contrast with the results reported by[23]. [24]reported that chicken egg generally contains about 12% by weight of protein. The difference in protein level may be as a result of diet variation or due to difference in climatic conditions. The recommended daily allowance of protein for children, adult male, adult female, pregnant woman and lactating mother are 28, 63, 50, 60 and 65g respectively[25]. Though, the protein contents of the egg samples are not up to the recommended daily allowance yet, egg

serve in part as a good source of protein for human nutrition.

Generally, lipids are soluble in ether, hence they are ether extractable. Fat can be store in the tissue and later mobilize to provide energy during starvation and fasting or stressful conditions[26]. There was a significant high amount of lipid in *Anas platyhyncha* egg (Table 1). Thus *Anas platyhyncha* egg can provide a higher considerable amount of energy than other eggs species. The fat level in *Numida melleagris* egg was in close range with the literature report of[27], (11.70%). Fat content of *Corturnix ypsilophora* obtained in this current work was higher compared to the value reported by[20], (8.22%). The crude fat recorded in this work for *Anas platyhyncha*, *Gallus domesticus*, *Numida melleagris* and *Columbia livia* egg was higher compared with the result reported by[23] who recorded 2.9±0.07, 4.5 ± 0.06 and 2.0 ± 0.04, 0.9±0.52), and 1.4±0.45 respectively. The consumption of dietary fat and oils being the principal source of energy but should not exceed the recommended daily allowance of not more than 30calories so as to avoid obesity[28].

The amount of ash in the egg compare to other nutrient is negligible. Ash content represents the presence of appreciable amount of mineral in a given sample. Samples with a high ash contents are expected to have high concentration of various mineral elements which are expected to speed up metabolic process, improves growth and development[29]. Shika brown ash content (Table 1) was in close range with the value 0.94% for ash content in chicken egg as recorded by[21]. Thus *Anas platyhyncha*, Shika brown, *Numida melleagris* and *Corturnix ypsilophora* eggs have high mineral compositions thus, they contains high concentration of mineral elements which are expected to speed up metabolic process, formation of red blood cells, conduction of nerve cells and generally improves cell growth and development.

A good source of energy is carbohydrate. It helps in the body's development and growth. *Anas platyhyncha* and *Numida melleagris* from the result on (Table 1) will serve as a good source of carbohydrate compared to other bird egg. This means that these two eggs will provide higher calorific value compared to other egg species. The reason for higher carbohydrate contents in Duck fowl and Guinea fowl egg may be due in part to the fact that these birds mostly feeds on plants leaves which is the ultimate source of carbohydrate.

The variation in nutritional contents of the egg species can result from differences in diet[13, 30, 31], genetics[32], age[33, 31, 34, 35] or sex, all of which have been demonstrated to cause significant changes in proximate composition.

3.3.2 Cholesterol Composition

The cholesterol content of the fresh eggs (yolk and albumen) was analyzed, because in human nutrition the yolk and albumen are mostly used, consumed, or included as a processed food ingredient in the form of powdered white and yolk mixture. The result obtained in this recent study was numerically different from what was reported by[36], who reported higher value of cholesterol for *Anas platyhyncha* egg (884mg per 100g). [36], also reported that the eggs of chicken, *Anas platyhyncha* and *Corturnix ypsilophora* contains 423, 884 and 844mg per 100g respectively which was not in agreement with these current findings. Even though the above reports on cholesterol contents were numerically different from the present finding, the cholesterol content in *Gallus domesticus*, *Anas platyhyncha* and *Corturnix ypsilophora* egg were higher than the cholesterol contents of Shika brown, *Numida melleagris* and *Columbia livia* egg. The reason for high level of cholesterol in *Gallus domesticus* egg and *Anas platyhyncha* egg may be due to the fact that they were raised extensively without much care and attention of their owners, so, they tend to feed for themselves eating all rubbish and waste in the environment. For example *Gallus domesticus* feeds on worms and insects which are animal source. The variation in cholesterol contents of the egg species can result from

differences in diet[13, 30, 31], genetics[32], and age[33, 31, 34, 35]. [37]reported that a large yolk contains more than two-third of the recommended daily intake of 300mg of cholesterol, although the study indicates that the human body may not absorb much cholesterol from egg. Also other research supports the idea that a high egg intake increases cardiovascular risk in diabetic patients[38]. Elevated low-density lipoprotein (LDL) cholesterol is a major risk factor for coronary heart disease (CHD): dietary cholesterol raises LDL cholesterol levels and causes atherosclerosis in numerous animal models. In controlled metabolic studies conducted in humans, the dietary cholesterol raises levels of total and LDL cholesterol in blood, but the effects are relatively small if compared with saturated and trans fatty acids. Studies have found that individuals vary widely in their responses to dietary cholesterol based on monitoring their plasma levels[39]. Recent studies, however, indicated that egg consumption is dangerous for people with diabetes, possibly because of their altered ability to metabolize cholesterol[40, 41, 42]. Moderate egg consumption led to a 40–50% increased risk of heart disease for diabetics[43]. Thus, this study suggest (as revealed in the result) that a diabetic patients should eat less *Gallus domesticus* eggs and *Anas platyhyncha* egg or should eat *Columbia livia* egg, *Corturnix ypsilophora* egg or shika brown egg if at all the patients' needs to eat egg because of its low cholesterol level.

4.0 Conclusion

Eggs have played an important role in the history of human nutrition in most parts of the world. Many different types of eggs have been used as human food some of which include exotic chicken egg, Turkey egg, Guinea fowl egg, Quail egg, Duck egg, Pigeon egg etc. The composition of the avian egg protein and other constituent will continue to provide sources of nutrients for human. In fact, knowledge of the nutrient content from various species of birds will also serve as nutritional guide in food composition table as well as providing valuable information on nutrient intake. The variation in the proximate composition and cholesterol of some avian eggs obtained in this study may serve as a guide of providing useful information on food composition; and it was found that exotic chicken egg has the highest content of crude protein, Pigeon egg has the highest level of moisture content, Quail egg has the least content of crude fat and local fowl egg has the highest content of cholesterol which makes it a bad option for diabetic patients to avoid the risk of cardio vascular diseases. Many different methods have been proposed and used for the cholesterol determination in egg and in particular the spectroscopic determination method has been questioned because of interfering compounds could lead to significant over estimation.

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Reference

1. USDA. (1995). Agricultural Marketing Service. Regulations Governing the Grading of Shell Eggs (7 CFR Part 56) Effective May 1, 1997, and United States Standards, Grades, and Weight Classes for Shell Eggs (AMS 56), Effective April 6, 1995. Washington, DC.

2. Dudusola, I.O. (2010). *Comparative evaluation of internal and external qualities of eggs from quail and guinea fowl.* International Research Journal of Plant Science. 1(5): 112-115.

3. Holland, B., Welch, A.A., Unwin, I.D., Buss, D.H., Paul A.A. and Southgate D.A.T. (1997). *The composition of foods*. 5th ed. Cambridge: Redwood Books; P462.

4. Hargis, P.S., Van Elswyk, M.E. and Hargis, B.M. (1991). *Dietary modification of yolk lipid with savelha oil.* Poultry Science, 70:874-83.

5. Tabas, I. (2002). *Consequences of cellular cholesterol accumulation: basic concepts and*

physiological implications. J Clin Invest; 110:905–911.
6. Tall, A.R., Wang, N., and Mucksavage, P. (2001). *Is it time to modify the reverse cholesterol transport model?* J Clin Invest., 108:1273–1275.
7. Bennion, L.J. (1975). *Effects of diabetes mellitus on cholesterol metabolism in man.* Engl J. Med., 296:1365–1371.
8. Gurr, M. I. (1989). *Dietary fat and plasma lipids Nutrition Research.* Reviews, 2: 63-86.
9. Feeley, R. M. (1972). *Cholesterol content of foods.* J. Am. Diet. Assoc, 61: 134-148.
10. Beyer, S. R. and Jensen, L. S. (1989). *Research note: Cholesterol commercially produced eggs in Georgia.* Poultry Sci., 68:1703.
11. Holden, J., Exler, J., McCharen, C. and Lockard, J. (1989). *A nationwide study cholesterol, proximate, vitamin, and mineral levels in large eggs,* Am. Soc. Exp. Biol., 3(A): 658.
12. Brothwell, Don, R. and Patricia, B. (1997). *Food in Antiquity: a Survey of the Diet of Early People*. Johns Hopkins University press pp. 54 – 55.
13. Clum, N.J., Fitzpatrick, M.P. and Dierenfeld, E.S. (1996). *Effects of diet on nutritional content of whole prey*. Zoo Biol. J., 15:525-537.
14. AOAC. (2005). Official methods of analysis, 18th ed. Association of Official Analytical Chemistry, Washington DC.
15. McLean B., Drake P. (2002): *Review of methods for the determination of fat and oil in foodstuffs*. Review No. 37. Campden & Chorleywood Food Research Association Group (CCFRA). Pp 52.
16. Allain, C.C., Poon, L.S., Chan, C.S. and Richmond, W. (1974). *Enzymatic determination of total serum cholesterol.* Clin. Chem., 20: 470-475.
17. Elvan, C.E., Simmonds, N. and McCollum, E.V. (2008). *The newer knowledge of nutrition*. 4th edition Macmillan Co. New York. Pp 873-890.
18. Hassan, L., Dangogo, S.M., Umar, K.J., Saidu, I. and Folorunsho, F.A. (2008). *Proximate, mineral & antinutritional factors of Danielliaohvevi seed kernel,* Chem class J., 5: 31-36
19. Xu, G.Y., Hou Z.C., Zhong, H.H., Yang, N. and Chang, S.H. (2003). *Analysis and comparison of different laying hens egg,* Guide to Chinese poultry, 20 (12): 3233.
20. Chen, Y.K., Chen-guang, E. and Liu, M.S. (2005). *Comparison of the egg, dark egg, and quail egg,* Feed Industry, 26 (7): 10-12.
21. USDA (1983). Egg grading manual; USDA, AMS, Agriculture handbook 75. U.S. Government Printing Office, Washington, DC.
22. Scott, T.A., Silversides, F.G. and Ross, D.A. (2001). *Effect of storage and layer age on quality of eggs from two lines of hens.* Poult. Sci., 80: 1245-1248.
23. Emmanuel, T.F., Omole, J.O., Joseph, E. and Utu, B.A. (2011). *Variation in Micronutrients Contents and lipid profile of some avian eggs.* America Journal of Experimental Agriculture, 1 (4): 343-354.
24. Gilbert, A.B. (1979). In Four and Faction in Birds (King, A.S and McLelland, J. Eds.). Academic press, London.
25. Ganong M.A. (2003). *Integrated food science & technology for tropics*. Macmillan Ltd. London pp 180-189.
26. Gordon, M.W. (2002). *Vitamin and mineral in contemporary nutrition.* 5th edition. McGram Hill New York pp 239-281.
27. Adenowo, J.A., Awe, F.A., Adebambo, O.A. and Ikeobi, C.N. (1999). *Species variations in chemical composition of local poultry eggs*. Book of Proceeding: 26th Annual NSAP Conference 21-25 March, 1999, University of Ilorin, Ilorin: 278-280.
28. Robbinson, D.S. (1990). Food Biochemistry & Nutritional value. Longman Science and Technology Publisher, New York. Pp57-62.
29. Muhammad, M.A. (2011). *Nutritonal & antinutritional analysis of Gardensa aquallce.* M.sc. Dissertation submitted to post graduate

school Usman Danfodio University Sokoto. Pp 63-88
30. Dierenfeld, E.S. (1994). *Vitamin E in exotics: effects, evaluation and ecology.* J. Nutr., 124:2579S-258.
31. Thonney, M.L., and Ross, D.A. (1987). *Composition of gain of rats fed low or high protein diets and grown at controlled rates from 80 to 205 grams.* J. Nutr. 117: 2135-2141.
32. Lepore, P.D., and Marks, H.L., (1971). *Growth rate inheritance in Japanese quail. Body composition following four generations of selection under different nutritional environments.* Poult. Sci. 50:1191-1193.
33. Douglas, T.C., Pennino, M. and Dierenfeld, E.S. (1994). *Vitamin E & A, and proximate composition of whole mice and rats used as feed.* Comparative Biochem. Physiol. 107A:419-424.
34. Bird, D.M., and HO, S.K. (1976). *Nutritive values of whole animal diets for captive birds of prey.* Raptor Res. 10:45-49.
35. Brisbin, I.L. and Tally, L.J. (1973). *Age-specific changes in the major body components and caloric value of growing Japanese quail.* Auk 90:624-635.
36. Jalaludeen, A., Peethambaran, P. A., Joseph, L. and Manomohan, C. B. (2004). Duck Production in Kerala. NATP on Ducks, Centre for Advanced Studies in Poultry Science, Kerala Agricultural University, Mannuthy, Thrissur, Kerala. Pp 44.
37. Unisci.com, (2010). University science article on eggs and cholesterol (www.unisci.com/stories/20014/1029013.htm.). Retrieve on 2010-01-10.
38. Schärer, M, and Schulthess, G. (2005). *Egg intake and cardiovascular risk.* Ther Umsch, 62(9): 611–3.
39. Hu, F., Stampfer, M., Rimm, E., Manson, J., Ascherio, A., Colditz, G., Rosner, B. and Spiegelman, D. (1999). *A prospective study of egg consumption and risk of cardiovascular disease in men and women.* JAMA, 281 (15): 1387–1394.
40. Njike, V., Faridi, Z., Dutta, S., Gonzalez, A.L. and Katz, D.L. (2010). *Daily egg consumption in hyperlipidemic adults – Effects on endothelial function and cardiovascular risk.* Nutrition Journal, 9, 28–36.
41. Spence, J.D., Jenkins, D.J. and Davignon, J. (2010). *Dietary cholesterol and egg yolks: Not for patients at risk of vascular disease.* Canadian Journal Cardioloy, 26(9): 336–339
42. Barman, N.L., Leeds, A.R., and Griffin, B.A. (2008). *Increased dietary cholesterol does not increase plasma low density lipoprotein when accompanied by an energy restricted diet and weight loss.* European Journal Nutrition, 47: 287–293.
43. Naviglio, D., Monica, G., Laura, G., Carmine, S., Lydia, F. and Antonello, S. (2011). *Determination of cholesterol in Italian chicken eggs.* J. Food Chemistry, 49: 80-131.