

Effect of age, season and housing system on cholesterol and fatty acids contents of table eggs

A. A. Hussein¹, A. A. Idris², B. H. Eljack³ and Mohamed T. Ibrahim³

¹Department of Animal Production, Faculty of Veterinary Science, University of Nyala; ²Department of Poultry Production, Faculty of Animal Production, University of Khartoum, ³Department of Animal Production Faculty of Animal Production Science and Technology, Sudan University of Science and Technology

Abstract

A survey was carried out in Khartoum State to examine the effects of hens' age (66, 42 and 20 weeks), season of production (winter and summer) and housing system (open sided and closed) on table egg contents of cholesterol and fatty acids. Eggs were collected and analyzed for cholesterol and fatty acids content using gas chromatography mass spectrometer. Eggs of 66 weeks old hens had a significantly ($P<0.05$) higher amount of cholesterol than eggs of 20 weeks and 42 weeks old ones. Eggs collected in winter season contained significantly ($P<0.05$) higher percentages of C16:19e fatty acid and vaccenic acid. Arachidonic acid was significantly ($P<0.05$) less in egg yolk of 66 weeks old hens. There were some variations in fatty acids level among all studied factors but the differences were not statistically significant. It could be concluded that eggs produced from younger hens contain less cholesterol than that of the older hens.

Key words: Layers, Fatty Acid, Housing System, Age, Season,

Introduction

In the recent years, the lipid composition of chickens' eggs has been an area of primary consumer concern due to the connection between specific dietary lipids and the development of coronary heart disease and some forms of cancer (Hartmann and Wilhelmson, 2001). Recent studies indicated that nutritional quality of the fat in food products should be evaluated taking into account the cholesterol levels, the saturated fatty acids, the monounsaturated fatty acids and the polyunsaturated fatty acids (Milinsk et al., 2003). Marion et al. (1964) showed that there occurs a variation in the proportionate parts of an egg due to physiological changes associated with age. Ahn et al. (1997) concluded that the yolk size increases proportionately with egg size and solids content of eggs of old or forced molted hens, which lay larger eggs and this may be significantly different from those of young birds. Scheideler et al. (1998) indicated that age significantly increased the level of docosahexaenoic acid in old hens. Chung et al. (1991) and Shafey et al. (1998) found a positive correlation between the

cholesterol concentration and the hen's age. The relationship between egg yolk lipid and age of the hen has been reported by Marion et al. (1966) and Menge et al. (1974) who found that yolk lipid and cholesterol concentrations increased with age of the hens. Contrarily, Pandey et al. (1989) revealed that the cholesterol levels in eggs decreased as the age of hens increased. Carmon and Huston (1965) examined the effect of environmental temperature on the egg size and observed that hens housed at 30°C produced eggs of relatively smaller size. Cerolini et al. (2005) did not observe any significant changes in the cholesterol concentration of eggs of hens in different housing systems. The objective of the present study was to examine the effect of housing system, season and age of hens on fatty acids and cholesterol contents of table eggs.

Materials and Methods

The chosen laying hens were of the same breed, having age 20, 42 and 66 weeks old and reared under two housing systems (closed versus open sided house).

Corresponding author: Mohamed T. Ibrahim, Department of Animal Production Faculty of Animal Production Science and Technology, Sudan University of Science and Technology, Sudan

All the other managerial techniques adopted by the experimental farms were similar. Birds were fed commercial balanced diets that fulfilled the requirements of layers. In winter, 24 eggs were collected from each of the three different age groups (20, 42 and 66 weeks) and the two experimental housing systems. The same procedure was adopted to collect eggs in summer season from the experimental poultry farms. After collection, eggs samples were transported directly to the laboratory for the chemical analysis.

In the laboratory, four eggs from each sample were taken at random and cracked. Yolks were then separated from the whites manually, pooled in a dish and homogenized to make a composite sample. Yolk lipids were extracted following the method of Folch et al. (1957) that was modified by Washburn and Nix (1974). The total cholesterol was determined according to the method of Kim and Goldberg (1969) using Liebermann-Burchard reagent. Quantification of fatty acids was done after preparation of fatty acid methyl esters according to the method of Christie (1990). Subsequently egg yolk fatty acids profiles were obtained by gas chromatography–mass spectrometer and reported as percentages.

Statistical Analysis

Completely randomized design was used in this experiment. The data were tested for the significance of the effect of housing system (closed versus open sided house) by independent T-test according to Petrie and Watson (2006). Similarly, for the significance of the effect of season of production, independent (winter versus summer) T-test was used.

Results

No significant difference was found in egg yolk saturated fatty acids profile of laying hens of the examined ages, seasons and housing systems as shown in Table 2. Among the unsaturated fatty acids (Table 3),

C 16:1 9e and vaccenic concentrations were significantly higher in winter compared to summer season. Arachidonic acid concentration was significantly lower in the egg yolk of the 66 weeks old hens' eggs. For cholesterol content, the eggs' yolk of the hens of 66 weeks was significantly higher than that of the other two age groups (20 and 42 weeks old hens). No significant difference was found in the summation of saturated, unsaturated and omega fatty acids contents of egg yolk (Table 3).

Discussion

It is clear from the results that these factors did not have a significant effect on the percentages of the saturated, most of the unsaturated fatty acids and the summation of saturated, unsaturated and omega fatty acids. It is well known that synthesis, digestion and degradation of fatty acids is carried out under complicated enzymes systems inside the cell and the activity of these enzymes is affected by many factors such as temperature, substrate (fatty acid) concentration, pH, enzyme concentration and the end-product concentration (Arsan and Mohammed, 2000, Michael et al., 2000).

The temperature is different in summer than in winter season and in closed than in open sided houses. Another fact is the thermal range for any enzyme to work perfectly. So perhaps the increase or decrease of the temperature of the different egg production conditions may have affected the production of certain fatty acids. Therefore, though non significant, the production of butyric, caprylic, myristic, C18:0e, palmitoleic, C17:2 8,10, oleic, vaccenic, C18:1 12, rumenic, C20:1 11, eicosapentaenoic, docosahexaenoic, total of saturated fatty acids, total of unsaturated fatty acids, total of monounsaturated fatty acids, total of polyunsaturated fatty acids and total of omega fatty acids is better in open sided houses than in closed houses. While the production of tridecylic, pentadecylic, palmitic, C16:0e, margaric, stearic,

Table 1: Saturated fatty acids contents as % of total fatty acids (mean \pm SE) of hens' egg yolk of the experimental groups

	Butyric	Caprylic	tridecylic	Myristic	Pentadecylic	palmitic
Housing						
0	0.10 \pm 0.10	0.09 \pm 0.02	0.13 \pm 0.09	0.37 \pm 0.10	0.02 \pm 0.02	25.84 \pm 3.31
1	0.03 \pm 0.03	0.03 \pm 0.02	0.16 \pm 0.13	0.24 \pm 0.06	0.40 \pm 0.00	27.29 \pm 2.98
Sig.	NS	NS	NS	NS	NS	NS
Season						
0	0.10 \pm 0.10	0.03 \pm 0.03	0.07 \pm 0.05	0.30 \pm 0.02	0.00 \pm 0.00	23.39 \pm 2.81
1	0.03 \pm 0.03	0.07 \pm 0.02	0.37 \pm 0.31	0.29 \pm 0.08	0.04 \pm 0.00	28.69 \pm 2.82
Sig.	NS	NS	NS	NS	NS	NS
Age						
0	0.1900 \pm 0.00	0.047 \pm 0.02	0.260 \pm 0.21	0.125 \pm 0.13	0.02 \pm 0.02	21.21 \pm 3.62
1	0.025 \pm 0.03	0.080 \pm 0.01	0.033 \pm 0.02	0.297 \pm 0.01	0.00 \pm 0.00	30.34 \pm 2.55
2	0.000 \pm 0.00	0.047 \pm 0.04	0.150 \pm 0.14	0.390 \pm 0.10	0.04 \pm 0.00	27.75 \pm 3.53
Sig.	NS	NS	NS	NS	NS	NS

Table 1 (Cont.): Saturated fatty acids contents as % of total fatty acids (mean \pm SE) of hens' egg yolk of the experimental groups

	C 16:0e	Margaric	Stearic	C 18:0e	nonadecylic	arachidic
Housing						
0	1.59 \pm 0.87	0.16 \pm 0.08	9.96 \pm 1.12	0.34 \pm 0.23	0.04 \pm 0.04	0.15 \pm 0.07
1	1.76 \pm 0.00	0.18 \pm 0.02	12.41 \pm 0.72	0.09 \pm 0.00	0.04 \pm 0.00	0.21 \pm 0.18
Sig.	NS	NS	NS	NS	NS	NS
Season						
0	1.63 \pm 0.62	0.18 \pm 0.04	9.57 \pm 1.01	0.28 \pm 0.17	0.04 \pm 0.00	0.29 \pm 0.17
1	0.00 \pm 0.00	0.17 \pm 0.05	12.27 \pm 0.83	0.00 \pm 0.00	0.04 \pm 0.04	0.08 \pm 0.02
Sig.	NS	NS	NS	NS	NS	NS
Age						
0	2.39 \pm 0.63	0.20 \pm 0.00	10.93 \pm 1.40	0.77 \pm 0.00	0.00 \pm 0.00	0.42 \pm 0.32
1	0.00 \pm 0.00	0.14 \pm 0.07	12.95 \pm 0.88	0.00 \pm 0.00	0.06 \pm 0.02	0.09 \pm 0.04
2	1.76 \pm 0.00	0.20 \pm 0.04	9.76 \pm 1.05	0.17 \pm 0.08	0.00 \pm 0.00	0.11 \pm 0.08
Sig.	NS	NS	NS	NS	NS	NS

Housing 0 = open sided house. Housing 1 = closed house. Season 1 = summer. Season 0 = winter. Age 0 = 20weeks old. Age 1 = 42weeks old. Age 2 = 66weeks old. The notation C 4:0 denotes to the follows C = carbon atom 4= the number of carbon atoms 0 = the number of double bonds. SE = standard error. Sig. = level of treatment significance. NS = treatment effect is not significant at P<0.05.

Table 2: Unsaturated fatty acids contents as % of total fatty acids (mean \pm SE) of hens' egg yolk of the experimental groups

	C 16:17	Palmitoleic	C 16:19e	C 17:28:10	C18:1 8	Oleic	Vaccenic
Housing							
0	0.19 \pm 0.08	2.51 \pm 0.45	0.07 \pm 0.07	0.28 \pm 0.00	0.14 \pm 0.09	49.63 \pm 9.40	0.12 \pm
1	0.22 \pm 0.09	1.26 \pm 0.45	0.07 \pm 0.05	0.09 \pm 0.07	0.19 \pm 0.19	45.35 \pm 3.62	0.06 \pm 0.05
Sig.	NS	NS	NS	NS	NS	NS	NS
Season							
0	0.20 \pm 0.03	1.04 \pm 0.30	0.13 \pm 0.01 ^a	0.12 \pm 0.08	0.23 \pm 0.12	48.66 \pm 9.56	0.14 \pm 0.02 ^a
1	0.21 \pm 0.08	2.20 \pm 0.47	0.01 \pm 0.01 ^b	0.15 \pm 0.15	0.06 \pm 0.06	46.31 \pm 3.37	0.02 \pm 0.02 ^b
Sig.	NS	NS	S*	NS	NS	NS	S*
Age							
0	0.11 \pm 0.11	1.32 \pm 0.79	0.07 \pm 0.07	0.28 \pm 0.00	0.19 \pm 0.19	41.93 \pm 5.29	0.12 \pm 0.00
1	0.22 \pm 0.18	1.90 \pm 0.74	0.00 \pm 0.00	0.17 \pm 0.12	0.31 \pm 0.00	58.74 \pm 11.08	0.04 \pm 0.00
2	0.26 \pm 0.05	2.22 \pm 0.53	0.07 \pm 0.05	0.02 \pm 0.02	0.06 \pm 0.06	41.8 \pm 6.63	0.08 \pm 0.08
Sig.	NS	NS	NS	NS	NS	NS	NS

Table 2 (Cont.): Unsaturated fatty acids contents as % of total fatty acids (mean \pm SE) of hens' egg yolk of the experimental groups

	C 18:112	rumenic	C 20:111	arachidonic	C 20:4 5:8; 11:14e	Eicosa pentaenoic	Docos ahexaenoic
Housing							
0	0.12 \pm 0.00	0.39 \pm 0.16	0.36 \pm 0.10	1.22 \pm 0.46	0.48 \pm 0.00	0.64 \pm 0.00	0.16 \pm 0.05
1	0.01 \pm 0.01	0.23 \pm 0.19	0.24 \pm 0.07	1.26 \pm 0.18	0.49 \pm 0.19	0.08 \pm 0.08	0.09 \pm 0.02
Sig.	NS	NS	NS	NS	NS	NS	NS
Season							
0	0.06 \pm 0.06	0.37 \pm 0.12	0.25 \pm 0.04	1.07 \pm 0.32	0.26 \pm 0.26	0.40 \pm 0.24	0.09 \pm 0.05
1	0.02 \pm 0.00	0.05 \pm 0.00	0.31 \pm 0.09	1.45 \pm 0.43	0.63 \pm 0.15	0.00 \pm 0.00	0.17 \pm 0.03
Sig.	NS	NS	NS	NS	NS	NS	NS
Age							
0	0.12 \pm 0.00	0.70 \pm 0.10	0.27 \pm 0.18	1.66 \pm 0.14 ^a	0.48 \pm 0.00	0.64 \pm 0.00	0.20 \pm 0.04
1	0.00 \pm 0.00	0.15 \pm 0.13	0.37 \pm 0.03	1.84 \pm 0.42 ^a	0.73 \pm 0.21	0.00 \pm 0.00	0.11 \pm 0.07
2	0.01 \pm 0.01	0.20 \pm 0.01	0.23 \pm 0.03	0.62 \pm 0.33 ^b	0.24 \pm 0.24	0.08 \pm 0.08	0.08 \pm 0.04
Sig.	NS	NS	NS	S*	NS	NS	NS

Housing 0 = open sided house. Housing 1 = closed house. Season 1 = summer. Season 0 = winter. Age 0 = 20weeks old. Age 1 = 42weeks old. Age 2 = 66weeks old. SE = standard error. Sig. = level of treatment significance. NS = treatment effect is not significant (P>0.05). S* = treatment effect is significant (P<0.05). ^{a-b} means within the same column with different superscript are different (P<0.05). The notation C 11:1 10 denotes to the follows C = carbon atom 11= the number of carbon atoms 1 = the number of double bonds the italic 10 number = the position of a double bond is after the carbon atom number 10

Table 3: Summation of saturated, unsaturated, omega fatty acids and cholesterol contents as % of total fatty acids (mean \pm SE) of hens' egg yolk of the experimental groups

	Σ Sat FA	Σ Un Sat FA	Σ M un Sat FA	Σ P un Sat FA	$\Sigma\omega$ 3FA
Housing					
0	38.41 \pm 2.87	64.15 \pm 6.28	55.96 \pm 8.64	15.03 \pm 7.49	0.44 \pm 0.14
1	37.60 \pm 5.26	54.93 \pm 3.49	48.70 \pm 4.23	6.23 \pm 1.62	0.14 \pm 0.05
Sig.	NS	NS	NS	NS	NS
Season					
0	32.12 \pm 5.36	66.22 \pm 5.89	55.61 \pm 8.90	12.66 \pm 4.44	0.29 \pm 0.20
1	42.84 \pm 1.88	52.86 \pm 2.75	49.06 \pm 3.79	4.80 \pm 1.82	0.29 \pm 0.02
Sig.	NS	NS	NS	NS	NS
Age					
0	30.63 \pm 6.43	58.31 \pm 5.32	49.71 \pm 5.65	10.36 \pm 1.98	0.39 \pm 0.26
1	43.94 \pm 3.40	64.21 \pm 10.40	61.94 \pm 11.07	2.90 \pm 0.38	0.23 \pm 0.13
2	40.83 \pm 2.47	56.10 \pm 1.49	45.35 \pm 6.38	14.247.61	0.23 \pm 0.02
Sig.	NS	NS	NS	NS	NS

Table 3 (Cont.): Summation of saturated, unsaturated, omega fatty acids and cholesterol contents as % of total fatty acids (mean \pm SE) of hens' egg yolk of the experimental groups

	$\Sigma\omega$ 6FA	$\Sigma\omega$ 9FA	Σ P un Sat FA / Σ Sat FA	Cholesterol
Housing				
0	7.21 \pm 4.54	49.88 \pm 9.39	0.26 \pm 0.13	20.83 \pm 2.45
1	5.30 \pm 2.38	45.55 \pm 3.64	0.21 \pm 0.08	25.76 \pm 3.77
Sig.	NS	NS	NS	NS
Season				
0	9.81 \pm 4.17	48.79 \pm 9.54	0.37 \pm 0.12	0.09 \pm 3.38
1	1.40 \pm 0.49	46.64 \pm 3.42	0.09 \pm 0.04	24.22 \pm 3.30
Sig.	NS	NS	NS	NS
Age				
0	6.32 \pm 2.46	42.16 \pm 5.37	0.34 \pm 0.10	16.75 \pm 0.23 ^a
1	1.38 \pm 0.55	59.02 \pm 10.99	0.07 \pm 0.04	20.72 \pm 2.44 ^a
2	10.34 \pm 6.57	41.97 \pm 6.68	0.29 \pm 0.19	32.42 \pm 2.51 ^b
Sig.	NS	NS	NS	S*

Housing 0 = open sided house. Housing 1 = closed house. Season 1 = summer. Season 0 = winter. Age 0 = 20weeks old. Age 1 = 42weeks old. Age 2 = 66weeks old. SE = standard error. Sig. = level of treatment significance. NS = treatment effect is not significant ($P>0.05$). S* = treatment effect is significant ($P<0.05$). ^{a-b} means within the same column with different superscript are different ($P<0.05$). Σ = summation. ω = omega. Sat = saturated. M = mono. FA = fatty acids. P = poly

arachidic, C16:1 7, C18:1 8, arachidonic, C20:4 5,8,11,14e and cholesterol is better in closed houses than in open sided houses. The absence of the significant differences between the cholesterol amounts in the two housing systems is in agreement with the findings of Cerolini et al. (2005). Whereas the production of butyric, myristic, C16:0e, margaric, C18:0e, arachidic, C16:1 9e, C18:1 8, oleic, vaccenic, C18:1 12, rumenic, eicosapentaenoic, total of unsaturated fatty acids, total of polyunsaturated fatty acids, total of monounsaturated fatty acids and total of omega fatty acids are better in winter season than in summer season. The production of caprylic, tridecylic, pentadecylic, palmitic, stearic, C16:1 7, palmitoleic, C17:2 8,10, C20:1 11, arachidonic, C20:4 5,8,11,14e, docosahexaenoic, total of saturated fatty acids and cholesterol are better in summer season than in winter season. The great amount of fatty acids in eggs collected in winter season or from hens reared in closed houses may be attributed to more suitable conditions in this season and housing for rearing hens than conditions

in the summer season and in the open sided houses. Such condition makes the hens consume more feeds and allow more of the dietary fatty acids to be secreted in the eggs (Carmon and Huston, 1965). The absence of differences between the amount of nonadecylic acid among the two seasons and the two housing systems indicated that the synthesis of this fatty acid perhaps was not affected by these factors.

Regarding the results of hens' age, some fatty acids and cholesterol were increased with the increase of hens' age. This may be attributed to the fact that when age of hens increases, the capacity of digestive system increases resulting in consumption of more feed, thus allowing more dietary fatty acids and cholesterol to be secreted into egg yolk (Marion et al., 1964; Marion et al., 1966; Menge et al., 1974; Pandey et al., 1989; Chung et al., 1991; Ahn et al., 1997; Shafey et al., 1998).

Some infrequent fatty acids (butyric, docosahexaenoic, C17:2 8;10 and $\Sigma\omega$ 3FA) were decreased by the increase of hens' age and that may be attributed to its

infrequency and its little amount. So when the hens' age increased the egg size increased leading to decrease the concentration of these fatty acids. The finding of docosaheptaenoic was conversing the finding of Scheideler et al. (1998) who noted that fatty acids increase with increasing age of hens, which may be due to the increase of feed intake, and thus more fatty acids are secreted into egg yolk.

Conclusion

In this study, we observed that eggs produced in winter season are richer in fatty acids than those of summer season. Eggs produced by young birds contain lower amounts of cholesterol and total saturated fatty acids than those produced by old birds.

Acknowledgments

The authors would like to thank Maysaa and the staff of gas chromatography lab in the Central Laboratory of the Ministry of Science and Technology at Soba, for their help.

References

- Ahn, D.U., Kim, S.M. and Shu, H. 1997. Effect of egg size and strain and age of hens on the solids content of chicken eggs. *Poultry Science*, 76: 914-919.
- Arsan, A.M. and Mohammed, S.H.K. 2000. Introduction to Clinical Biochemistry (1). 1st (Ed.), Dar Wael Printing and Publishing Jordan, Pp: 37-50.
- Carmon, L.G. and Huston, T.G. 1965. The influence of environmental temperature upon egg components of domestic fowl. *Poultry Science*, 44: 1237-1240.
- Cerolini, S., Zaniboni, L. and Cognata, L.R. 2005. Lipid characteristics in eggs produced in different housing systems. *Italian Journal of Animal Science*, 4: 520.
- Christie, W.W. 1990. Preparation of ester derivatives of fatty acids for chromatographic analysis in advances in lipid methodology. Pp: 69-111. Oily Press, Dundee.
- Chung, S.L., Ferrier, L.K. and Squires, E.J. 1991. Survey of cholesterol level of commercial eggs produced on Canadian farms. *Canadian Journal of Animal Science*, 71: 205-209.
- Folch, J., Lees, M. and Sloan-Stanely, G.H. 1957. A simple method for isolation and purification of total lipids from animal tissues. *Journal of Biological Chemistry*, 226: 497-509.
- Hartmann, C. and Wilhelmson, M. 2001. The hen's egg yolk: A source of biologically active substances. *World's Poultry Science Journal*, 57: 13-28.
- Kim, E. and Goldberg, M. 1969. Serum cholesterol assay using a stable liebermann-burchard reagent. *Clinical Chemistry*, 15: 1171 - 1179.
- Marion, J.E., Woodroff, J.G. and Tindell, D. 1966. Physical and chemical Properties of eggs as affected by breeding and age of hens. *Poultry Science*, 45: 1189-1195.
- Marion, W.W., Nordskog, A.W., Tolman, H.S. and Forsythe, R.H. 1964. Egg composition as influenced by breeding, egg size, age and season. *Poultry Science*, 43: 255-264.
- Menge, H., Littlefield, L.H., Frobish, L.T. and Weinland, B.T. 1974. Effect of cellulose and cholesterol on blood and yolk lipids and reproductive efficiency of the hen. *Journal of Nutrition*, 104: 1554-1556.
- Michael, L.B., Janet, L.D. and Edward, P.F. 2000. Clinical chemistry 4th (Ed.), Lippincott Williams & Wilkins. New York, Pp: 188-189.
- Milinsk, M.C., Murakami, A.E., Gomes, S.T.M., Matsushita, M. and De Souza, N.E. 2003. Fatty acid profile of egg yolk lipids from hens fed diets rich in omega-3 fatty acids. *Food Chemistry*, 83: 287-292.
- Pandey N.K., Panda B., Maitra D.N., Mahapatra C.M. 1989. The influence of strain, age and season on cholesterol, vitamin A and fatty acid contents of egg. *Journal of Food Science Technology-India*, 26: 161-163.
- Petrie, A. and Watson, P. 2006. Statistics for Veterinary and Animal Science. 2nd (Ed.) Blackwell publishing, Oxford, UK.
- Scheideler, S.E., Jaroni, D. and Froning, G.W. 1998. Strain and age effect on egg composition from hens fed diets rich in n-3 fatty acids. *Poultry Science*, 77: 192-196.
- Shafey, T.M., Dingle, J.G. and McDonald, M.W. 1998. The relationships between egg yolk cholesterol, egg production and age of the hen in three Australian layer strains. *J. King Saud University Agricultural Science*, 10: 33-41.
- Washburn, K.W. and Nix, D.F. 1974. Genetic basis of yolk cholesterol content. *Poultry Science*, 53 (1): 109-115.