Scientific Papers. Series D. Animal Science. Vol. LXIV, No. 2, 2021
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

FATTY ACID PROFILE IN EGGS AND EGGS PRODUCTS

Marius Giorgi USTUROI, Roxana Nicoleta RAȚU, Răzvan Mihail RADU-RUSU, Mihaela IVANCIA, Alexandru USTUROI

"Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine of Iasi, 3 Mihail Sadoveanu Alley, Iasi, Romania

Corresponding author email: umg@uaiasi.ro

Abstract

Aim of this research was to determine the fatty acid profile of eggs from various poultry species, as well as the relationships between them, including fatty acids Ω-6 and Ω-3. The tests were carried out using a Perkin Elmer Clarus 500 chromatograph with a BP x 70 flame ionization detector and column on hen's eggs, quail, guinea fowl, and a pasteurized liquid mixture made from hen's eggs. The results found that quail eggs had the highest fatty acid content (101.485 g FAME / 100 g overall FAME), which was 0.90 percent higher than guinea fowl eggs, 1.48 percent higher than eggs, and 2.04 percent higher than the pasteurized chicken egg mixture. Quail eggs had an SFA/UFA ratio of 0.480, compared to 0.545 for pasteurized mix, 0.551 for chicken eggs, and 0.716 for guinea fowl eggs, and a PUFA/MUFA ratio 0.635 for pasteurized mix, 0.679 quail eggs, 0.730 hen eggs, and 0.744 for guinea fowl eggs. The researchers concluded that, in terms of fatty acid content and ratio, quail eggs are a safer alternative to chicken eggs in the human diet.

Key words: *eggs, fatty acid, guinea fowl, hens, quail, ratio Ω-6/Ω-3.*

INTRODUCTION

Lately, human nutrition is increasingly emphasizing the fat content of foods of animal origin and especially their composition in fatty acids (Gopinath et al., 2020).

Lipids from food have an energetic role (1 g of lipids produces about 9 kcal), structural (part of cell membranes), hormonal (steroid hormones), vitamin (fat-soluble vitamins) and organ insulators (mechanical, thermal and electrical) (Grandall et al., 2009; Hidalgo et al., 2008).

Saturated fatty acids can be synthesized by the human body, which is why they are not an essential part of the diet. This group of acids is responsible for the increase of low-density lipoproteins-LDL ("bad" cholesterol), because it reduces the synthesis of LDL receptors and their activity; Coconut oil, palm oil and butter have a strong hypercholesterolemic effect. To lower cholesterol, it is twice as effective to reduce the intake of saturated fatty acids (fats from dairy products and meat) than the additional intake of polyunsaturated fatty acids (Anton et al., 2003; Grobas et al., 2001; Jolivet et al., 2006).

Monounsaturated fatty acids can be produced by the human body; the most important is oleic acid, which is found in large amounts in olive, almond, avocado and peanut oil (Hu F.B et al., 2001; Xiao et al., 2020).

Polyunsaturated fatty acids are not produced by the human body, therefore an intake from exogenous sources is necessary, because they are indispensable for a proper diet; from the omega 6 group, the most representative is linoleic acid, contained in vegetable oils (sunflower, hemp, soybean, pumpkin and sesame) (Hur et al., 2003; Kovacs-Nolan et al., 2005; Imai et al., 2019).

Specialist studies have shown that some of the fatty acids, through the different physiological roles they play, influence the health of consumers (Katarzyna & Ignatowicz, 2019).

For example, conjugated linoleic acid is believed to have anticancer and antioxidant effects, but also to have a beneficial influence on the immune system (Schaefer, 2002; Seah et al., 2019).

The Ω-3 fatty acids (α-linolenic, eicosapentaenoic, docosapentaenoic and docosahexaenoic), together with linoleic acid contribute to fetal development and the prevention of premature births, lower blood cholesterol, improve visual acuity, but also intellectual development (Nistor et al., 2017) .

Diets with high levels of omega 9 monounsaturated fatty acids and with an optimal ratio between omega 6 and omega 3 help lower cholesterol, but are also recommended in the treatment of diabetes, arthritis, depression, etc (Radu-Rusu et al., 2014).

Nutritional imbalances due to low consumption of essential fatty acids (especially docosahexaenoic and eicosapentaenoic acid) can cause various diseases and therefore the recommendations of specialists aim to ingest them from natural sources, such as fish oil (Simopoulos, 1991).

Of all the products of animal origin, eggs are considered nutritionally complete foods, which is why they have been declared as the standard food of protein efficacy in children.

Worldwide, the highest consumption is recorded for chicken eggs, whose chemical composition depends, among other things, on the rearing system and the quality of the feed administered. However, in recent times, hen's eggs have been frequently challenged (as they contain harmful elements such as hormones, heavy metals, pathogens, etc. and as being involved in raising cholesterol), and eggs from other poultry species, such as quail, biblical, ostrich, etc.

MATERIALS AND METHODS

The research aimed to establish the profile of fatty acids and the relationships between them in eggs from several poultry species; to achieve the proposed purpose, chicken, quail and biblical eggs (30 pcs./lot) and pasteurized liquid mixture of chicken eggs (one packing unit, 1.5 kg) were studied.

The determinations were performed according to the methodology specific to scientific research.

The determination of the fatty acid content of the eggs was performed with the Perkin Elmer Clarus 500 chromatograph equipped with a flame ionization detector and a BP x 70 column, on previously dried samples at + 65°C (mass = 1 g). The principle of the method consists in transforming the fatty acids from the analyzed sample into methyl esters, separating them by chromatographic column and then identifying them by comparison with the standard chromatogram and quantifying the percentage of fatty acid esters (SR EN ISO 5508:2002). The calculation of the amount of fatty acid esters in the samples was made by relating the surface area of the sample to the standard and to the dilution used; expression was done in g AG/100 g lipids.

The ratio between the fatty acid groups was established by calculation, as follows:

SFA/UFA = saturated fatty acids (SFA)/totally unsaturated fatty acids (UFA);

PUFA/MUFA = polyunsaturated fatty acids (PUFA)/monounsaturated fatty acids (MUFA).

To establish the Ω-6/Ω-3 ratio, the total omega 6 fatty acids were calculated (c. Linoleic acid C18:2n6; linolenic acid C18:3n6; eicosadienic acid C20:2n6; eicosatrienoic acid C20:3n6; arachidonic acid C20:4n6; Decosatetraenoic acid C22:4n6) and, respectively, the total omega 3 fatty acids (Linolenic acid α C18:3n3; Octadecatetraenoic acid C18:4n3; Eicosatrienoic acid C20:3n3; Decosapentenoic acid C22:5n3; Decosahexaenoic acid C22:6n3).

RESULTS AND DISCUSSIONS

The sum of the fatty acids. From the sum of saturated, monounsaturated and polyunsaturated fatty acids, a total amount of fatty acids of 99.417 g FAME/100 g total FAME (methyl esters of fatty acids) resulted in the pasteurized mixture made from chicken eggs, of 99.985 g FAME/100 g total FAME for chicken eggs, 100.570 g FAME/100 g total FAME for biblical eggs and 101.485 g FAME/100 g total FAME for quail eggs (Table 1).

Table 1. Fatty acids content (g FAME/100 g total FAME)

Fatty acids		Chicken eggs	Pasteurized liquid mixture	Quail eggs	Biblical eggs
Saturated fat		***35.525***	***35.073***	***32.925***	***40.803***
Myristic acid	C14:0	0.290	0.333	0.675	0.552
Pentadecylic acid	C15:0	0.105	0.062	0.190	0.111
Palmitic acid	C16:0	24.520	25.532	21.250	26.220
Margaric acid	C17:0	0.190	0.134	0.160	0.240
Stearic acid	C18:0	10.420	9.012	10.650	13.680

Fatty acids	Chicken eggs	Pasteurized liquid mixture	Quail eggs	Biblical eggs	Fatty acids
Monounsaturated acids		***37.855***	***39.356***	***40.835***	***33.689***
Myristoleic acid	C14:1	0.075	0.062	0.555	0.102
Pentadecanoic acid	C15:1	0.100	0.054	0.405	0
Palmitoleic acid	C16:1	3.150	3.482	3.970	3.590
Heptadecanoic acid	C17:1	0.120	0.071	0.210	0.133
Cis oleic acid	C18:1n9	34.040	35.374	35.250	29.670
Erucic acid	C22:1n9	0.085	0.092	0.110	0
Neurronic acid	C24:1n9	0.285	0.221	0.335	0.194
Polyunsaturated acids		***26.605***	***24.988***	***27.725***	***26.078***
Conjugated linoleic acid	C18:2	0	0	1.000	0.190
Cis linoleic acid (Ω-6)	C18:2n6	19.580	18.674	16.730	17.590
Linolenic acid y (Ω-6)	C18:3n6	0.145	0.111	0.120	0.133
Linolenic acid α (Ω-3)	C18:3n3	0.420	0.434	1.295	1.050
Octadecatetraenoic acid (Ω3)	C18:4n3	0	0	1.700	0.501
Eicosadienic acid (Ω-6)	C20:2n6	0.165	0.142	0.070	1.000
Eicosatrienoic acid (Ω-6)	C20:3n6	0.275	0.163	0.215	0.234
Eicosatrienoic acid (Ω-3)	C20:3n3	0.395	0.384	0.395	0.355
Arachidonic acid (Ω-6)	C20:4n6	3.500	2.901	2.790	2.900
Decosatetraenoic acid (Ω-6)	C22:4n6	0.835	0.964	0.850	0.210
Decosapentenoic acid (Ω-3)	C22:5n3	0.185	0.142	0.400	0.145
Decosahexaenoic acid (Ω-3)	C22:6n3	1.105	1.073	2.160	1.770
Total fatty acids		**99.985**	**99.417**	**101.485**	**100.570**

Fatty acid profile. For saturated fatty acids, the lowest content was measured in quail egg yolk, of only 32.925 g FAME/100 g total FAME (methyl esters of fatty acids), and the highest in biblical egg yolk, of 40.803 g FAME/100 g total FAME. In the case of chicken eggs, the saturated fatty acids recorded levels of 35.525 g FAME/100 g total FAME in the case of those in shell and 35.073 g FAME/100 g total FAME in the case of those processed into pasteurized mixture.

As expected, C16:0 palmitic acid predominated among the saturated fatty acids (quail = 21.250 g FAME/100 g; chicken = 24.52 g FAME/100 g; pasteurized chicken mixture = 25.532 g FAME/100 g; biblical = 26.220 g FAME/100 g) and stearic acid C18:0 (with values between 9.012 g FAME/100 g total FAME as it was in the pasteurized liquid mixture and 13.680 g FAME/100 g total FAME in biblical eggs).

In the case of monounsaturated fatty acids, the highest content was found in quail eggs (40.835 g FAME/100 g total FAME), followed by a decrease in the pasteurized mixture of chicken eggs (39.356 g FAME/100 g total FAME), eggs chicken (37.855 g FAME/100 g total FAME) and biblical ones with the lowest level (33.689 g FAME/100 g total FAME).

The highest amounts detected were for cis oleic acid C18:1n9 (29.670-35.374 g FAME/100 g total FAME) and palmitoleic acid C16:1 (3.150-3.970 g FAME/100 g total FAME). It should be noted that quail eggs found the highest amounts for each of the monounsaturated fatty acids tested, with the exception of the cis oleic acid in which they were surpassed only by the pasteurized mixture of chicken eggs.

Another finding was that no monounsaturated pentadecanoic and erucic acids were identified in biblical eggs.

Polyunsaturated fatty acids also recorded higher levels in quail eggs (27.725 g FAME/100 g total FAME), followed at a distance by chicken eggs (26.605 g FAME/100 g total FAME), by biblical eggs (26.078 g FAME/100 g total FAME) and pasteurized mixture of chicken eggs (26.078 g FAME/100 g total FAME).

Quantitatively detached cis linoleic acid C18:2n6, with values between 16.730 g FAME/100 g total FAME as it was for quail eggs and 19.580 g FAME/100 g total FAME for chicken eggs, but also arachidonic acid C20:4n6 with values between 2.790 g FAME/100 g FAME for quail eggs and 3.500 g FAME/100 g total FAME for chicken eggs.

C18:2 conjugated linoleic acid credited with anticancer effects was found only in quail eggs

(1.000 g FAME/100 g) and biblical eggs (0.190 g FAME/100 g)

The ratio of fatty acids. The closest ratio between saturated fatty acids (SFA) and total unsaturated fatty acids (UFA) was for quail eggs (0.480), and the widest for biblical eggs (0.716); in the case of chicken eggs, intermediate values were found, both for those in shell (0.551) and for those transformed into pasteurized mixture (0.545) (Table 2).

The ratio between polyunsaturated fatty acids (PUFA) and monounsaturated fatty acids (MUFA) was 0.703 for hen's eggs, 0.635 for pasteurized mixture made from hen's eggs, 0.679 for quail eggs and 0.774 for eggs, respectively of biblical.

Omega 3 and omega 6 acid content. Omega 3 fatty acids were found in an amount of 2.033 g in pasteurized molasses, 2.105 g in chicken eggs, 3.821 in biblical eggs and 5.950 in quail eggs; for omega 6 fatty acids were detected amounts of 24.500 g for chicken eggs, 22.955 g for pasteurized mixture, 22.067 g for biblical eggs and, respectively, only 20.775 g for quail eggs Table 3).

Table 2. Ratio between fatty acid groups

The system growth	Fatty acids				Fatty acid ratio	
	SFA Saturated fatty acids	**MUFA** Monounsaturated fatty acids	**PUFA** Polyunsaturated fatty acids	**UFA** Totally unsaturated acids	SFA/ UFA	PUFA/ MUFA
Chicken eggs	35.525	37.855	26.605	64.460	0.551	0.703
Pasteurized liquid mixture	35.073	39.356	24.988	64.344	0.545	0.635
Quail eggs	32.925	40.835	27.725	68.560	0.480	0.679
Biblical eggs	42.803	33.689	26.078	59.767	0.716	0.774

Table 3. Omega 3 and omega 6 fatty acid content

Specification	Ω3	Ω6	Ω6 / Ω3
Chicken eggs	2.105	24.500	11.639
Pasteurized liquid mixture	2.033	22.955	11.291
Quail eggs	5.950	20.775	3.492
Biblical eggs	3.821	22.067	5.775

Regarding the ratio between omega 6 and omega 3 acids, the values obtained were very high in chicken eggs (11.639) and pasteurized mixture (11.291) and much lower in biblical eggs (5.775) and especially in quail eggs (3.492).

CONCLUSIONS

The analysis of the data on the total fatty acid content showed that the quail eggs had the highest level (101.485 g FAME/100 g total FAME), 0.90% higher than the biblical eggs, with 1.48% than for hen's eggs and 2.04% compared to the pasteurized mixture of hen's eggs.

The highest amount of saturated fatty acids (40.803 g FAME/100 g total FAME) was found in biblical eggs, 12.95% higher than in chicken eggs, by 14.04% compared to pasteurized melange and 19.30% than in quail eggs.

As for mono and polyunsaturated fatty acids, the highest level (68.560 g FAME/100 g total FAME) was recorded in quail eggs, followed at a long distance by chicken eggs (less by 5.98%), by the milling pasteurized chicken eggs (6.15% less) and biblical eggs (12.83%).

Consistent with the above data, the ratio between saturated fatty acids (SFA) and total unsaturated fatty acids (UFA) was only 0.480 in quail eggs, compared to 0.545-0.716 found in the other categories of eggs analyzed.

Regarding the ratio between polyunsaturated fatty acids (PUFA) and monounsaturated fatty acids (MUFA), the values resulting from the calculations performed were 0.635 for the pasteurized mixture, 0.679 for quail eggs, 0.703 for chicken eggs and 0.774 for eggs, respectively of biblical.

The best ratio between omega 6 and omega 3 fatty acids was recorded in quail eggs, of only 3.492, followed quite closely by biblical eggs by 5.775; In the case of chicken eggs, the ratio between the two fatty acids was much higher, standing at 11.291 (processed eggs) and 11.639 (natural eggs), respectively.

In conclusion, it can be stated that the fatty acid profile of quail eggs is a good one, as well as the ratios between the fatty acid groups, being able to successfully replace chicken eggs in the human diet; the eggs of other poultry species considered as food alternatives (biblical ones) contain large amounts of saturated fatty acids, to the detriment of monounsaturated and polyunsaturated ones.

REFERENCES

Anton, M, Martinet, V., Dalgalarrondo, M., Beaumal, V., David-Briand, E., & Rabesona, H. (2003). Structural and chemical characterisation of low density lipoproteins purified from hen egg yolk. *Food Chemistry*, 83, 175-183.

Gopinath, B., Liew, G., Tang Diana, Burlutsky G., Flood, V. & Mitchell, P. (2020). Consumption of eggs and the 15-year incidence of age-related macular degeneration. *Clinical nutrition*, 39(2), 580-584.

Grandall, P.G., Seideman, S., Ricke, S.C., O'Bryan, C.A., Fanatico, A.F., & Rainey, R. (2009). Organic poultry: consumer perception, opportunities and regulatory issues. *Journal of Applied Poultry Research*, 29, 795-802.

Grobas, S., Mendez, J., Lazaro, R., Blas, C. & Matheos, G.G. (2001). Influence of source and percentage of fat added to diet on performance and fatty acid composition of egg yolks of two strains of laying hens. *Poultry Science*, 80 (8), 1171-1179.

Hidalgo, A., Rossi, M., Clerici, F. & Ratti, S. (2008). A market study on the quality characteristics of eggs from different housing systems. *Food chemistry*, 106, 1031-1038.

Hu, F.B., Manson, J.E. & Willett, W.C. (2001). Types of dietary fat and risk of coronary heart disease: a critical review. *Journal of the American College of Nutrition*, 20(1), 5-19.

Hur, S.J., Kang, G.H., Jeong, J.Y., Yang, H.S., Ha, Y.L., Park, G.B. & Joo, S.T. (2003). Effect of dietary conjugated linoleic acid on lipid characteristics of egg yolk. *Asian-Australas Journal Animals Science*, 16, 1165-1170.

Imai, T., Miyamoto, K., Sezaki, A., Kawase, F., Shirai, Y., Abe, C., Fukaya, A., Kato, T., Sanada, M. & Shimokata H. (2019). Traditional Japanese Diet Score-Association with Obesity, Incidence of Ischemic Heart Disease, and Healthy Life Expectancy in a Global Comparative Study. *Journal of nutrition health & aging*, 23(8), 717-724.

Jolivet, P., Boulard, C., Beaumal, V., Chardot, T. & Anton, M. (2006). Protein components of low-density lipoproteins purified from hen egg yolk. *Journal of agricultural and food chemistry*, 54(12), 4424-4429.

Kovacs-Nolan, J, Phillips, M. & Mine, Y., (2005). Advances in the value of eggs and egg components for human health. *Journal of Agricultural and Food Chemistry*, 53, 8421-8431.

Nistor, A.C., Nistor (Cotfas), L.I., Usturoi, M.G. (2017). A review of fatty acid and amino acids profile from pasteurized liquids produced in Romania. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Food Science and Technology*, 75(2), 143-148.

Papterska, K. & Ignatowicz, E. (2019). Functional food in prevention of cardiovascular diseases and obesity. *Acta poloniae pharmaceutica*, 76(6), 945-958.

Radu-Rusu, R.M., Usturoi, M.G., Leahu, A., Amariei, S., Radu-Rusu, C.G., & Vacaru-Opriş, I. (2014). Chemical features, cholesterol and energy content of table hen eggs from conventional and alternative farming system. *South African Journal of Animal Science*, 44(1), 33-42.

Schaefer, E.J. (2002). Lipoproteins, nutrition, and heart disease. *The American Journal of Clinical Nutrition*, 75, 191-212.

Seah, Y.H., Ong, C.N., Koh, W.P., Yuan, J.M. and Van, Dam, R.M. (2019). A dietary pattern derived from reduced rank regression and fatty acid biomarkers is associated with lower risk of type 2 diabetes and coronary artery disease in Chinese adults. *Journal of nutrition*, 149(11), 2001-2010.

Simopoulos, A.P. (1991). Omega 3 fatty acids in health and disease and in growth and development. *The American Journal of Clinical Nutrition*, 54, 438-463.

Xiao, N., Zhao, Y., Yao, Y., Wu, N., Xu, M., Du, H. & Tu, Y. (2020). Biological Activities of Egg Yolk Lipids: A Review. *Journal of agricultural and food chemistry*, 68(7), 1948-1957.

***SR EN ISO 5508:2002- Vegetable and animal oils and fats. Analysis by gas chromatography of methyl esters of fatty acids