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Research Article

Differences in Fatty Acid Profiles, ADEK Vitamins and Sterols of the Yolk between Native Chickens and Geese

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Abstract

The aim of this study was to assess the differences in the yolk lipid composition of geese and chickens which are free to select their diets from the environments. The proportion of oleic acid (18:1n-9) and linolenic acid (18:3n-3) was far greater in both of species of yolk lipids. In particular, the proportion of docosahexaenoic acid in the total lipid of the yolk was greater for the chicken compared to the geese. By contrast, the proportion of arachidonic acid in total yolk lipid was approximately two times greater for the goose than the chicken. Thus the chicken was more efficient at incorporating long-chain (C_{22}) fatty acid of the n-3 series into yolk lipid whereas the geese incorporated C_{20} fatty acid of the n-6 series. The ADEK vitamins of the goose egg in mg/g yolk were very similar to that of the chicken egg. The cholesterol content of the geese egg in mg/g yolk was far greater to that of the chicken egg.

Keywords: Fatty acid, Yolk, Goose, Chicken, ADEK vitamins, Cholesterol

1. Introduction

Appreciated for their nutritive value and functional properties, eggs are an important item in the human diet. In developing countries, it is often the only animal protein source that is accessible to the general population (Bragagnolo et al. 2003).

A very large proportion of the current information on the composition of yolk lipids has been obtained from studies on the eggs of the domestic chicken (*Gallus gallus domesticus*), simply because such eggs are easily available. As a consequence should be discard, it has often been assumed that the fatty acid profile of the commercially-produced chicken egg, characterized by high proportions of 18:2n-6 and very low levels of 18:3n-3 (Kuksis 1992, Insis 1991), represents a standard composition for avian eggs in general (Carey 1996). Studies on chickens have clearly shown that the polyunsaturated profile of the yolk, far from conforming to an inflexible archetype, is highly dependent on the types of polyunsaturated fatty acids present in the diets of the laying hen (Cherian et al. 1991, 1992, Crawford 1993). For example, dietary supplementation of the hen with fish oil (a rich source of 22:6n-3) readily produces large increases in the proportion of 22:6n-3 in the yolk lipid (Farrell 1998, Hargis et al. 1993, Lin et al. 1991). The inclusion of linseed oil (a rich source of 18:3n-3) in the hens' diet results in increased levels of both 18:3n-3 and 22:6n-3 in the yolk lipids (Lin et al. 1991). The predominance of n-6 fatty acids in the yolk lipids of commercial poultry may simply reflect the use of standard grain-based diets in which the main fatty acyl components 18:2n-6 (Noble et al. 1986).

ADEK vitamins and sterols in the diet of the chicken can substantially increase their concentrations in the yolk.

The aim of the present study was to compare the yolk fatty acid profiles ADEK vitamins and sterols of geese and chicken in Kars.

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2. Materials and Method

Six samples which were collected 3 different parts were used in this study. The eggs were collected in Kars.

2.1 Preparation of Fatty Acid Methyl Ester and Gas Chromotographic Analysis

Total lipids were extracted with hexane-isopropanol (3:2 v/v) by the method of Hara and Radin (1978). About 1, 2 g of the samples were taken and homogenized. Fatty acids in the lipid extracts were converted into methyl esters by means of 2% sulphuric acid (v/v) in methanol (Christie 1990). The mixture was incubated at 55°C for 16 hr. Nonlipid contaminants in lipid extracts were removed by NaCl solution. 1 ml KH_2CO_3 was added to it. The solvent of extracts was evaporated in a rotary evaporator at 45°C by using vacuum and lipid residue was dissolved in purified hexane.

Then the methyl esters were separated and quantified by gas chromatography and flame-ionization detection (Shimadzu GC 17 Ver.3) coupled to a Glass GC 10 software computing recorder. Chromatography was performed with capillary column (25m in length) and 0.25mm in diameter, Permabound 25, Machery-Nagel, Germany using nitrogen as a carrier gas (flow rate 0.8 ml/min). The temperatures of the column, detector and injection valve were 130–220, 240, 280°C, respectively. Identification of the individual methyl esters was performed by frequent comparison with authentic standard mixtures that were analyzed under the same conditions.

2.2 Analysis of ADEK vitamins and Sterols with HPLC

ADEK vitamins and sterols were extracted with hexane-isopropanol (3:2 v/v) by the method of Hara and Radin[1]. About 1.2g of the samples were taken and homogenized. 5ml KOH was added to it. The mixture was incubated at 85°C for 30 min. It was then cooled under room condition and 5ml of distilled water were added. After centrifugation was collected, the extraction was repeated twice. Hexane-isopropanol extracts were combined and evaporated and the residue was dissolved in 2ml of acetonitrile:methanol centrifuged and the supernatant was used for ADEK vitamins and sterols determination.

For the analysis and separation ADEK vitamins and sterols were used the fully automatic High Performance Liquid Chromatography equipment (HPLC). The equipment for HPLC consisted of a pump (LC-10AD*VP*), a UV–vis detector (SPD-10A*VP*) a column oven (CTO-10AS*VP*), an autosampler (SIL-10AD*VP*) a degasser unit (DGU-14A) and a computer system with *Class VP software* (Shimadzu, Kyoto, Japan). Discovery RP-Amide C16 column (150mm×4.6 mm, 5µm; Sigma, USA) was used as the HPLC column and 50mM $NaClO_4$ 0.1% H_3PO_4 was used as the mobile phase and flowrate 1 ml/min. Detection was performed at 215 nm by UV–vis detector and 40°C column oven.

3. Results

The fatty acid profiles of the yolk lipid of geese differed from those of chicken (Table 1).

The most striking difference was the presence of much greater proportions of 18:1n-9 in the yolk samples. The proportion of 18:3n-3 was substantially lower in the samples from the chicken although the level of 18:3n-6 was similar in both groups. The proportion of 18:2n-6 was low in eggs from the geese but was a further 3 times greater in eggs the chicken. The proportion of 22:5n-3 was actually slightly lower in the yolks of the both groups whereas the levels of 20:1n-9 was similar in the two groups.

The content of α-tocopherol in yolk was approximately three times greater for the chicken than the goose and the content of D_3 in yolk was two two greater for the chicken than the goose. The other vitamins of ADEK were similar in both groups (Table 2).

The most striking difference was the presence of much greater levels of cholesterol in the yolk samples in both groups. The levels of ergosterol in yolk were approximately two times greater for the chicken than the goose whereas the levels of betasterol were five times greater for the goose than the chicken (Table 3).

Table 1. Fatty acid composition (%w/w) of total lipids of the yolk

	Goose 1 (N=3)	Goose 2 (N=3)	Chicken 1 (N=3)	Chicken 2 (N=3)	P
Fatty acid (wt.% of total fatty acids)					
14:0	0.57±0.04	0.63±0.04	0.35±0.18	0.34±0.01	*
16:0	34.42±0.65	39.65±0.53	36.64±1.22	38.75±1.18	-
16:1n-7	2.39±0.34	1.05±0.04	0.76±0.12	0.89±0.34	*
18:0	8.06±0.42	8.22±0.50	11.46±1.01	11.29±0.61	*
18:1n-9	40.95±1.59	36.63±0.94	33.25±0.40	31.39±0.20	*
18:2n-6	2.91±0.11	3.02±0.16	8.76±0.45	8.56±0.38	*
18:3n-3	0.45±0.06	0.39±0.05	0.25±0.13	0.24±0.02	*
18:3n-6	0.46±0.02	0.48±0.02	0.77±0.08	0.68±0.04	*
20:1n-9	7.74±0.79	8.14±0.72	4.99±0.26	5.18±0.09	_
20:4n-6	0.41±0.07	1.88±1.41	0.46±0.03	0.88±0.02	_
22:5n-3	0.31±0.05	0.17±0.01	0.33±0.24	0.12±0.06	_
22:6n-3	1.12±0.07	1.09±0.04	2.21±0.02	2.13±0.02	*

Values are means ±S.E.M
*: $P < 0.05$, slightly significant
-: Differences among the groups were not statistically significant (P>0.05).

Table 2. ADEK vitamin contents of egg yolks from chicken and geese

	Goose 1 (N=3)	Goose 2 (N=3)	Chicken 1 (N=3)	Chicken 2 (N=3)	P
ADEK vitamins (wt.% of total ADEK vitamins)					
Retinol	10.73±0.18	10.73±0.56	9.93±1.06	11.97±0.75	_
Retinol ast	1.39±0.16	0.78±0.06	2.72±0.26	2.79±0.15	*
D_2	4.38±0.84	3.39±0.24	4.21±0.45	4.28±0.01	_
D_3	1.50±0.12	1.00±0.03	2.17±0.04	2.43±0.20	*
α-tocopherol	8.24±2.13	10.14±1.04	32.48±1.12	28.04±1.49	*
β- tocopherol	0.39±0.10	0.39±0.00	0.39±0.00	0.58±0.05	_
K_1	12.06±0.80	14.23±0.47	2.79±0.51	7.63±0.93	*
K_2	15.40±0.99	16.73±0.14	16.02±1.17	15.41±1.93	_

Values are means ±S.E.M.
*: $P < 0.05$, slightly significant
-: Differences among the groups were not statistically significant (P>0.05).

Table 3. Sterols contents of egg yolk from chicken and geese

	Goose 1 (N=3)	Goose 2 (N=3)	Chicken 1 (N=3)	Chicken 2 (N=3)	P
Sterols (wt.% of total Sterols)					
Betasterol	0.99±0.00	0.79±0.00	2.27±0.40	1.69±0.29	_
Ergosterol	44.22±8.30	56.15±1.26	114.46±9.71	83.66±5.69	*
Stigmasterol	28.18±2.53	52.39±4.37	131.29±0.55	84.45±17.15	*
Cholesterol	3081.06±74.62	2989.18±118.00	2550.06±103.00	2813.80±77.84	*

Values are means ±S.E.M.
*: $P < 0.05$, slightly significant
-: Differences among the groups were not statistically significant (P>0.05).

4. Discussion

Chickens are granivorous birds and consume grains (Scott et al. 1982) which supply 18:2n-6 as the main polyunsaturated. It has been observed that the eggs of wild geese and pheasant, by contrast, contain far higher levels of 18: 3n-3 in the yolk lipids in comparison with their domesticated counterparts (Speake et al., 1999). Possibly ducks and geese tend to compensate for the dietary predominance in nature of n-3 fatty acids by expressing an enhanced ability to synthesize and incorporate 20:4n-6 into yolk lipids (Surai et al. 1999). Conversely, the chicken may compensate for the excess of n-6fatty acids in the natural diet by the efficient synthesis and incorporation of 22:6n-3 into yolk lipid (Surai et al. 1999). The overwhelming predominance of 20:4n-6 as the major polyunsaturated in the yolk of the free-range chicken and geese presumably reflects the almost exclusive consumption of grass and other plant material, undistracted by any provision of compound feed.

The yolks of the geese contained more than three times the concentration of α-tocopherol than those of the chicken. The chloroplast membranes of grasses and leaves are particularly rich in a-tocopherol (Hess 1993). Thus the increased levels of a-tocopherol in the free-range chicken and geese are consistent with the intake of grass by these birds. The content of D_3 in yolk was approximately three two greater for the chicken than the goose. Vitamin A level in yolk of the chicken and geese is similar to that in gull liver (Surai et al. 2000).

Sterols are an important class of organic molecules. They occur naturally in plants, animal, and fungi, with the most familiar type of animal sterol being cholesterol. Cholesterol is vital to cellular function, and a precursor to fat-soluble vitamins and steroid hormones. Sterols of animals are called zoosterols. Important zoosterols are cholesterol and some steroid hormones; notable phytosterols include campesterol, sitosterol, and stigmasterol. Ergosterol is a sterol present in the cell membrane of fungi, where it serves a role similar to cholesterol in animal cells. There was no significant difference in the cholesterol level of both of them, but levels of cholesterol was further greater than chicken and quail eggs produced in Brazil (Bragagnolo et al. 2003). In addition, the level of ergosterol was extremely great because of feeding in free-range.

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