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A Comparative Study of Fatty Acid Content in Yolk of Native Eggs and Ordinary Eggs Available in the Market

Su-Hu Duan, Liu-An Li*, Zai-Qiang Li, Meng-Ran Qin, Zhen-Zhen Fan, Qian Wang, Ke-Yan Zhang, Zhong-Mou Zhang, Bai-Liang Yang and Tian-Ming Jin

Tianjin Key Laboratory of Agricultural Animal Breeding and Healthy Husbandry, College of Animal Science and Veterinary Medicine, Tianjin Agricultural University, Tianjin 300384, China

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Authors' Contribution
L-AL designed this study. S-HD, Z-QL and M-rQ conducted the experiments. S-HD, Z-ZF, QW, K-YZ, Z-MZ analyzed the main data. B-LY and T-MJ supervised the study. L-AL and S-HD wrote the manuscript.

Key words
Native eggs, Ordinary eggs, Yolk, Fatty acid, Content comparison

ABSTRACT

In this test, gas chromatographic method was used to determine the fatty acid content of ordinary eggs and native eggs of brands A, B and C. The results indicate that: In the test samples, totally 7 types of SFA, 7 types of MUFA, and 8 types of PUFA were detected. Specifically, no significant difference was found in the content of C14:0~C18:0 ($P>0.05$). The content of C16:0 in the yolk of both native eggs and ordinary eggs was high; in the yolk of native eggs of the three brands, the content of C14:1 and C16:1 was both significantly higher than that of ordinary eggs ($P<0.05$); the content of C17:1 in yolk of native eggs of brand A was significantly higher than that of brand C native eggs ($P<0.05$); the content of C18: 2n6t and C20:2 in yolk of ordinary eggs and brand C eggs was significantly higher than that of brand A and B native eggs ($P<0.05$); the content of C18:2n6c in yolk of ordinary eggs was significantly higher than that of brands A and C native eggs ($P<0.05$); the content of C22:6n3 in yolk of ordinary eggs was significantly higher than that of brand A native eggs ($P<0.05$); there was no significant difference in ω-6/ω-3 PUFA ratio of yolk of ordinary eggs and native eggs of three brands ($P>0.05$). The study provides theoretical and practical reference for customers for selection of eggs.

INTRODUCTION

At present, in addition to the price, people are attaching an increasing importance to nutritional value of eggs when buying eggs in the market. Native eggs are also called "farm eggs" and "free-range eggs", and are tasty, with premium quality and rich nutrients. Furthermore, they are healthy. Yolk of eggs contains a variety of nutrient substances, and fatty acid is one of the main substances. People may get beneficial fatty acid that is necessary for our body by eating eggs (Shinn *et al*., 2018).

Fatty acids are classified into saturated fatty acid (SFA), monounsaturated fatty acid (MUFA), and polyunsaturated fatty acid (PUFA) by the unsaturation degree of the carbon chain (Duan *et al*., 2019). Specifically, MUFA has functions including anti-inflammation, prevention and delay of type-2 diabetes, and inhibition of atherosis; PUFA has functions including anti-inflammation, anti-cancer, promotion of growth and development and protection of heart and cerebral vessels (Diep *et al*., 2000; Wai *et al*., 2015; Manni *et al*., 2015).

By now, many studies have been carried out on enrichment of fatty acid and content of fatty acid in eggs. However, there have been very few reports on comparative study of fatty acid content in native eggs and ordinary eggs. In this study, ordinary eggs and native eggs of different brands available in the market were taken as the objects of study to determine the content of fatty acid in yolk, so as to find out the difference in fatty acid content in yolk of native eggs and ordinary eggs, thus providing theoretical and practical reference for customers for selection of eggs.

MATERIALS AND METHODS

Materials

Twenty five eggs were randomly selected from the ordinary eggs, and native eggs of brands A, B and C with similar date of manufacturing and date of packaging in a large supermarket of Tianjin. The 37 types of standard substances mixed with constituent FAME and triglyceride undecanoate (C11:0) were purchased from Nu-Chek of America; petroleum ether (boiling range 30°C-60°C, analytically pure), methyl alcohol (chromatographically pure) and hydrochloric acid (analytically pure) were purchased from Tianjin Fengchuan Chemical Reagent

* Corresponding author: anliuli2003@163.com
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Technology Co., Ltd. Normal hexane (chromatographically pure) was purchased from Tianjin Fine Chemical Engineering Research Institute. The 15 boron trifluoride-methanol (analytically pure) was purchased from Panjin Yanfeng Technology Co., Ltd. Absolute ether (analytically pure) was purchased from Rionlon Bohua (Tianjin) Medical Chemistry Co., Ltd. Pyrogallic acid (analytically pure) was purchased from Tianjin Guangfu Fine Chemical Engineering Research Institute. Anhydrous sodium sulfate (analytically pure) was purchased from Tianjin Bodi Chemical Engineering Co., Ltd. Sodium chloride was purchased from Tianjin Jizhun Chemical Reagent Co., Ltd.; 95% ethyl alcohol (analytically pure) was purchased from Tianjin Fuyu Fine Chemical Engineering Co., Ltd. Sodium hydroxide (analytically pure) was purchased from Bo'oute (Tianjin) Chemical Trade Co., Ltd.; 50mL centrifuge tube; gas chromatography sample bottle.

Equipment and instrument

The gaschromatograph 7890B was purchased from Agilent; capillary-column chromatography SP2560 was purchased from Supelco; thermostat water bath was purchased from Shanghai Zhicheng Analytical Instrument Manufacturing Co., Ltd.; analytical balance was purchased from Shanghai Shunning Hengping Scientific Instrument Co., Ltd. The above instrument and equipment were all provided by Lab of the School of Animal Science and Animal Medicine of Tianjin Agricultural College.

Method

Five eggs were randomly selected from each type of eggs. The yolk was evenly mixed and the specimen was taken and hydrolyzed, fat extracted and saponified, followed by methyl esterification and conversion of fatty acid. The content of fatty acid was carried out according to GB5009.168—2016 standard.

Gas-phase conditions

Gas chromatographic column: SP2560 (100 m×250 μm×0.2 μm); chromatographic column flow: 1 mL/min; hydrogen flow: 30 mL/min; carrier gas: He; split ratio: 20:1; FID detector; detector temperature: 280 °C; column oven temperature: 250 °C; column oven temperature raising program: starting temperature: 140 °C, holding for 5 min; then the temperature rose at a rate of 4 °C/min to 220 °C, and then at a rate of 0.5 °C/min to 230 °C; eventually, the temperature rose at a rate of 4 °C/min to 240 °C, holding for 15 min; make-up gas rate: 25 mL/min; sample size: 5 μL.

Statistical analysis

SPSS 20.0 software was used and one-way ANOVA analysis, Duncan' D was used for multiple comparisons among mean values and significance testing. All data used in the test were expressed with mean value± standard error. $P<0.05$ was deemed as significant difference.

RESULTS

Fatty acids content of yolk

As shown in Figure 1, there was no significant difference ($P>0.05$) in the content of total fatty acids (FA), SFA, unsaturated fatty acid (UFA), MUFA, and ω-3 polyunsaturated fatty acid (ω-3 PUFA) in yolk of ordinary eggs and native eggs available in the market. The content of PUFA and ω-6 Polyunsaturated fatty acid (ω-6 PUFA) was significantly higher than that of the native eggs of the three brands ($P<0.05$); there was no significant difference in content of total PUFA and ω-6 PUFA in yolk of the three brands of native eggs ($P>0.05$).

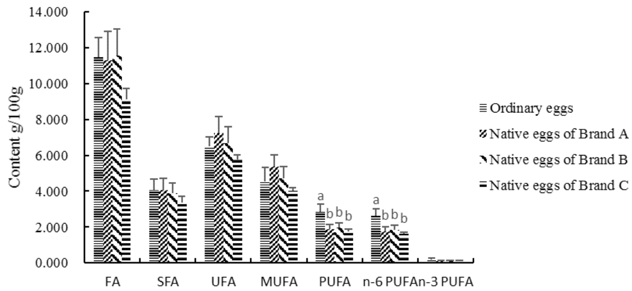

Fig. 1. Fatty acids contents of yolk of native eggs and ordinary eggs. Note: The lowercase letters represent the significant differences among different groups ($P<0.05$). The same applies below.

Saturated fatty acids (SFA) in yolk

As indicated in Table I, 7 types of SFA were detected in the yolk of native eggs and ordinary eggs available in the market. Specifically, there was no significant difference in the content of C14:0~C18:0 ($P>0.05$); the content of C16:0 in yolk of native eggs and ordinary eggs was high; the content of SFA C22:0 in yolk of ordinary eggs and brand C native eggs was significantly higher than that of native eggs of brands A and B ($P<0.05$).

Monounsaturated fatty acids (MUFA) in yolk

According to Table II, seven MUFA were detected in the yolk of ordinary eggs and eggs of the three brands available in the market. Specifically, the content of C14:1 and C16:1 in yolk of native eggs.

Table I. Comparison of content (g/100g) of various SFA in yolk of native eggs and ordinary eggs available in the market.

Types of fatty acid	Ordinary eggs	Native eggs of brand A	Native eggs of brand B	Native eggs of brand C
C4:0	ND	ND	ND	ND
C6:0	ND	ND	ND	ND
C8:0	ND	ND	ND	ND
C10:0	ND	ND	ND	ND
C11:0	ND	ND	ND	ND
C12:0	ND	ND	ND	ND
C13:0	ND	ND	ND	ND
C14:0	0.028±0.003	0.029±0.004	0.033±0.006	0.022±0.004
C15:0	0.006±0.002	0.005±0.001	0.006±0.002	0.003±0.001
C16:0	2.927±0.414	2.916±0.480	2.794±0.442	2.459±0.144
C17:0	0.013±0.004	0.028±0.003	0.024±0.003	0.039±0.015
C18:0	1.069±0.167	1.094±0.208	1.001±0.164	0.813±0.033
C20:0	ND	ND	ND	ND
C21:0	0.016±0.015	ND	ND	0.019±0.009
C22:0	0.016^{a}±0.004	0.003^{b}±0.001	0.002^{b}±0.001	0.009^{a}±0.002
C23:0	ND	ND	ND	ND
C24:0	ND	ND	ND	ND

Note: ND indicates there was no result, the difference in the lowercase letters of the peer data indicates that the difference is significant ($P<0.05$), and the same lowercase letters indicate that the difference is not significant ($P>0.05$). the same below.

Table II. Comparison of content (g/100g) of various MUFA in yolk of native eggs and ordinary eggs available in the market.

Types of fatty acid	Ordinary eggs	Native eggs of brand A	Native eggs of brand B	Native eggs of brand C
C14:1	ND	0.005^{a}±0.001	0.005^{a}±0.001	0.005^{a}±0.001
C15:1	ND	ND	ND	ND
C16:1	0.142^{b}±0.034	0.293^{a}±0.050	0.280^{a}±0.052	0.286^{a}±0.023
C17:1	0.008^{ab}±0.002	0.018^{a}±0.004	0.013^{ab}±0.006	0.004^{b}±0.002
C18:1n9t	0.056±0.028	0.011±0.001	0.012±0.001	0.077±0.035
C18:1n9c	4.322±0.791	5.032±0.629	4.404±0.590	3.746±0.182
C20:1	0.010^{a}±0.003	ND	ND	0.012^{a}±0.001
C22:1n9	0.008^{ab}±0.004	ND	0.001^{b}±0.001	0.010^{a}±0.004
C24:1	ND	ND	ND	ND

Polyunsaturated fatty acids (PUFA) in yolk

According to Table III, 8 PUFA were detected in ordinary eggs and native eggs of 3 brands available in the market. Specifically, the content of C18:2n6t and C20:2 in yolk of ordinary eggs and native eggs of brand C was significantly higher than that of native eggs of brands A and B ($P<0.05$); no C20:2 was detected in yolk of brand B native eggs; the content of C18:2n6c in yolk of ordinary eggs was significantly higher than that of brands A and C native eggs ($P<0.05$); no C20: 3n6 was detected in yolk of brand C native eggs; there was no significant difference in content of C20: 4n6 in yolk of ordinary eggs and native eggs of the three brands ($P>0.05$); the content of C22: 6n3 in yolk of ordinary eggs was significantly higher than that of brand A native eggs($P<0.05$); there was no significant difference in content of C22: 6n3 among native eggs of the three brands ($P>0.05$).

Table III. Comparison of content (g/100g) of various PUFA in yolk of native eggs and ordinary eggs available in the market.

Types of fatty acid	Ordinary eggs	Native eggs of brand A	Native eggs of brand B	Native eggs of brand C
C18:2n6t	$0.037^{a}\pm0.016$	$0.003^{b}\pm0.001$	$0.003^{b}\pm0.001$	$0.040^{a}\pm0.010$
C18:2n6c	$2.064^{a}\pm0.156$	$1.461^{b}\pm0.226$	$1.562^{ab}\pm0.253$	$1.358^{b}\pm0.076$
C18:3n6	0.016±0.003	0.011±0.002	0.013±0.002	0.010±0.001
C18:3n3	0.063±0.010	0.047±0.008	0.053±0.007	0.041±0.007
C20:2	$0.010^{a}\pm0.005$	ND	ND	$0.005^{a}\pm0.003$
C20:3n6	$0.011^{a}\pm0.004$	ND	$0.003^{ab}\pm0.003$	$0.009^{a}\pm0.003$
C20:3n3	ND	ND	ND	ND
C20:4n6	0.223±0.056	0.298±0.032	0.248±0.022	0.215±0.017
C22:2	ND	ND	ND	ND
C20:5n3	ND	ND	ND	ND
C22:6n3	$0.113^{a}\pm0.036$	$0.056^{b}\pm0.013$	$0.068^{ab}\pm0.015$	$0.084^{ab}\pm0.006$

Of the three brands was significantly higher than that of ordinary eggs ($P<0.05$); the content of C17:1 in yolk of native eggs of brand A was slightly higher than that of native eggs of brand C ($P<0.05$); compared with ordinary eggs and native eggs of brand C, native eggs of brands A and B were found to contain no C20:1; no C22:1n9 was detected in yolk of native eggs of brand A; neither C15:1 nor C24:1 was detected in ordinary eggs and the three brands of native eggs.

As indicated in Figure 2, there was no significant difference in ω-6/ω-3 PUFA ratio of yolk of ordinary eggs and native eggs of three brands available in the market ($P>0.05$). The ratios order is as follows: ordinary eggs < native eggs of brand C< native eggs of brand A< native eggs of brand B.

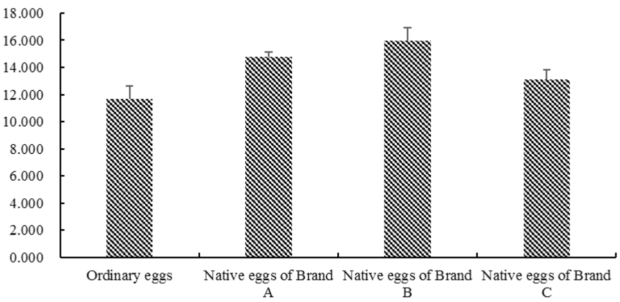

Fig. 2. The ω-6 / ω-3 PUFA ratio of yolk of ordinary eggs and native eggs of three brands.

DISCUSSION

C16:0 (palmitic acid), as one of the saturated fatty acids, plays a substantial role in growth and metabolism of body cells. Related studies indicate that the palmitic acid is able to induce cell death and autophagy, and change the phospholipid level in the myocardial cell, thus posing an impact on the functions of mitochondria in cells (Ostrander *et al*., 2001; Chang *et al*., 2016). This study shows that the content of C16:0 in yolk of ordinary eggs and native eggs was the highest, without significant difference. This result is similar to the study result of Kaya *et al*. (2018).

The study of Feng *et al*. (2016) indicates that there was significant difference in content of C16: 1 (palmitoleic acid) and C18:1 (oleic acid) among the three types of eggs, namely, Lhasa white chicken, Tibetan chicken and Liuhonggu fragrant chicken. In the results of this study, the content of C16:1 of eggs of the three brands was significantly higher than that of ordinary eggs. The reason might be related to the species, daily ration and feeding model of the laying hens. C18: 1n9c is an important MUFA. In this study, the content of C18:1n9c in yolk reached 3.746~5.032g/100g, which was generally lower than the study result of Zhang *et al*. (2018). The reason might be related to the species of chicken, composition of feedstuff and feeding model.

PUFA, ω-3 PUFA and ω-6 PUFA in particular, are essential fatty acids that our human body is not able to synthesize and has to get from our food. The C18:2n6 (linoleic acid) and (arachidonic acid), as ω-6 PUFA, could be transformed into C18:3n6 (γ- linolenic acid) through metabolism; C18:3n3 (α-linolenic acid), as ω-3 PUFA, could be transformed into C20:5n3 (EPA) and C22:6n3 (DHA) through metabolism (Silvia *et al*., 2013). C18:2n6c is able to adjust the cholesterol content in our body (Yang *et al*., 2017; Harauma *et al*., 2017). The study of Devlin *et al*. (2017) indicates that intake of a proper amount of C20:4n6 and C22:6n3 was good for development of cranial nerve of infants (Angela *et al*., 2017). The study of Cherian (2017) indicates that addition of flaxseed into the daily ration of laying hens could result in settlement of a great amount of ω-3 PUFA in the yolk, with significant increase of deposition of C18:3n3 (Cherian 2017). Results of this study indicate that the C18:2n6c content in yolk of native eggs available in the market was lower than that of ordinary eggs; there was no significant difference in content of C20: 4n6 in yolk of ordinary eggs and native eggs of three brands; the content of C20: 4n6 in yolk of brand A and B native eggs was higher than that of ordinary eggs. The content of C22:6n3 in yolk of ordinary eggs was significantly higher than that of brand A native eggs. This means that the feedstuff for the two types of laying hens was different, or there was difference in the nutritional ingredients contained in the feedstuff.

Related studies indicate that the ideal ratio of acceptable daily intake of ω-6 PUFA to ω-3 PUFA in the diet was 2:1. Excessive intake of ω-6 PUFA may result in reduction in intake of ω-3 PUFA such as C20:5n3 and C22:6n3 (Simopoulos, 2008; Harris *et al*., 2009). The study result shows that the range of ω-6 PUFA to ω-3 PUFA ratio in yolk of ordinary eggs and native eggs available in the market is from 11 to 16. According to the ratio range, the eggs available in the market are not quite ideal for consumers.

CONCLUSIONS

Seven types of SFA, 7 types of MUFA, and 8 types of PUFA were detected in the yolk of ordinary eggs and native eggs of three brands available in the market. Specifically, no significant difference was found in the content of C14:0~C18:0 (P>0.05). The content of C16:0 in the yolk of both native eggs and ordinary eggs was high; in the yolk of native eggs of the three brands, the content of C14:1 and C16:1 was both significantly higher than that of ordinary eggs (P<0.05); the content of C17:1 in yolk of native eggs of brand A was significantly higher than that of brand C native eggs ((P<0.05); the content of C18: 2n6t and C20:2 in yolk of ordinary eggs and brand C eggs was significantly higher than that of brand A and B native eggs (P<0.05); the content of C18: 2n6c in yolk of ordinary eggs was significantly higher than that of brands A and C native eggs (P<0.05); the content of C22: 6n3 in yolk of ordinary eggs was significantly higher than that of brand A native eggs (P<0.05); there was no significant difference in ω-6/ω-3 PUFA ratio of yolk of ordinary eggs and native eggs of three brands (P>0.05).

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Statement of conflict of interest

We declare that there is no conflict of interests regarding the publication of the manuscript.

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