Characteristics of Korean Value-added Eggs and Their Differences in Oxidative Stability

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Abstract Twenty brands of eggs including 17 value-added ones from different egg suppliers on the Korean markets were examined for their oxidative status and oxidative stability. The contents of hydroperoxides and malondialdehyde (MDA) were low over all the eggs, and were not appreciably different from supplier to supplier and between value-added eggs and ordinary control ones. When the eggs were subjected to iron-induced oxidation system to assess their oxidation stability, MDA contents of the ordinary control eggs increased rapidly with the incubation time. On the other hand, the value-added eggs showed large variations in their susceptibility to lipid oxidation from supplier to supplier. It indicates that, for the different brands of eggs that are claimed to be enriched with same functional materials, the claim of egg suppliers (feed supplementation with same functional materials) might not always guarantee the same magnitude of functionality of the eggs.

Keywords: value-added egg, oxidative stability, hydroperoxide, malondialdehyde (MDA)

Introduction

There have been growing interests in the preparation of functional foods that conform to the consumers’ demand for the food products of superior health quality (1-3). In line with which, a number of researches have focused on the fortification of functional ingredients into animal origin foods such as meat or eggs through feed modification method (1,4-6). As a result, a wide variety of value-added eggs, including n-3 polyunsaturated fatty acids (PUFA)-, selenium-, conjugated linoleic acid (CLA)-, or antioxidants-enriched ones, become available to health-conscious consumers, and their sales potentials have been highly increasing (3,7,8). In particular, substantial attention was paid to the eggs that were produced by hens fed with a feed containing n-3 PUFA or antioxidants, because of their preventive health benefits associated with non-communicable diseases such as cardiovascular disease, obesity, type II diabetes, and cancer (2,9).

Several studies reported that a diet of hen clearly affected the compositions of fatty acids or the levels of certain nutrients in the eggs produced (10-13). It indicates that the consumption of the value-added eggs could be a viable means to deliver specific nutrients even in the amounts of comparable to the daily requirement. Among the functional constituents enriched, PUFA involves the risk of the development of oxidative rancidity as the fatty acids become oxidized in the feed or in the gastrointestinal tract, and the resulting toxic lipid oxidation products are eventually transferred to the eggs (14). Indeed, studies on the oxidative stability of the eggs that were from hens fed with unsaturated lipids showed that the eggs contained oxidation products that might lower their nutritional values (15). On the other hands, herbs, carotenoids, selenium, or tocopherols have been demonstrated to affect beneficially on the stability of egg lipids (4,5,16). Eggs are relatively abundant in fatty acids and fat soluble compounds, and their fatty acids compositions and ratios are important index determining the quality of the eggs as a human diet (3). In the light of which, lipid oxidation in eggs has to be controlled to prevent loss of nutritional quality as well as to
prevent the formation of potentially toxic compounds.

There are wide varieties of value-added eggs, which are enriched with potentially either pro-oxidative or anti-oxidative ingredients, available on the Korean markets. In this study, the value-added eggs were investigated according to 3 specific study objectives as follows. Firstly, this study focused on determining if the value-added eggs currently on sale were favorable or detrimental in terms of the oxidative stability of the eggs. Secondly, it focused on extracting the characteristics of value-added eggs currently produced in Korea. Thus, various value-added eggs available on the markets were collected, and their fatty acid profiles, the contents of lipid oxidation products, and the oxidative stabilities under induced oxidation system were investigated. Thirdly, it also focused on determining if there were any differences in the oxidation susceptibility of the eggs depending on the suppliers or fortified ingredients. Thus, the oxidative stability was compared between value-added eggs and ordinary control ones, let alone among the different brands of eggs that were enriched with same functional materials.

Materials and Methods

Chemicals All the reagents were of the highest grade commercially available. HPLC-grade methanol and benzene were purchased from Fisher Scientific (Chicago, IL, USA). Tridecanoic acid, acetyl chloride, cumene hydroperoxide, xylenol orange, and malondialdehyde precursor 1,1,3,3-tetraethoxypropane were purchased from Sigma-Aldrich (St. Louis, MO, USA). Fatty acid methyl ester mixture was purchased from Supelco (Bellefonte, PA, USA). Butylated hydroxy toluene (BHT) and ascorbic acid were purchased from Junsei Chemical Co., Ltd. (Tokyo, Japan). Trichloroacetic acid (TCA) and 2-thiobarbituric acid (TBA) were from Wako Pure Chemical Industries, Ltd. (Osaka, Japan) and Tokyo Chemical Industry Co., Ltd. (Tokyo, Japan), respectively. Diethylether and ferrous sulfate (FeSO₄) were obtained from Showa Chemical Industry Co., Ltd. (Tokyo, Japan). Distilled and deionized water was used for the preparation of all solutions.

Sample preparation A total of 20 kinds of eggs, including 17 value-added eggs and 3 ordinary control eggs, commercially available on the Korean markets were selected for the determination of oxidative stability of the egg yolks (Table 1). All kinds of value-added eggs that were available on the markets were collected, while 3 different brands of ordinary eggs that were consumed most were selected as controls for the comparison purpose. The egg samples were obtained from food sections in supermarkets or grocery markets as well as traditional local markets in 2009. Most egg samples, except those from local markets, were sold with being kept in refrigerators when purchased. All eggs (9-15 individual eggs/each kind of egg) were weighed and then broken to separate out the egg yolks immediately after being delivered to laboratory. Same kind of egg yolks were pooled together and homogenized using a kitchen blender for 1 min without added solvent. Then, the egg yolk homogenates were stored at −80°C until analyses.

Moisture and crude fat determination Moisture and crude fat contents of the egg yolks were determined following AOAC methods, i.e., oven drying method at 105°C and Soxhlet extraction (E-816; Buchi, Flawil, Switzerland) with diethylether, respectively (17).

Fatty acid analysis Fatty acids in the samples were converted to their corresponding fatty acid methyl esters (FAME) according to the method of Lepage and Roy (18). In detail, 2 mL of methanol/benzene 4:1 (v/v) solution was added to 0.1 g of the egg yolk homogenate. One-hundred µg of tridecanoic acid (C13:0) was included in the solution as an internal standard. While stirring, 200 µL of acetyl chloride was slowly added. Glass sample tubes were tightly closed with Teflon-lined caps and subjected to methanolation at 100°C for 1 h. Tubes were weighed before and after heating to check the leakages of any volatile contents. After tubes had been cooled in water, 5 mL of 6% aqueous K₂CO₃ was slowly added to stop the reaction and neutralize the mixture. The reaction mixture was centrifuged (5810R; Eppendorf, Hamburg, Germany) at 1,811×g, 10°C for 10 min and an aliquot of benzene upper phase was subjected to GC. All of these reactions were performed in triplicate for each sample.

Analysis of FAME was performed by a GC (Agilent 6890N; Agilent Technologies, Santa Clara, CA, USA) on a fused silica HP-Innowax column (30.0 m×320 µm×0.25 mm i.d., Agilent Technologies). Carrier gas was nitrogen at a flow rate of 1.0 mL/min and detector mode was flame ionization detector (FID). Ten mL of the sample was injected with a split ratio of 5:1 and run in constant flow mode. Chromatographic conditions were as follows: injector and detector temperatures, 200°C; initial oven temperature, 90°C for 5 min, rising to 150°C at 10°C/min with a hold time of 3 min, to 230°C at 3°C/min with a hold time of 3 min, and then to 240°C at 2°C/min with a final hold time of 20 min. Each peak was identified by comparison with the retention times of 34 known fatty acids standards. Fatty acids were quantified from the standard curves of individual fatty acids because saturated fatty acids were reported to show higher GC-FID response than unsaturated fatty acids (18). Based on the fatty acid compositions and contents of the egg yolks, intrinsic peroxidability index (PI) of each