Pakistan Veterinary Journal

ISSN: 0253-8318 (PRINT), 2074-7764 (ONLINE)
Accessible at: www.pvj.com.pk

Impact of Processing Methods on Nutritive Value and Fatty Acid Profile of Hen Eggs

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ARTICLE HISTORY

Received: February 06, 2010
Revised: July 01, 2010
Accepted: July 06, 2010

Key words:
Cholesterol
Fatty acid composition
Hen eggs
Nutritional value

ABSTRACT

The objective of the current study was to determine the effect of refrigeration, freezing and spray-drying processing method on nutritive components and fatty acid composition of egg yolk, egg white and whole egg. Spray-dried egg products showed higher values than those of frozen or refrigerated products as having higher total solids and comprise the contents in concentrated amounts. There was non-significant difference in the cholesterol levels of processed whole eggs and yolks. Fatty acid compositions of whole eggs and yolks that were processed either by refrigeration or freezing or spray-drying revealed major fatty acids as oleic, stearic, linoleic and linolenic acid. It was concluded that processing method do affects nutrient composition of egg products.

To cite this article: Akpinar-Bayizit A, T Ozcan, L Yilmaz-Ersan and O Gurbuz, 2010. Impact of processing methods on nutritive value and fatty acid profile of hen eggs. Pak Vet J, 30(4): 219-222.

INTRODUCTION

Hen (*Gallus domesticus*) eggs are considered to be near perfect foods in nature and are essential components of a balanced diet. These are inexpensive worldwide-consumed food and food ingredient and accepted in all cultures. As being a primary source of high quality proteins including all essential amino acids and offer a balanced distribution of minerals and vitamins, as well as high amounts of lipids such as fatty acids, triacylglycerols, phospholipids and cholesterol, required for a new life, i.e. the chicken. The yolk and white components are of high biological value and are readily digested (Cherian *et al.,* 2002).

It is evident that health is inter-related with diet which can be improved. Animal fat has undoubtedly limited the consumption of eggs due to their high cholesterol content (Bovet *et al.,* 2007). Recently, the focus has been on lipid composition of eggs due to the consumer concern about the association between specific dietary lipids and the development of coronary heart disease and some forms of cancer (Milinsk *et al.,* 2003; Tesedo *et al.,* 2006). Consumers consider eggs as a highly atherogenic food due to relatively high-cholesterol contents. The egg industry has centered on reduction of cholesterol level with enrichment of nutritional value in sense of fatty acid modifications. Dietary manipulation of the egg fatty acid composition is not a new concept, and several genetic, management, nutrition, and pharmacological approaches have been explored (Gao and Charter, 2000).

Eggs are favorite food ingredients because of their flavor and functional properties of thickening, foaming and moisturizing which contribute desirable characteristics and physical functions in industrial production of many food products (Ndife *et al.,* 2010). Fresh eggs are difficult to transport because of their fragility, bulkiness and perishable nature. Therefore, recently the focus is on egg-derived products in the food industry for ready-for-use packages and handling considerations. The term egg products refers to processed and convenience forms of eggs for commercial, foodservice, and home use with the portion of the egg needed in convenient quantities. These are safe and economical ingredients, and are easily transported. There are refrigerated liquid, frozen, dried, and further processed egg products or blends to meet every need of the customer (Caboni *et al.,* 2005; Bakalivanova *et al.,* 2008; Jaekel *et al.,* 2008; Rossi *et al.,* 2010).

However, it is significant that the processing method leads to many changes in egg components, resulting in different functional properties (Franke and Kießling, 2002; Ayadi *et al.,* 2008). The objective of the current study was to compare the effect of the refrigeration, freezing and spray-drying processing methods on the nutritional value and fatty acid composition of whole egg, egg yolk and egg white (albumen).

MATERIALS AND METHODS

Sample collection and preparation

Fresh grade A eggs (n=360) were procured from the farm of Faculty of Agriculture, Uludag University, Bursa, Turkey. They were less than 24 h of lay eggs from White Leghorn hens having 58-weeks of age. At the arrival in the laboratory, the eggs were kept at 5°C and processed within 24 hours.

Processing of egg products

The eggs were washed and dried with an aseptic towel. The shelling of the eggs and the separation of yolk from albumen were made manually. For production of egg products the whole eggs, yolk and albumen were mixed at 2500 rpm for 50 s with a mixer (Model K1433, Arcelik Inc., Turkiye). The liquidified whole eggs, yolk and albumen were either pasteurized at 64°C for 2 min prior to refrigeration and chilled immediately to 4°C, frozen at -20±0.5°C (Model LF700 Laboratory Freezer, Skadi Europe Co., Netherlands), and spray-dried (Model B-290 Mini Spray Dryer, Buchi Labortechnik AG, Germany) (Fig. 1). Each processed egg sample group consisted of 120 eggs of the same lot, contained in 12 packages.

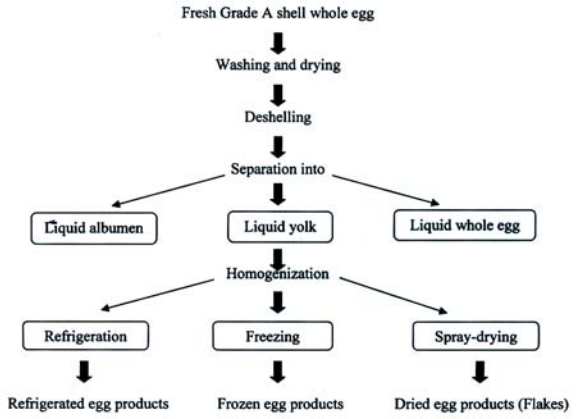

Fig. 1: Flow diagram of processed egg products

Determination of nutritional components and cholesterol content

Chemical analyses were performed twice on processed yolk, albumen and whole eggs. The analysis of moisture, protein, and ash contents were assessed following the approved methods (AOAC, 1990a-c). Total lipid contents of egg products were determined using method of Folch *et al.* (1957). Carbohydrate content was defined as the difference after the total value of moisture, protein, ash and lipid subtracted from the total weight. The extraction and quantification of cholesterol were carried out by the method published by Smith *et al.* (1995) using HP 5890 gas chromatograph equipped with a flame ionization detector and a fused silica capillary column (15 m x 0.53 mm).

Determination of fatty acid composition

For evaluating fatty acid profiles, aliquots of fatty acid methyl esters (l µl), prepared by hydrolysis and esterification with 3N methanolic HCl, were analyzed by using an Auto-System XL Gas Chromatograph (Perkin-Elmer, Pomona, CA, USA) equipped with a flame ionisation detector (FID) and an integrator. Separation of fatty acids was achieved using a Supelco SP-2330 capillary column (80% bicyanopropyl/20% cyanopropyl-siloxane, 30 m x 0.25 mm). The FID temperature was set at 250°C. C17:0 was used as internal standard. Fatty acid methyl ester peaks were identified comparing retention times with authentic fatty acid methyl esters as standards (Sigma Chemical Co., USA) (Wang *et al.,* 2000).

Statistical analysis

Data from each sampling stage were analyzed statistically by one-way analysis of variance (ANOVA). Means with a significant difference ($P<0.01$) were compared by the least squares difference (LSD) test. All analyses were performed using the Minitab for Windows (Version 14) Statistical Software Package (Minitab Inc., State College, PA).

RESULTS AND DISCUSSION

Table 1 contains results of nutritional and cholesterol content analysis of refrigerated, frozen and spray-dried egg products. The obtained results indicate that the processing method used affected nutrient composition of egg products. It is well established that hen age, diet, strain, other environmental factors, hygienic quality of the raw material and processing method influence the size and composition of eggs (Jaekel *et al.,* 2008; Rossi *et al.,* 2010). Moisture, protein, lipid, ash and carbohydrate contents of the processed egg samples were similar to the values determined previously by other researchers (Cherian *et al.,* 2002; Caboni *et al.,* 2005). Eggs contain numerous substances with potential functional and health promoting properties beyond supplying basic nutritional requirements, and consist of 9.5% egg shell, 63% albumen and 27.5% yolk. The main components are water (75%), proteins (12%), and lipids (12%), as well as carbohydrates and minerals. The lipids are found in egg yolk mainly in the form of lipoproteins (Kovacs-Nolan *et al.,* 2005).

Spray-dried egg samples showed higher values than frozen or refrigerated egg products as they had higher total solids and comprise the contents in concentrated amounts. Due to increasing demand of using egg products, particularly dried eggs, in food preparations because of long shelf-life, microbiological safety and reduced volume, spray-drying is the appropriate processing method to preserve nutritional properties without additives. The moisture contents were low enough to extend the shelf-life of spray-dried egg products in an environment of low humidity. Although the highest cholesterol was in spray-dried processed eggs, no significant effects on the cholesterol levels were observed in response to refrigeration or freezing. Since egg white contained trace amounts of lipid, processing method did not affect the lipid or cholesterol content.

The results showed that little differences exists in the fatty acid compositions of whole eggs and yolks that are produced either by refrigeration or freezing or spray-drying. Fatty acid composition of processed egg whites were not detected since egg white contained trace amounts of total lipid (<0.10%). The major fatty acids

were oleic, stearic, linoleic and linolenic acids in processed whole eggs and yolks (Tables 2). Our results were in agreement with the findings reported by Wang *et al.* (2000), Milinsk *et al.* (2003), Tesedo *et al.* (2006), Hidalgo *et al.* (2008), Samman *et al.* (2009) and Aydin and Dogan (2010). The highest percentages of unsaturated fatty acids were in spray dried whole eggs as 57.95% of total fatty acids. The unsaturated fatty acid contents of refrigerated and frozen whole eggs were found as 57.01 and 56.64%, respectively. For processed yolks the highest unsaturated fatty acid percentage was determined in spray-dried products as 56.61%.

Table 1: Influence of processing methods on nutritive profile and cholesterol contents of hen eggs (g/100 g)

Parameters	Treatment			ANOVA
	Refrigeration	Freezing	Spray-Drying	*p* value
Whole egg				
Moisture	75.54 ± 0.021[b]	79.76 ± 0.009[a]	5.98 ± 0.015[c]	0.007**
Protein	12.62 ± 0.028[b]	10.31 ± 0.026[c]	47.68 ± 0.021[a]	0.008**
Fat (Total Lipid)	10.04 ± 0.008[b]	8.64 ± 0.017[c]	40.36 ± 0.027[a]	0.001**
Ash	0.85 ± 0.022[b]	0.64 ± 0.026[b]	3.61 ± 0.017[a]	0.001**
Carbohydrate	0.95 ± 0.013[b]	0.65 ± 0.022[b]	2.37 ± 0.040[a]	0.000**
Cholesterol	0.51 ± 0.022[b]	0.42 ± 0.026[b]	1.21 ± 0.013[a]	0.001**
Egg yolk				
Moisture	53.51 ± 0.016[b]	55.93 ± 0.043[a]	4.66 ± 0.024[c]	0.001**
Protein	18.07 ± 0.29[b]	16.40 ± 0.015[c]	32.64 ± 0.020[a]	0.005**
Fat (Total Lipid)	25.74 ± 0.037[b]	25.18 ± 0.034[b]	56.64 ± 0.022[a]	0.001**
Ash	1.48 ± 0.018[b]	1.29 ± 0.033[b]	3.41 ± 0.015[a]	0.002**
Carbohydrate	1.20 ± 0.027[b]	1.20 ± 0.044[b]	2.65 ± 0.026[a]	0.001**
Cholesterol	1.02 ± 0.005[b]	0.91 ± 0.025[b]	1.72 ± 0.021[a]	0.003**
Albumen				
Moisture	88.53 ± 0.026[b]	89.14 ± 0.019[a]	6.44 ± 0.026[c]	0.001**
Protein	9.10 ± 0.026[c]	9.76 ± 0.017[b]	84.48 ± 0.014[a]	0.000**
Fat (Total Lipid)	0.01 ± 0.017[c]	0.05 ± 0.022[b]	0.08 ± 0.039[a]	0.004**
Ash	0.47 ± 0.029[c]	0.52 ± 0.022[b]	4.89 ± 0.017[a]	0.003**
Carbohydrate	0.93 ± 0.027[b]	0.53 ± 0.024[c]	4.11 ± 0.029[a]	0.000**
Cholesterol	ND	ND	ND	

Values (Mean ± SD) within a row having different superscript letters are significantly different by one-way ANOVA followed by Range test (**P<0.01; *P<0.05). ND; lower than detectable limits

Table 2: Influence of processing methods on Fatty acid (%) profile of whole hen eggs and egg yolk

Fatty Acid	Whole hen egg				Egg yolk			
	Treatment			ANOVA	Treatment			ANOVA
	Refrigeration	Freezing	Spray-Drying	P value	Refrigeration	Freezing	Spray-Drying	P value
Saturated								
1	28.97±0.03[a]	28.82±0.17[a]	28.19±0.13[b]	0.016*	28.35±0.07[a]	27.91±0.01[ab]	27.69±0.13[b]	0.001**
2	0.66 ±0.13	0.55±0.03	0.51±0.06	0.466	0.54 ± 0.02	0.53 ± 0.042	0.52 ± 0.03	0.905
3	ND	ND	0.12±0.03	-	ND	ND	0.33 ± 0.04	-
4	12.41±0.09	12.53±0.04	12.63±0.18	0.410	14.38 ± 0.11	14.55 ± 0.07	14.68 ± 0.26	0.254
Unsaturated								
1	2.47±0.10	2.52±0.08	2.34±0.01	0.405	2.35 ± 0.21	2.40 ± 0.04	2.15 ± 0.07	0.277
5	37.99±0.01	37.63±0.18	38.29±0.10	0.086	36.48 ± 0.26	36.59 ± 0.13	36.56 ± 0.09	0.814
6	1.28±0.11	1.13±0.04	1.47±0.24	0.238	0.42 ± 0.01	0.35 ± 0.09	0.39 ± 0.03	0.813
7	ND	ND	0.11±0.01	-	ND	ND	0.12 ± 0.03	-
8	14.64±0.06[a]	14.23±0.16[b]	14.55±0.07[ab]	0.047*	15.43 ± 0.11	15.75 ± 0.35	15.45 ± 0.21	0.399
9	ND	ND	0.13±0.028	-	ND	ND	0.20 ± 0.04	-
10	0.14±0.06	0.17±0.10	0.18±0.01	0.907	0.34 ± 0.06	0.37 ± 0.10	0.30 ± 0.07	0.695
11	ND	ND	0.11±0.00		ND	ND	0.12 ± 0.01	-
12	ND	ND	0.21±0.06	-	0.42 ± 0.07	0.28 ± 0.01	0.33 ± 0.04	0.348
13	0.21±0.03	0.16±0.03	0.19±0.02	0.636	0.31 ± 0.01	0.26 ± 0.09	0.27 ± 0.02	0.798
14	ND	ND	0.13±0.04	-	ND	0.11 ± 0.00[b]	0.29 ± 0.06	-
15	0.28±0.02	0.39±0.01	0.36±0.09	0.537	0.47 ± 0.00	0.39 ± 0.05	0.43 ± 0.03	0.328

1= Hexadecanoic acid; 2= Docosanoic acid; 3=Tetradeconoic acid; 4= Octadecanoic acid; 5=9-Octadecenoic acid; 6=11-Eicosenoic acid; 7=13-Docosenoic acid; 8=9, 12-Octadecadienoic acid; 9=9, 12, 15-Octadecatrienoic acid; 10=5, 8, 11-Eicosatrienoic acid ; 11=6, 9, 12, 15-Octadecatetraenoic acid; 12=5, 8, 11, 14-Eicosatetraenoic acid; 13=5, 8, 11, 14, 17-Eicosapentaenoic acid; 14=7, 10, 13, 16, 19-Docosapentaenoic acid; 15=4, 7, 10, 13, 16, 19-Docosahexaenoic acid. Values (Mean±SD) within a row having different superscript letters are significantly different by one-way ANOVA followed by Range test (**P < 0.01; *P < 0.05). ND=lower than detectable limits.

In recent years the focus is on the role of unsaturated fatty acids in human health and development including prevention and treatment of hypertension, arthritis, and autoimmune disorders, inhibition of certain cancers, and necessity for fetal brain and visual development (Kovacs-Nolan *et al.,* 2005; Bovet *et al.,* 2007). The relatively high amounts of the unsaturated fatty acids obtained in this study, compared to the results of others, may be a result of combined effects of age and strain, together with the dietary regime applied. The age and strain importance have been shown to have effects on FA composition (Milinsk *et al.,* 2003).

Besides direct consumption, eggs have various applications; for instance, they are consumed as liquid mixtures, frozen and dried egg products for use in instant soups, cake mixtures and meat products. Food manufacturers complain about a variability in nutritional and functional properties in egg products that complicate the standardization of processes and of final food quality (Rossi *et al.,* 2010) depending on the quality of the raw material in terms of egg freshness and composition as well as processing treatments such as homogenisation, pasteurisation and freezing (Caboni *et al.,* 2005; Guilmineau and Kulozik, 2007).

From this study, it can be concluded that spray-dried egg yolk could be thought as an excellent source of linoleic and linolenic fatty acids, which are essential fatty acids for metabolism and health, refrigerated or frozen egg products. Further research to identify new and existing biological functions of hen egg components, being excellent source of mono- and polyunsaturated fatty acids, will help to define new methods to further improve the value of eggs, since eggs with tailored nutritional composition might become a requested food and food ingredient.

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