INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 25, No. 2, p. 172-179, 2024

RESEARCH PAPER OPEN ACCESS

Study on the egg components and fatty acid composition of organic egg and commercially available table eggs obtained from different establishments commonly consumed in Riyadh

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Key words: Egg, Organic, Commercial establishments, Fatty acid, Egg components

http://dx.doi.org/10.12692/ijb/25.2.172-179 Article published on August 07, 2024

Abstract

This study compares the egg components and fatty acid composition of organic eggs and commercially available table eggs commonly consumed in Riyadh. The analysis included weight, cholesterol content, and fatty acid composition determined via gas chromatography. Eggs from minimarkets had the lowest values for weight, yolk percentage, yolk weight, and albumen weight, while hypermarket eggs had the highest, except for albumen, which was highest in supermarket samples. Commercial eggs had higher egg and yolk weights compared to organic eggs, but organic eggs had a higher percentage of albumen. The edible portion was greater in organic eggs, with the order for commercial eggs being hypermarket > supermarket > minimarket. An inverse relationship was observed between yolk cholesterol concentration and egg weight, except for organic eggs. The ω-6 to ω-3 ratio was lowest in hypermarket samples and lowest overall in organic eggs when compared to commercial eggs. Total saturated fatty acids were highest in minimarket eggs, total PUFA and ω-6 were highest in supermarket eggs, and total MUFA and ω-3 were highest in hypermarket eggs. Organic eggs had higher contents of total PUFA, ω-6, ω-3, linoleic acid, and caprylic acid, and a more favorable n-6 to n-3 fatty acid ratio than commercial eggs. Organic eggs contained more n-3 and fewer n-6 fatty acids compared to conventional eggs.

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Introduction

Egg is very significant component of human diet and it is composed of proteins, carbohydrates, vitamins, minerals, lipids and essential fatty acids. Each and every component of egg has a specific role to fulfill individual's nutrition requirements. Eggs are more commonly eaten by humans because of its ease in availability and affordable prices. Higher bio-availability of egg's protein makes it a reference food for protein quality. Fats are important for health and life but the nutritional quality of fat in egg should be evaluated by taking into account the content of polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA) and saturated fatty acids (SFA) (Milinsk *et al.*, 2003). More amounts of PUFA and MUFA and lesser amount of SFA could reduce the negative biological effect of high cholesterol intakes (Estruch *et al.*, 2018).

Experts believe that dietary PUFA of the n-3 series play significant role in human health (Van Dael *et al.*, 2021). Omega-3 (ω-3) fatty acids plays an important role in the reduction of inflammatory diseases, blood pressure, and the risk of sudden death from cardiac arrest (Connor, 2000; Juturu, 2008). The positive association of high plasma total cholesterol and low density lipoprotein cholesterol levels with atherosclerosis has been well established (Carlson *et al.*, 1979).

Cholesterol content of chicken egg continues to gain substantial notice especially due to correlation between dietary lipids and occurrence of atherosclerosis (Sugano *et al.*, 2021). Lifestyle diseases arising from nutritional deficiencies are taking frightening positions in Saudi Arabia (Alquraishi *et al.*, 2011; Prentice, 2014). This study was undertaken to compare the egg components and fatty acid composition of organic and commercially available table eggs obtained from different establishments commonly consumed in Riyadh.

Materials and methods

Sample collection and preparation

Eggs were procured from mini, super and hypermarkets and were stored at 4°C for further experimentation. All the chemicals used were of analytical grade.

Egg components

Weight: Weight of egg was measured and then yolk was separated with an egg separator and weighed. The shell was cleaned and weighed. The albumen weight was calculated by subtracting yolk and shell weight from the total egg weight.

Cholesterol content of egg yolk

The colorimetric assay for yolk cholesterol was determined using a modified procedure of Pearson *et al.* (1953), also described by Bair and Marion (1978).

Analysis of fatty acid composition

Samples were homogenized at 4°C (Bench top Homogenizer 300 DS PRO Scientific, Inc., Oxford, CT, USA). Fatty acid methyl esters (FAMEs), was obtained by trans methylating extracted lipids according to method given by Folch *et al.* (1957).

Quantitative and qualitative analysis was performed according to the method proposed by Eder (1995) with a Shimadzu Gas Chromatograph equipped with flame ionization detector (1.8 m-3 mm internal diameter) packed glass column. The injector and detector temperatures were 270°C and 260°C respectively. Nitrogen was used as a carrier gas. The injection volume was 1.0 µl. Column temperature was programmed for 190°C for 41 min, rising progressively at 30°C/min up to 220°C where it was maintained for 10 min at 220°C. Fatty acid methyl ester was identified by comparing their retention times with those of the authentic standard mixtures. Fatty acid concentration was expressed as weight percentage of each fatty acid in total fatty acids.

Statistical analysis

Data were analyzed using SPSS statistical software package and expressed as mean ±standard deviation. The differences among the quality parameters of eggs obtained from different commercial establishments were analyzed by ANOVA at a significance level of $p \leqslant 0.05$; if significant differences were found, a Post-hoc analysis using Duncan's multiple range tests was performed.

Results and discussion

Components of organic eggs and commercial eggs obtained from different establishments

Nutritive value and functional properties of egg makes it an important animal protein source. But, due to high cholesterol content, consumption of eggs is often considered as responsible for some health problems leading to coronary heart diseases (Bragagnalo and Amaya, 2003). Table 1 depicts the components of organic eggs and commercial egg obtained from different establishments. For the commercial eggs, the egg weight, yolk weight, yolk percentage of egg weight, albumen weight and albumen percentage of egg weight was found to be least for the egg samples obtained from minimarket (stored at room temperature) and highest for the samples obtained from hypermarket (stored in chiller) (Table 1). From the study it has been analyzed that as the storage temperature increased the egg weight, albumen weight, yolk weight decreased. In a previous study weight of egg was not reduced significantly for 0 to 10 days at 5°C and 21°C but, it was significantly reduced by storage at 29°C (Jin *et al.*, 2011). In another study the average weight obtained from different establishments ranged from 48.98 to 58.02g, however statistical difference was insignificant between them (Pereira *et al.*, 2014). In this study the average weight value of egg ranged from 51.82 to 63.05g but no statistical difference was found between the samples obtained from mini and super market but difference was significant between commercial and organic eggs.

Table 1. Components of organic eggs and commercial eggs obtained from different establishment

Egg quality	Commercial			Organic
	Mini market	Supermarket	Hypermarket	
Egg weight (g)	56.757 ±1.417 [ab]	59.496±2.799 [ab]	63.053±4.302 [b]	51.824 ±0.657[a]
Yolk (g)	16.7±0.707 [ab]	18.04±0.636 [b]	21.31±1.421 [c]	13.9±1.344[a]
Yolk percentage of egg weight	29.42±0.042 [ab]	30.32±1.032[ab]	33.79±2.878 [b]	26.82±3.253[a]
Albumen (g)	32.15±5.049	33.65±0.636	32.7±1.414	32.71±1.329
Albumen percentage of egg weight	56.64±1.421 [b]	56.55±1.006[b]	51.86±0.368 [a]	63.12±1.555[c]
Shell (g)	7.91±1.329 [ab]	7.81±1.471[ab]	9.04±1.358[b]	5.21±0.014[a]
Shell percentage of egg weight	13.94±2.757	13.12±1.414	14.33±2.793	10.05±1.414

Values are mean ± standard deviation (SD). *indicates significant difference among different groups (in rows) as indicated by ANOVA followed by Duncan's multiple range test.

The percentages of albumin and yolk percentages reported by Hermiz *et al.* (2012) in his study averaged 55.22 and 29.26 % which is quite similar to the result obtained in this study. Weight loss in the eggs that was stored without any temperature control was reported by Freitas *et al.* (2011). Samli *et al.* (2005) reported that shell weight changed significantly with storage time and temperature. Besides being an important indicator of egg freshness; albumen quality is also important for egg processing industry. Quality of albumen is influenced by environmental factors such as storage time and temperature (Samlli *et al.*, 2005). The Food and Agricultural Organization of the United Nations (FAO, 1999) defines "organic" as "a process whereby natural inputs are approved and synthetic inputs are prohibited". As compared to organic eggs, egg weight and yolk weight was higher for commercial egg, but the percentage of albumen was significantly higher for organic eggs. Samman *et al.*, 2009 also reported the highest weight for conventional eggs as compared to organic and omega 3 rich eggs.

The total edible portion (egg yolk + egg albumen) constitutes about 85 to 90% (Table 1). The edible portion was higher in organic eggs as compared to commercial eggs and for commercial egg the edible portion was in the following order: hypermarket > supermarket>minimarket (Table 1). Several factors such as hen, size of eggs and strains affect the total edible portion and yolk: white ratio (Ahn *et al.*, 1997).

Shell content was significantly higher in commercial eggs as compared to organic eggs but the difference in shell content was not significant between the commercial eggs obtained from mini and supermarket. Strength and quality of shell are vital factors in egg appearance. In a study, Patterson *et al.*, (2001) reported more egg breaking and leakage in specialty eggs when compared with regular white shelled eggs. Conventional or commercial eggs have thicker egg shell. The effect of production system on shell thickness cannot be easily explained. As compared to conventional eggs, thicker shells in organic eggs was reported by Mugnai *et al.* (2009), but on the other hand Hidalgo *et al.* (2007) reported different results.

In this study cholesterol value ranged from 8.8 to 10.85 mg/g, which is lesser then the value reported by Han and Lee, (1992). It has been revealed by Beyer and Jensen, (1989) that, the common colorimetric method of cholesterol detection overvalued the cholesterol content of eggs. According to Han and Lee, (1992), almost all of the determination based upon calorimetric determination gives cholesterol values of 12 to 18 mg/g yolk. Foods high in PUFA and low in cholesterol and saturated fats are gaining interest of consumers. Egg consumption has reduced due to its high content of cholesterol (Paik and Blair, 1996), despite of the claims that eggs are incorrectly considered to the atherogenic because egg yolk contains a factor or factors accountable for accelerated cholesterol metabolism and excretion (Sim, 1984).

Cholesterol is required by all animal cells for growth and maintenance, and is one of the structural components of all cellular and intracellular membranes in animal and human body (Choi *et al.*, 2001). Cholesterol serves a variety of functions in human body such as maintenance of our body temperature, assisting the liver in the manufacture of bile acids, the manufacture of steroids, or cortisone-like hormones, modulating the fluidity of cell membranes and so on. Yolk cholesterol value of commercial egg was 10.85, 10.5 and 8.8 mg/gm yolk for the egg obtained from minimarket, supermarket and hypermarket respectively. In a previous study the average cholesterol on 8 different white strains of breeding hens was 17.41 mg/gm yolk which is higher than the result obtained in this study (Han and Lee, 1992). Bair and Marion (1978) reported that the cholesterol averaged 14.5 mg/g of yolk, among 7 inbreeds line and 15 breeds of chicken. An inverse relationship between yolk cholesterol concentration and egg weight was observed with an exception of organic egg (Fig. 1). Bair and Marion, (1978) also reported an inverse relationship in other avian species.

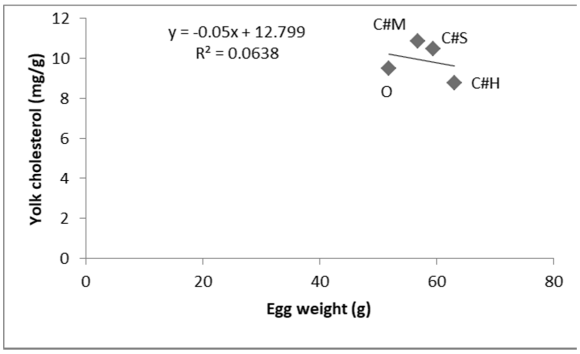

Fig. 1. Relationship between yolk cholesterol content and egg weight

C#M-Commercial Minimarket; C#S- Commercial Supermarket; C#H- Commercial Hypermarket; O-Organic

Fatty acid composition of organic eggs and commercial egg obtained from different establishments

Mean values obtained for the fatty acid composition in the egg samples analyzed are given in Table 2. In this study the major fatty acid were oleic acid followed by palmitic acid, linoleic acid and stearic acid. Total saturated fatty acid was significantly highest in eggs procured from mini market and least in organic eggs. Total PUFA (15.84%) and total ω-6 (15.13%) was significantly highest in samples obtained from supermarket and total MUFA (42.08%) and total ω-3 (0.82%) was significantly highest in samples obtained from hypermarket. Ratio of ω-6 and ω-3 was least in sample obtained from hypermarket. Organic eggs were characterized by significantly higher content of total PUFA, total ω-6, total ω-3, linoleic acid and caprylic acid. Noble *et al.*, (1990) mentioned that, ordinary hen egg yolk comprises 34.2% of saturated fatty acids, 45.7% of MUFA, and 20.1% of PUFA, but in this study total saturated fatty acid ranged from approximately 42-44%, total MUFA ranged from 40-42% and total PUFA was almost between 13-16. The substantial presence of several PUFA, especially n-3 series such as DHA has been noticed which is very important from a nutritional point of view. Eggs may be suitable for enriching weaning foods (Simpoulos and Salem, 1992) because of this high DHA and C20:4 (n-6) levels. Claims of beneficial health effect of n-3 fatty acids have led to extensive research on manipulating the fatty acid composition of hen egg (Lekanich and Noble, 1997). Douny *et al.*, (2015) found no significant difference of LNA, ARA and DHA content of eggs stored at difference temperature.

Table 2. Fatty acid composition of organic and commercial eggs obtained from different establishment.

Fatty acids	Commercial			Organic
	Mini market	Supermarket	Hypermarket	
Caproic acid	0.025±0.007 ab	0.01±0a	0.03±0.014a	0.05±0b
Heptanoic acid	0.02±0	0.02±0	0.02±0	0.04±0
Caprylic acid	0.05±0a	0.055±0.007a	0.085±0.007b	0.115±0.007c
Nonaoic acid	0.02±0a	0.015±0.007a	0.02±0a	0.04±0b
Capric acid	0.02±0a	0.015±0.007a	0.04±0.028a	0.045±0.007a
Lauric acid	0.045±0.007a	0.055±0.021a	0.07±.028a	0.08±0.014a
Myristic acid	0.64±0.014b	0.65±0.042ab	0.77±0.014a	0.68±0.071ab
Myristoleic acid	0.09±0a	0.085±0.007b	0.115±0.007b	0.075±0.007b
Pentadecanoic acid	0.08±0b	0.075±0.007a	0.095±0.007ab	0.115±0.007c
Palmitic acid	33.78±0.113b	33.08±0.113b	33.54±0.361b	31.25±0.594a
Palmitoleic acid	3.545±0.007c	2.835±0.035a	3.935±0.191b	3.045±0.163a
Margaric acid	0.155±0.007a	0.175±0.007a	0.175±0.007a	0.225±0.007b
Stearic acid	9.53±0.07a	9.45±0.155a	8.77±0.085a	10.075±0.94a
Oleic acid	37.52±0.071a	36.89±0.042a	37.82±0.339a	38.45±1.075a
Linoleic acid	11.59±0.042a	13.64±0.071c	11.42±0a	12.43±0.438b
Arachidic acid	0.03±0.014a	0.04±0a	0.015±0.007a	0.03±0.014a
Linolenic acid	0.135±0.007a	0.195±0.007a	0.225±0.078a	0.18±0.014a
11-eicosenoic acid	0.185±0.007a	0.2±0a	0.21±0.012a	0.545±0.520a
11, 14 eicosadienoic acid	0.11±0.014a	0.135±0.007a	0.135±0.007a	0.145±0.007b
5,8,11-eicosatrienoic acid	0.14±0.014a	0.135±0.007a	0.12±0a	0.085±0.007b
5,8,11,14- eicosatetraenoic acid	1.215±0.007ab	1.105±0.007a	1.14±0ab	1.38±0.169b
Docosatetraenoic acid	0.075±0.007a	0.09±0.014a	0.09±0a	0.075±0.007a
Eicosapentaenoic acid	0.305±0.007c	0.315±0.02b	0.395±0.021b	0.23±0.028a
Docosapentaenoic acid	0.03±0a	0.02±0a	0.03±0a	0.025±0.007a
Docosahexaenoic acid	0.205±0.007a	0.02±0a	0.195±0.007a	0.31±0.056b
Total SAT	44.39±0.177b	43.64±0.141a	43.64±0.191a	42.74±1.449a
Total MUFA	41.34±0.05c	40.01±0.071a	42.08±0.127b	42.11±1.747b
Total PUFA	13.81±0.106a	15.84±0.078b	13.75±0.057a	15.33±0.183b
Total ω-6	13.16±0.085b	15.13±0.078a	12.94±0.007b	14.14±0.269a
Total ω-3	0.65±0.021a	0.71±0.00ab	0.82±0.064c	1.19±0.085d
ω-6/ ω-3	20.40±0.5397b	21.30±0.109b	15.87±1.252a	11.88±0.922a

Similarly in this study no significant difference was observed for LNA, ARA and DHA among the eggs obtained from different establishments. Neuringer and Connor, (1986) suggested that, the n-6/n-3 ratio must be between 4/1 and 10/1 for balancing the nutritional needs of these PUFA. It has been observed that n-6/n-3 ratio of samples obtained from hypermarket was least among the commercial eggs and when commercial egg was compared with organic egg, this ratio was least for organic eggs and quite near to the value suggested by Neuringer and Connor, (1986). It is widely accepted that the current western diets are low in n-3 PUFA and high in SFA (Cherian *et al.*, 2002). Both in commercial and organic eggs; palmitic acid (C16:0) prevailed among the saturated fatty acids, oleic acid (C18:1, n-9) amongst the MUFA and linoleic acid (C18:2, n-6) amongst the PUFA. Organic acid also shows more favorable ratio of n-6 to n-3 fatty acids than commercial eggs. Organic eggs contain more n-3 in comparison to conventional eggs (Lopez-Bote*et al.*, 1998). Unlike this result, Matt *et al.* (2009) and Tercic *et al.* (2012) did not found any significant differences in the content of SFA, MUFA and PUFA in eggs produced in conventional and organic production system.

Conclusion

From this study, it can be concluded that the egg components were better for the samples obtained from hypermarkets and organic eggs showed better result in terms of egg components, edible portion and fatty acid composition, when compared with the commercial eggs. An inverse relationship between yolk cholesterol concentration and egg weight was observed with an exception of organic egg. Organic eggs shows more favorable ratio of n-6 to n-3 fatty acids than commercial eggs.

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