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EGG QUALITY AND ORGANOLEPTIC EVALUATION OF NUTRIENT ENRICHED DESIGNER EGGS

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An experiment was conducted to evaluate egg quality and organoleptic parameters of nutrient enriched designer eggs. Chicken eggs enriched with different micronutrients (>300 mg omega-3 fatty acids, >55 µg selenium and >6 mg vitamin E per 100 g) were produced by giving layers a special diet. These eggs were compared with regular eggs obtained from same type and age of birds fed on regular diet for egg quality and sensory attributes. Internal egg quality indicated by albumen height and Haugh units showed non-significant differences. Proportion of different egg components (viz shell yolk and albumen), and egg shell quality were also independent of dietary treatments. Nevertheless, colour of egg yolk revealed significant ($P<0.05$) difference between enriched and regular eggs. Organoleptic tests of both type of eggs for different sensory attributes demonstrated non-significant results as panelists did not find any considerable differences between regular and nutrient enriched eggs. Based on results obtained it may be concluded that eggs could be enriched with different micronutrients by nutritional manipulations without deteriorating egg internal and sensory qualities.
Keywords: Eggs, omega-3 fatty acids, selenium, vitamin E, sensory, egg quality

INTRODUCTION

Omega-3 polyunsaturated fatty acids are dietary essential as they cannot be synthesized by mono-gastric animals indigenously. Several researchers reported low intake of these critical nutrients by human (Leskanich and Noble, 1997; Baucells *et al*., 2000; Simopoulos, 2000). Thus scientists utilized their expertise to enhance omega-3 concentrations of different food items (Kris-Etherton *et al*., 2000; Cherian, 2002; Rymer and Givens, 2005; Whelan and Rust, 2006). Chicken eggs are considered as a suitable ingredient for omega-3 fatty acid fortification (Bean and Leeson, 2003; Jia *et al*., 2008; Kang, 2008; Hayat *et al*., 2009, 2010a).

Many research studies were accomplished on omega-3 enrichment of layers eggs in different parts of the world but mainly concentrated in the developed nations (Kamińska *et al*., 2001; Ajuyah *et al*., 2003; Mazalli *et al*., 2004; Payet *et al*., 2004; Cherian 2008, 2009). Indigenous research on this topic is very important as availability of feedstuffs used for designer eggs production is not same in different parts of World and locally available ingredients may provide an opportunity of more economical production. However, very limited information is available on designer eggs production and/or their impact on human health and acceptability in Pakistan. Only one project conducted by us has been reported to date on this very important topic (Hayat *et al*., 2009, 2010a, 2010b). Findings of this study have demonstrated that 1) Dietary fatty acids, particularly omega-3, can modulate lipid metabolism in laying hens without compromising the production performance and egg quality and 2) Incorporating antioxidants in diets enriched in poly unsaturated fatty acids reduce oxidative damage to these bioactive components. Based on these results, it is hypothesized that other nutraceuticals vital for health such as tocopherols, lutein and selenium along with omega-3 fatty acids may be incorporated into eggs and will enhance product stability by aiding the antioxidant defense system. A project was therefore planned to study the effects of tocopherols, and selenium in the diets of layers and subsequent influence on quality and sensory evaluation of omega-3 enriched eggs.

MATERIALS AND METHODS

***Egg production*:** Layers (n = 2880; LSL lite) were housed in an environmental controlled poultry house in cages (9 layers per cage). Standard husbandry and management practices were followed throughout the experimental period. Special diets were prepared according to the standard specifications set by breeding company. These diets were gradually introduced and eggs enriched with different micronutrients (>300 mg omega-3 fatty acids, >55 µg selenium and >6 mg vitamin E per 100 g) were obtained. Regular eggs were collected from same type and age of birds fed on regular diet.

***Egg quality determination*:** Eggs collected were subjected to egg quality determination within 24 hours of collection. Egg weight, yolk color, albumen height, egg grade and Haugh units (Haugh, 1937) were determined by egg analyzer (Orka

Food Technology). Shell thickness was measured manually with the help of micrometer.

Egg colour analysis and separation**:** The detailed colour analysis of eggs was carried out by spectrophotometer (CM-5; Konica Minolta). Colour values were recorded as "L" (0 black; 100 white), "a" (-a greenness; +a redness) and "b" (-b blueness; +b yellowness).Hue angle represented by ratio of arctan (b/a) is a good indicator of changes in colour by a single value. Hue angle is the attribute of colour perception by means of which an object is judged to be red, yellow, green, blue or purple, while chroma is the attribute of colour perception that expresses the degree of departure from grey colour of the same lightness. CM-5 spectrophotometer equipped with dual 40-element silicon photodiode arrays detector and planar diffraction grating as spectral separation device was used to critically analyze the colors of different egg components (Konica Minolta Coporation Japan). Different readings of L*a*b*, and color differences in these spaces were obtained and analyzed for differences if any. Chroma and Hue angle (h^0) were calculated using the following formula:

$$\text{Chroma} = \sqrt{a^2 + b^2}$$

$$\text{Hue angle } (h^o) = \tan^{-1}\left[\frac{b}{a}\right]$$

Sensory evaluations: Ten adult untrained panelists were selected by invitation and willingness to consume eggs by signing informed content performa. All the participants declared no allergy to eggs and egg products. It was a double blind study, however, they were given a preliminary training and protocol was explained before the actual testing session. For each sensory characteristic participants were instructed to score the intensity of evaluation on a 15 points hedonic scale developed for this purpose (0=not intense, 4 =slightly intense, 8 =moderately intense, 12 =largely intense, and 15 =extremely intense). Descriptions of different sensory attributes are presented in Table 1.

Egg samples were prepared as described earlier by Hayat *et al*. (2010b). **"**Briefly**,** three eggs, per treatment or control sample, were boiled in a stainless steel pot which contained 32 oz (~900 ml) of ambient tap water. After boiling, the water was drained from the pot and the strained eggs were cooled under running tap water. The eggs were peeled and then cut into quarters (length-wise) for delivery to sample plates. For the treated sample, one egg from that treatment was quartered and then ¼ egg was delivered to a 6-inch, white paper board plate identified with a 3-digit blind code. For the control and blind control, care was taken so that each panelist received a "control" sample and a "blind control" sample from the same egg."

Statistical analysis**:** A paired comparison (t-test) was employed to calculate the probability of statistical difference between the treatments associated with the two groups using Cohort version 6.1 (Co-stat 2003. If P</=0.05, there were significant differences between the two groups and Duncan's Multiple Range test (DMR) was used to separate means (Duncan, 1955).

RESULTS AND DISCUSSION

Internal egg quality indicated by albumen height and Haugh units showed non-significant differences. Proportion of different egg components (viz shell yolk and albumen), and egg shell quality were also independent of dietary treatments. Nevertheless, colour of egg yolk revealed significant ($P<0.05$) difference between enriched and regular eggs.

The statistics for albumin of control and enriched eggs showed significant results. The L value was higher for control as compared to enriched in fresh eggs category showing that the whiteness of albumin was more towards control (27.90) than enriched (25.90) eggs, however the difference was very minor depicting that enriched eggs were slightly better than the control eggs. Similar trends were observed for boiled eggs also. The ''a'' value was also greater for control (1.53) than enriched (-1.47) eggs showing

Table 1. Description of sensory attributes for the evaluation of egg white and yolk

Attributes	Egg White	Egg Yolk
Color	Intensity of "whitish" color, typical of boiled egg white	Intensity of "yellowish" color, typical of boiled egg yolk
Aroma	Intensity of aroma, typically associated with boiled egg white	Intensity of aroma, typically associated with boiled egg yolk
Taste	Intensity of perceived taste, typical of boiled egg white	Intensity of perceived taste, typical of boiled egg yolk
Flavor	Intensity of perceived flavor, typical of boiled egg white	Intensity of perceived flavor, typical of boiled egg yolk
Mouth feel	Intensity of texture perception while chewing, typically associated with boiled egg white	Intensity of texture perception while chewing, typically associated with boiled egg yolk
Overall quality	Overall impression of quality/acceptability of egg white based on all quality attributes	Overall impression of quality/acceptability of egg yolk based on all quality attributes

that the value of control was more towards for reddish and the enriched eggs were more towards for greenish side in both fresh and boiled eggs. The ''b'' value showed similar results as compared to ''a'' in which value for control was greater than the mean values for enriched eggs indicating that that they are more yellowish in color. Greater the value of chroma and hue angle more it is acceptable. Overall results showed that mean values for white L, a, b, chroma was significant for control and enriched eggs and also significantly different for fresh and boiled eggs while for white, Hue angle the results were non-significant for control and enriched eggs and also for fresh and boiled eggs.

Colour analysis of egg yolks are presented in Table 2. Mean values for fresh and boiled eggs showed significant results. The "L" value for both fresh and boiled eggs is higher in control (56.07) than the enriched (54.57) one.

Table 2. Color analysis of different portions of control and enriched eggs

Color attributes[1]	Fresh eggs		Boiled eggs	
	Control	Enriched	Control	Enriched
White L	27.90	25.90	90.83	79.27
White a	1.53	-1.47	-2.23	-2.97
White b	1.77	1.33	9.07	5.73
White chroma	2.34	1.99	9.34	6.48
White hue angle	48.32	3.01	-76.42	-16.84
Yolk L	56.07	54.57	69.73	63.90
Yolk a	-0.23	4.00	0.87	2.20
Yolk b	32.97	39.00	32.90	34.90
Yolk chroma	32.97	39.21	32.92	34.98
Yolk hue angle	-89.57	84.03	28.39	86.42
Shell L	90.47	88.17	94.43	94.50
Shell a	2.67	2.40	1.33	1.47
Shell b	2.43	2.23	3.87	3.93
Shell chroma	3.61	3.30	4.09	4.20
Shell hue angle	42.19	42.24	70.75	69.18

[1]Color attributes are; L = 0 black; 100 white, a = -a greenness; +a redness, b = -b blueness; +b yellowness, Chroma = Square root of $a^2 + b^2$ and Hue angle = ratio of arctan (b/a)

The statistical results showed that the values of yolk "L" is significantly different for boiled and fresh eggs while non-significant for control and enriched eggs. The "a" value for yolk is higher in enriched eggs (4.00) as compared to the control (-0.23) eggs and statistically also the control and enriched eggs for yolk were significant but non- significant for fresh and boiled eggs. Similarly b value is also greater in enriched eggs (39.00) than control eggs (32.97) of both fresh and boiled category. Statistically the results regarding yolk b, Chroma and Hue angle were non significant for fresh and boiled eggs also for control and enriched eggs they were non-significant except for hue angle.

Table 2 shows the colour analysis of egg shells for control and enriched eggs. The "L" value for control is greater in fresh eggs (90.47) whereas slightly lower in boiled eggs (94.43) as compared to the enriched eggs. Similar results were seen for "a" and "b" value that is higher in control eggs of fresh category and lower in controls of boiled category. However, Chroma was greater in control eggs (3.61) than enriched eggs (3.30) in both fresh and boiled category. Whereas, hue angle was greater in enriched eggs (42.24) than control eggs (42.19) but it was lower in enriched eggs (69.18) than control (70.75) in boiled eggs. Overall, the values for Shell "L", "a", "b" Chroma and Hue angle were non-significant for control and enriched eggs and significant for fresh and boiled eggs.

Colour depicts the first impression for acceptance of any product by consumers. Producers can differentiate their products with different colours. Colour differences between regular and enriched eggs are considered as desirable feature. These findings are in line with the results of previous researchers who also reported change in egg colour due to differences in ration formulations (Hayat *et al*., 2009; Zahroojian *et al*., 2013; Zhang and Kim, 2013). However, Maryam *et al*. (2013) demonstrated non-significant difference in yolk color due to incorporation of different vegetable oils in rations of laying hens.

Results of sensory tests of regular as well as nutrient enrich eggs whites by untrained panelists are presented in Tables 3. Average scores given to white portion of regular eggs by different participants for color, aroma, taste, flavor, mouth feel and overall quality were 11.26, 9.65, 11.94, 12.06, 12.34, and 11.66, respectively. On the other hand ratings of nutrient enriched eggs for these parameters were 11.28, 10.85, 12.30, 11.90, 12.04 and 12.36, respectively. These scores were out of 15 points. Non-significant differences were revealed for all the parameters under study.

Table 3. Sensory scores[1] for the eggs white

Sensory attributes	Control eggs	Enriched eggs	P-value
Color	11.26	11.28	0.942 ns
Aroma	9.65	10.85	0.175 ns
Taste	11.94	12.30	0.330 ns
Flavor	12.06	11.90	0.722 ns
Mouth feel	12.34	12.04	0.354 ns
Overall quality	11.66	12.36	0.367 ns

[1]Mean values from 10 panelists during different testing sessions, ns = non significant differences

Table 4 presents sensory evaluation of egg yolks. Mean values given to egg yolks of regular eggs by different participants for color, aroma, taste, flavor, mouth feel and overall quality were 11.20, 12.10, 12.50, 11.27, 12.57, and 12.08 respectively. On the other hand ratings of nutrient enriched eggs for these parameters were 12.82, 12.58, 12.16, 11.83, 12.22 and 12.18, respectively. It was observed that only color of the yolk demonstrated significant difference ($P<0.05$).

Table 4. Sensory scores[1] for the eggs yolk

Sensory attributes	Control eggs	Enriched eggs	P-value
Color	11.20	12.82	0.007 **
Aroma	12.10	12.58	0.369 ns
Taste	12.50	12.16	0.142 ns
Flavor	11.27	11.83	0.425 ns
Mouth feel	12.57	12.22	0.564 ns
Overall quality	12.08	12.18	0.802 ns

[1]Mean values from 10 panelists during different testing sessions, ns = non significant differences, ** = significant

Statistical analysis of the comparisons between two treatment groups with data points, mean difference, standard error of mean t value and probability for egg albumen and egg yolk are presented in Tables 3 and 4, respectively.

Non-significant differences were observed for all important sensory attributes which were in line with the findings of Valavan *et al*. (2013). Although the contents of omega-3 fatty acids were considerably high in the nutrient enriched eggs and these polyunsaturated acids are prone to oxidative rancidity. Oxidation of PUFA is major cause of deterioration of sensory qualities of enriched eggs. However, absence of any change in smell, flavour and taste in experimental eggs might be due to supplementation of two antioxidants; selenium and vitamin E. These antioxidants may work at cellular levels to check oxidative rancidity and able to protect quality and sensory attributes of enriched eggs. These findings corroborate those of earlier scientists that panellists were unable to differentiate any considerable diversity between regular and designer eggs (Marshall *et al*., 1994; Van-Elswyk *et al*., 1992, 1995; Ayerza and Coates, 2002; Hayat *et al*., 2010b). Recent studies of Mridula *et al*. (2012) and Goldberg *et al*. (2013) also concluded the maintenance of sensory qualities of designer eggs produced through dietary modifications.

***Conclusion*:** Based on results obtained it may be concluded that eggs could be enriched with different micronutrients like omeg-3 fatty acids, selenium and vitamin E through nutritional manipulations without deteriorating egg internal and organoleptic qualities.

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