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External, Internal and Sensory Qualities of Table Eggs as Influenced by Two Different Production Systems

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Abstract

This study was conducted to determine the effects of two production systems (organic vs conventional cages) on egg quality parameters during the late laying period. The effects of a production system were investigated on external and internal quality and on the sensory attributes. The eggs produced in organic system had paler yolks ($P<0.001$) and thinner egg shells ($P<0.05$) than the eggs produced in the cages. Overall sensory quality was improved in eggs deriving from hens allocated in cages. Differences between organic and cage eggs indicated lower redness and higher yellowness ($P<0.001$) in organic eggs than in cage eggs. The organic eggs were characterised by a higher content of α-linolenic and docosapentaenoic acid ($P<0.05$) and lower content of linoleic acid ($P<0.05$) than the eggs from cages. The ratio of omega fatty acids, n-6/n-3, was most favourable in the organic eggs (5.93:1). In the cage eggs, the ratio n-6/n-3 was significantly ($P<005$) higher (955:1).

Key words: laying hens, table eggs, quality, cages, organic.

Introduction

The quality of eggs is influenced by characteristics that are appropriate from the point of view of consumers. Consumers look forward to freshness, smell, shell colour and yolk colour. The quality of eggs is determined by microbiological, hygienic, sensory and technological qualities as well. Nowadays, the nutritional quality and healthiness of table eggs are particularly in favour with consumers. Moreover, they are interested in production systems and welfare of laying hens. In the EU member countries, the breeding in conventional cages has been forbidden since 2012. The so-called enriched cages and less intensive production systems like barn, free range and organic are allowed. The prohibition of conventional cages would contribute to hen welfare and health, which will further on contribute to better quality of products.

Therefore, we studied the impacts of two production systems (organic and conventional) on some physical and sensory characteristics of eggs as well as fatty acid composition.

Materials and methods

Pullets from Slovenian Prelux-G strain were housed in a barn system with litter till age 18 weeks when 113 pullets were moved to conventional cages and 50 pullets to free range on an organic farm. In each cage a hen had 1287 cm^2 of floor space. Hens in conventional cages were fed with complete feeding mixture for laying hens while in the organic system two thirds of a diet represented feeding mixtures from maize, triticale, wheat, rye, oats and oilseed and one third of a diet was commercial organic feed for laying hens. Eggs were sampled three times: at the end of July, at the beginning of September and at the end of September. At first sampling, the hens were 69 weeks old, at the second one 75 weeks and at the third one 78 weeks, whilst eggs were divided into three subsamples. The physical characteristics were measured on eggs from the first subsample; sensory attributes were measured on eggs from the second subsample and fatty acid composition of yolk from the third one (Table 1).

Tab. 1. Number of analysed eggs per sampling and per group of studied characteristics
Broj analiziranih jaja po uzorkovanju, ispitivanoj grupi i analiziranim osobinama

Production system	Sampling	Physical characteristics	Sensory attributes + pH of egg white and yolk + yolk colour	Fatty acid profile of egg yolk
Conventional cages	1	15	21 (three replications)	3
	2	15	7	3
	3	15	7	/
Organic	1	15	21 (three replications)	3
	2	15	7	3
	3	15	7	/

Physical characteristics were measured on one-day old eggs, whilst sensory attributes of fresh and hard boiled eggs on four-day old eggs. The fatty acid content was determined only in eggs from subsample of first and second samplings. Each sample was analysed in duplicate. Physical characteristics of eggs were measured by calliper (width and height), mechanical micrometer (shell thickness) and electronic apparatus (Technical Services and Supplies, York, England) that include reflectometer, scales, tripod micrometer and colorimeter. The incidence of blood and meat spots was noticed and the share of eggs with meat and blood spots was calculated but this characteristic was not included into statistical analysis. Sensory attributes were determined by a team of four trained panellists. The samples were coded. The quantitative descriptive analysis was used to evaluate sensory attributes in the same order as they were perceived.

We used a non-structural numerical scale. In the 1 – 7 scale, 1 point means that the trait is not expressed or that it is unacceptable, while 7 points mean that the trait is strongly or excellently expressed. pH value was measured by combined glass electrode type 8431 connected to pH meter (ISKRA Ma 57219). Instrumental analysis of yolk colour of hard boiled egg was performed by using the chromameter Minolta CR 200b with computer DATA DP 100. Fatty acid content of yolk was determined by gas chromatography according to Park and Goins (1994). The effect of production system on studied characteristics was statistically evaluated by SAS/STAT (SAS User's Guide, 2000) programme package.

Results and discussion

The studied physical characteristics of eggs from two production systems showed statistically significant differences only in yolk colour and shell thickness (Table 2).

Tab. 2. Differences in physical characteristics between conventional and organic eggs
Razlike u fizikalnim osobinama jaja iz konvencionalnog i organskog sistema držanja

Characteristic	LSM ± SE		Difference ± SE	p – value
	Conventional	Organic		
Shape index	73,94 ± 0,46	73,00 ± 0,46	0,94± 0,65	0,1535
Shell colour (%)	37,73 ± 0,87	37,64 ± 0,87	0,09 ± 1,23	0,9426
Egg weight (g)	64,08 ± 0,64	64,46 ± ,64	-0,38 ± 0,90	0,6719
Albumen height (mm)	6,65 ± 0,17	6,25 ± 0,17	0,39 ± 0,25	0,1138
Haugh units	78,89 ± 1,37	76,18 ± 1,37	2,71 ± 1,94	0,1662
Yolk colour (Roche)	13,11 ± 0,12	11,13 ± 0,12	1,98 ± 0,17	<0,0001***
Shell thickness (mm)	0,35 ± 0,00	0,33 ± 0,00	0,01 ± 0,00	0,0262*

LSM= least squares mean; SE=standard error

Yolk colour of conventional eggs was significantly more intensive, by two units according to Roche colour fan, which is due to the fact that hens were fed with complete feeding mixture that contains natural and synthetic pigments in quantities and proportions that result in desired yolk colour which is not the case in organic production. Hidalgo et al. (2007), Minelli et al. (2007) and Kucukyilmaz et al. (2012) reported on higher yolk yellowness from conventional eggs in comparison to yolks from organic eggs. Conventional eggs had thicker shell. The effect of production system on shell thickness cannot be easily explained. Rizzi et al. (2006) and Mugnai et al. (2009) found thicker shells in organic eggs in comparison to conventional eggs, but on the other hand Hidalgo et al. (2007) reported on diverse results.

In conventional eggs, the incidence of meat and blood spots (46,7 %) was higher than in organic eggs (40,0 %). Some meat and blood spots were big but also

smaller spots were also found. In literature data, external characteristics of eggs produced in different production systems differ considerably, which might be due to differently formed experiments, not to mention environmental effects in diverse production systems that affect some of the egg traits.

Fifteen studied sensory attributes determined in fresh and hard boiled eggs from two production systems demonstrated statistically significant differences in nine attributes (Table 3).

Tab. 3. Sensory differences between conventional and organic eggs (Wilcox's test)
Razlike u senzornim osobinama jaja iz konvencionalnog i organskog sistema držanja (Wilcox-ov test)

Sensory trait (points)	p-value	Conventional system		Organic system	
		$\bar{X}$	sd	$\bar{X}$	sd
FRESH egg					
Appearance (1 – 7)	0,9133	6,58	0,42	6,60	0,36
Smell (1 – 7)	0,0193*	7,00	0,00	6,84	0,29
Other smells (1 – 7)	1,0000	1,00	0,00	1,00	0,00
Yolk shape (1 – 7)	0,2063	6,50	0,47	6,24	0,63
Yolk consistency (1 – 7)	0,0248*	6,58	0,42	6,18	0,53
Albumen consistency (1 – 7)	0,5801	5,95	0,40	5,66	1,46
HARD BOILED egg					
Smell (1 – 7)	0,0090**	6,29	0,45	5,89	0,36
Other smells (1 – 7)	0,0726	1,03	0,11	1,21	0,38
Colour steadiness in yolk (1–7)	0,0080**	5,97	0,56	5,42	0,58
Texture (1 – 7)	0,0034**	6,34	0,33	5,95	0,44
Taste (1 – 7)	0,0019**	6,45	0,37	6,05	0,33
Extra tastes (1 – 7)	0,2974	1,03	0,11	1,10	0,27
After taste (1 – 7)	0,0254*	1,24	0,54	1,50	0,44
Total impression (1 – 7)	0,0051**	6,26	0,30	5,92	0,38
Yolk colour (1-15)	<0,0001***	14,42	0,51	9,31	1,70

$\bar{X}$ =mean, sd = standard deviation

Conventional eggs differed significantly from organic eggs regarding smell of fresh egg, yolk consistency in fresh egg, smell of hard boiled egg, yolk colour steadiness in hard boiled egg, texture, taste and after taste in hard boiled egg, total impression and yolk colour of hard boiled egg. All the above attributes were better in conventional eggs. Yolk colour in hard boiled conventional eggs (Table 3) was for 1,3 units darker, and in organic eggs for 1,8 units lighter in comparison to fresh eggs (Table 2).

The yolk colour in fresh eggs was measured by colorimeter while in hard boiled eggs Roche colour fan was used. Albumen pH value and yolk pH value were measured in four-day old eggs hence the expected average pH values were higher than pH values in fresh eggs (immediately after laying). The pH value of albumen in

conventional eggs was 9,0±0,34 and in organic eggs 9,25±0,20 while the corresponding pH value of yolk was 6,14±0,09 and 6,37±0,32. Yolks of hard boiled eggs from different production systems statistically significantly differ in colour shade, which is shown by values a* and b* (Table 4).

Tab. 4. Differences in yolk colour of conventional and organic eggs (measured by Minolta)
Razlike u boji žumanca između jaja iz konvencionalnog i organskog sistema držanja (mereno sa Minoltom)

MINOLTA (CIE system)	LSM ± SE		Difference ± SE	p - value
	Conventional	Organic		
L* (lightness)	61,78 ± 1,04	59,36 ± 1,04	2,42 ± 1,47	0,1090
a* (redness)	10,03 ± 0,64	2,83 ± 0,64	7,19 ± 0,91	<0,0001***
b* (yellowness)	57,40 ± 1,73	67,00 ± 1,73	-9,59 ± 2,45	0,0004***

Yolk colour in conventional eggs was significantly more red and significantly less yellow in comparison to yolks from organic eggs. Similar results for intensiveness of red and yellow yolk colour from conventional and organic eggs were also reported by Minelli et al. (2007).

Organic eggs were characterised by a higher content of essential linolenic acid (18:3, n-3), and docosapentaenoic acid (22:5, n-3) and n-3 fatty acids and more favourable ratio of n-6 to n-3 fatty acids than conventional eggs. Conventional eggs contained more linoleic acid (18:2, n-6) which is an essential acid (Table 5). Different contents of fatty acids in eggs showed different contents of those acids in feeds that hens were fed on. Lopez-Bote et al. (1998) reported that organic eggs contained more n-3 (2.6 times) and less n-6 fatty acids in comparison to conventional eggs. It is well known that fresh fodder (grass, legumes) is rich in n-3 and poor in n-6 fatty acids. The total content of saturated fatty acids (SFA), mono unsaturated fatty acids (MUFA) and poly unsaturated fatty acids (PUFA) did not differ in eggs from both production systems. Similar results were found by Matt et al. (2009) who did not find significant differences in contents of SFA, MUFA and PUFA in eggs produced in conventional and organic production systems.

Conclusion

Eggs produced by Prelux –G hens of the same age in conventional and organic production systems differed significantly in external traits, namely intensity of yolk colour and thickness of shell. Yolks from conventional eggs were more yellow ($p \leq 0.0001$) and had thicker shell ($p=0.0262$) than organic eggs.

Fresh eggs from conventional cages achieved better marks than organic eggs in smell and yolk consistency while hard boiled eggs in smell, steadiness of yolk colour, texture, taste, total impression and yolk colour.

The redness in yolks of hard boiled conventional eggs was significantly higher while yellowness was significantly lower than in organic eggs.

Eggs produced by Prelux-G hens in organic production system had more favourable fatty acid composition than conventional eggs because they contained significantly more linolenic acid (18:3, n-3), docosapentaenoic acid (22:5, n-3) and total n-3 fatty acids. The ratio of n-6 to n-3 (5,93) fatty acids was more favourable in organic eggs than in conventional ones (9,55). Conventional eggs contained more linoleic acid (18:2, n-6).

Tab. 5. Different fatty acid contents in conventional and organic eggs
Razlike u sadržaju masnih kiselina u jajima iz konvencionalnog i organskog sistema držanja

Fatty acid*	p-value	Conventional		Organic	
		$\bar{X}$	sd	$\bar{X}$	sd
16:00	0,0671	26,13	0,09	25,35	0,50
16:1, n-7	1,0000	3,00	1,10	3,22	0,23
18:00	1,0000	9,52	2,40	9,04	1,02
18:1, n-9c; 18:1, n-9t; 18:1, n-12t; 18:1, n-7c	0,3123	38,05	3,63	39,80	2,31
18:2, n-6c	0,0304*	15,67	0,11	15,06	0,11
18:3, n-3	0,0304*	0,35	0,09	0,97	0,09
20:4, n-6	0,1124	3,49	1,53	2,20	0,64
20:5, n-3 (EPA)	0,4356	0,01	0,00	0,02	0,01
22:5, n-3	0,0304*	0,18	0,06	0,33	0,06
22:6, n-3 (DHA)	0,6650	1,58	0,72	1,63	0,46
SFA	1,0000	36,35	2,41	35,33	1,37
MUFA	1,0000	41,47	4,87	43,61	2,55
PUFA	1,0000	22,34	2,42	21,19	1,18
n-3 FA	0,0304*	2,20	0,66	3,06	0,44
n-6 FA	0,1124	20,03	1,81	18,01	0,74
EPA + DHA	0,6650	1,60	0,72	1,66	0,48
PUFA/SFA	1,0000	0,61	0,03	0,60	0,01
n-6/n-3	0,0304*	9,55	2,03	5,93	0,54

X =mean, sd = standard deviation; * % w/w of total fatty acids

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Spoljašnje, unutrašnje i senzorske osobine kvaliteta konzumnih jaja iz dva različita sistema držanja

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Sažetak

U ovom radu su izneti rezultati uticaja dva sistema držanja kokoši nosilja (organski uzgoj vs uzgoj u baterijskim kavezima) na parametre kvaliteta jaja u završnoj fazi nošenja. Ispitan je uticaj sistema držanja na spoljašnje i unutrašnje osobina kvaliteta jaja kao i na intenzitet senzornih svojstava. Jaja iz organskog sistema su imala svetliju boju žumanca ($P<0,001$) i tanju ljusku ($P<0,05$) u odnosu na konvencionalne kaveze. Što se tiče senzorskih svojstava najbolji rezultati ostvareni su kod nosilja, koje su držane u kavezima. Držanje nosilja u organskoj proizvodnji izazvalo je porast udela žute boje (b*) i istovremeno smanjenje udela crvene boje (a*) ($P<0,001$) u odnosu na kaveze. U poređenju sa jajima iz kaveza, veći sadržaj α-linolenske i dokozapentaenske kiseline i manji sadržaj linolne kiseline ($P<0,05$) zabeležen je u jajima iz organskog sistema. Najpovoljniji odnos omega-6:omega-3 kiselina utvrđen je u organskim jajima (5,93:1). U jajima iz kaveza odnos n-6/n-3 bio je statistički signifikantno ($P<0,05$) veći (9,55:1).

Ključne reči: kokoši nosilje, konzumna jaja, kvalitet, kavezi, organska proizvodnja.

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