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Content of some mineral elements in eggs from farms and free range

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ABSTRACT

The aim of our work was to investigate the relationship between different laying hens housing systems and content of some minerals in their eggs. Samples of eggs were collected from four commercial farms with intensive rearing systems (cage and deep litter eggs) and from four family farms with extensive rearing system (village hens – free range eggs). From each farm two samples, each consisted of three eggs, were randomly taken on a bi-weekly basis. Composited samples from three whites and three yolks respectively were formed in order to determine the minerals content. Exception was one family farm where ten eggs represented a sample. So 24 samples were collected from commercial farms and 24 from family farms. For the potassium, sodium, magnesium, calcium and zinc, the analysis was performed with atomic absorption spectrometry after dry ashing at 520°C and dissolving in HCl acid. Phosphorus was analysed by spectrophotometer. The accuracy of the methods was validated by analysing the standard reference materials (SRM) of whole egg powder SRM 8415. Different housing systems had statistically significant effect ($P<0.05$) on potassium and magnesium levels in whites and yolks. Significant differences ($P<0.05$) between intensive and extensive rearing systems were also observed for sodium content in whites and for phosporus and zinc content in yolks. Levels of calcium did not statistically differ between the groups and were generally consistent. Concentrations of Zn in whites as well as in yolks were low and did not exceed of the maximum permitted concentration.
(Keywords: eggs, mineral elements, free range, battery cages, deep litter)

INTRODUCTION

Many modern consumers are interested in the provenance and nutritional value of their food. In the case of eggs there has been much interest in housing systems (*Charles,* 2002). During the traditional period in the history of egg production (up to 1950s), birds were generally kept on free range or in semi-intensive systems. The need for more efficient production methods saw the introduction of cage systems (*Duncan,* 2000) . The method worked well, but since the 1980s there has been increasing concern expressed by consumer and animal welfare groups about intensive systems. Although the cost of production is lowest in cage systems, in response to consumer demand, the past 20 years or so have seen a major revival of the free range method, as well as the development of the other non-cage systems (deep litter, perforated floor systems, aviaries, percheries etc.) (*Charles,* 2002). Since a significant number of consumers seek eggs from alternative systems there is a need to put together the egg quality and the quality of life of the hens (*Verga,* 1999). Determination of the ash and mineral content of eggs is important for a number of reasons including nutritional labeling, quality, microbiological stability, nutrition and processing. In spite of the great amount of literature actually at disposal on this issue, little is known about the minerals content in eggs, deriving from different housing systems.

In Slovenia free range poultry has been run with other farm enterprises historically and most households used to keep a few hens for egg production in free range conditions. Within this context the main objective of our research was to examine the differences/similarities in minerals content between the free range eggs and eggs coming from commercial farms.

MATERIALS AND METHODS

In the experiment there were two trials:

Trial 1

Battery cage/deep litter - hens housed on two farms in conventional battery cages and on two farms in deep litter system. The hens in this trial were fed only with complete feed mixtures for laying hens. Experimental design for trial 1 is shown in *Table 1*.

Table 1

Basic informations about the origin of the eggs from battery/deep litter system

Sampling site (commercial farm)	Housing system	Sampling period	Number of samples	Number of eggs per sample	Age of hens (weeks)	Provenance of hens
A	Battery cages	I.	2	3	45	Hisex
		II.	2	3	47	
		III.	2	3	49	
B	Battery cages	I.	2	3	60	ISA
		II.	2	3	62	
		III.	2	3	64	
C	Deep litter	I.	2	3	45	Hisex
		II.	2	3	47	
		III.	2	3	49	
D	Deep litter	I.	2	3	50	Hisex
		II.	2	3	52	
		III.	2	3	54	

Trial 2

Village hens in four family farms of a free range system. Free range eggs were produced by village hens with daily access to the outdoors. The village hens were free to run around, but in event of bad weather they were kept inside. They were fed with feed produced in surrounding countryside (barley, wheat, maize, beet, potato) and pasture was also available. Experimental design for trial 2 is shown in *Table 2*.

Table 2

Basic informations about the origin of the eggs from village hens

Sampling site (family farm)	Sampling period	Number of samples	Number of eggs per sample	Age of hens	Provenance (breed) of hens	Composition of daily ration
E	I.	2	3	1-3 years	Brown commercials	barley, wheat, maize, pasture
	II.	2	3			
	III.	2	3			
F	I.	2	3	1, 2, 3 years	Styrian hen, Hisex, ISA-Brown	wheat, maize, pasture
	II.	2	3			
	III.	2	3			
G	I.	2	3	2 years	Hisex	barley, maize, beet, complete mixture for laying hens, pasture
	II.	2	3			
	III.	2	3			
H	I.[1]	3	10	1,5 year	Prelux-R	wheat, potatoes in their skins, pasture
	II.[1]	3	10			

[1]*Sample composed of ten eggs from one hen*

Sample preparation
As with all food analysis procedures it is crucial to carefully handle a sample to ensure that its composition does not change significantly prior to analysis. In our case the eggs were first wiped with dry paper towels and weighed. After the egg breaking on the flat surface, the whites and yolks were manually separated. Thereupon two composite samples of whites and yolks respectively were placed into upright freezer for 24 hours and then lyophilised for 24 hours at low pressure and at temperature of -30°C.

Dry ashing (AOAC, 1998)
Prior to analysis the minerals in egg samples the dry ashing method was used.

Determination of Ca, Na, K, Mg and Zn content (AOAC, 1998)
Levels of Ca, Na, K, Mg and Zn in egg whites and yolks were determined by atomic absorption spectrometry using Opton and Perkin-Elmer 1100 B atomic absorption spectrometers. A calibration curve was prepared with standards of known concentration using the same reagents as used to prepare the sample. Samples were analyzed in duplicate.

Determination of P content (AOAC, 1998)
The phosphorus content of a sample was determined by adding a vandate-molybdate reagent to the sample. This formed a colored complex (yellow-orange) with the prosphorus which was quantified by measuring the absorbance of the solution at 420 nm, and comparing with a calibration curve. To take into account any impurities in the reagents that might interfere with the analysis we also run a blank sample. The accuracy and reliability of analysing procedure was assessed by analysis of reference sample of Standard Reference Materials (SRM) Whole Egg Powder 8415 (SRM catalog 1998). The results of these SRMs in this study were satisfactory and in close agreement with the certified values.

RESULTS AND DISCUSSION

Tables 3 and *4* give the concentrations of the six elements in egg whites and yolks collected from four commercial and four family farms.

Table 3

Mean values and standard deviations for concentrations of K, Na, Mg, P, Ca and Zn in whites and yolks of eggs from four commercial farms (all mg/100 g of sample)

Ele-ments	White (W) / Yolk (Y)	Commercial farms				Mean value ± Standard deviation
		A (battery cages)	B (battery cages)	C (deep litter)	D (deep litter)	
K	W	146.7±6.3	142.8±25.2	148.2±4.8	157.4±9.2	161.4±14.1
	Y	118.2±6.3	120.0±10.7	120.0±4.9	111.3±5.1	117.4±7.6
Na	W	173.6±10.4	166.4±31.0	184.3±5.8	179.2±15.2	175.9±18.4
	Y	55.7±3.4	60.4±3.8	60.5±4.4	52.5±2.8	57.3±4.9
Mg	W	12.6±1.0	12.1±1.8	11.6±1.3	12.4±1.0	12.2±1.3
	Y	12.3±0.8	13.5±1.8	13.5±1.0	13.7±1.4	13.2±1.2
P	W	11.5±1.0	16.4±5.0	12.7±1.2	15.4±2.3	14.0±3.4
	Y	542.9±52.7	517.2±35.8	528.4±24.3	491.0±18.8	519.9±38.3
Ca	W	7.5±0.9	11.7±3.6	9.2±5.9	9.2±2.0	9.2±3.6
	Y	140.9±6.2	149.5±15.4	140.8±8.1	148.0±5.9	144.8±9.9
Zn	W	0.04±0.01	0.04±0.01	0.04±0.01	0.05±0.02	0.04±0.01
	Y	4.1±0.2	4.0±0.5	4.1±0.2	3.8±0.1	4.0±0.3

Table 4

Mean values and standard deviations for concentrations of K, Na, Mg, P, Ca and Zn in whites and yolks of eggs obtained from four family farms (all mg/100 g of sample)

Ele-ments	White (W) / Yolk (Y)	Family farms (village hens)				Mean value ± Standard deviation
		E[2]	F	G	H	
K	W	128.0±9.2	122.0±13.8	120.0±16.4	165.2±26.6	133.8±24.9
	Y	121.7±22.1	101.3±12.6	111.2±14.8	102.7±7.2	109.2±16.4
Na	W	183.2±10.9	186.8±12.1	187.0±17.2	207.3±30.4	191.1±20.4
	Y	51.7±4.8	54.7±7.6	54.0±5.5	63.5±2.9	56.0±6.9
Mg	W	14.3±2.4	12.2±0.8	13.2±1.2	15.7±4.8	13.8±2.9
	Y	15.3±1.5	13.5±1.4	14.5±1.0	15.0±2.3	14.6±1.7
P	W	13.3±1.2	12.3±1.9	12.2±3.5	22.8±7.8	15.2±6.1
	Y	501.5±48.5	491.0±71.6	483.5±31.4	427.0±23.6	477.8±53.1
Ca	W	9.7±2.5	8.0±1.7	6.3±1.4	7.2±1.9	7.8±2.2
	Y	126.0±5.0	117.7±13.3	115.2±6.8	195.0±55.1	138.5±42.9
Zn*	W*	0.04±0.01*	0.03±0.01	0.05±0.08	0.11±0.02*	0.06±0.03
	Y	3.6±0.3	4.0±0.6	3.5±0.2	3.5±0.3	3.6±0.04

**Due to large deviation one sample was not taking into account; [2]Sample composed of ten eggs from one hen*

Tables 5 and *6* show the average content of K, Na, Mg, P, Ca and Zn in egg whites and yolks sampled from both type of farms. For the differences in mean values we performed statistical analysis using t-test.

Table 5

Average content of K, Na, Mg, P, Ca and Zn in whites as related with the rearing system (in mg/100 g of sample)

Elements	Egg whites			
	Commercial farms		Family farms (village hens)	
	Number of samples	$x^1 \pm SD^2$	Number of samples	x±SD
K	24	161.4 ± 14.1^a	24	133.8 ± 24.9^b
Na	24	175.9 ± 18.4^a	24	191.1 ± 20.4^b
Mg	24	12.2 ± 1.3^a	24	13.8 ± 2.9^b
P	24	14.0±3.4	24	15.2±6.1
Ca	24	9.2±3.6	24	7.8±2.2
Zn	24	0.04±0.01	**22**	0.06±0.03

[1]Mean value; [2]Standard deviation; [a,b]Statistically significant (P<0.05)

Table 6

Average content of K, Na, Mg, P, Ca and Zn in yolks as related with the rearing system (in mg/100 g of sample)

Elements	Egg yolks			
	Commercial farms		Family farms (village hens)	
	Number of samples	$x^1 \pm SD^2$	Number of samples	x±SD
K	24	117.4 ± 7.61^a	24	109.2 ± 16.4^b
Na	24	57.3±4.85	24	56.0±6.9
Mg	24	13.2 ± 1.22^a	24	14.6 ± 1.7^b
P	24	519.9 ± 38.28^a	24	477.8 ± 53.1^b
Ca	24	144.8±9.92	24	138.5±42.9
Zn	24	4.0 ± 0.29^a	24	3.6 ± 0.4^b

[1]Mean value; [2]Standard deviation; [a,b]Statistically significant (P<0.05)

On the basis of the data presented in *Tables 3,4,5* and *6* the following observations can be made:

Whites from family farm H contained the highest K levels among the whites sampled from the village hens, whereas on the commercial farms site, the whites from D farm had the highest K levels (*Tables 3* and *4*). Yolks from family farm E contained the highest levels of K among the yolks analyzed from both management systems (*Tables 3* and *4*). There were statistically significant differences (P<0.05) in potassium content between whites and yolks coming from commercial farms on one hand and whites and yolks coming from family farms on the other hand. The differences were in favour of eggs from commercial farms (*Tables 5* and *6*). *Dobrzanski et al*., 1999 have reported similar findings.

The mean Mg content of whites ranged from 11.6±1.3 mg per 100 g of fresh sample in whites from the C deep litter system to 15.7±4.8 mg per 100 g of fresh sample in free range whites from H family farm (*Tables 3* and *4*). The lowest value for Mg content in yolks was detected in yolks from A battery cage system (12.3±0.8 mg per 100 g of fresh sample) whereas the highest Mg content was noticed in yolks from E farm free range eggs.

As compared with whites and yolks from commercial farms, whites and yolks from family farms contained significantlly ($P<0.05$) higher amounts of magnesium (*Tables 5* and *6*). Results for magnesium are in close agreement to those reported by *Dobrzanski et al*. (1999).

Sodium content of whites significantly ($P<0.05$) differ among whites sampled from both types of farms (*Table 5*). Whites from family farms were better supplied with sodium than whites from commercial farms. This result is in the contrast with findings of *Dobrzanski et al*. (1999) who found greater amounts of sodium in free range eggs. The yolks taken from two different types of farms did not show any significant difference in sodium levels (*Table 6*).

Higher amounts of P and Zn were detected in yolks collected from commercial farms compared to those samples of family farms (*Table 6*). Regarding P and Zn levels in whites from both systems, t-test revealed no significant differences (*Table 5*).

Calcium levels of whites and yolks showed no relation to rearing system (*Table 5* and *6*).

Zinc, phosphorus and calcium are to be found primarily in yolks. On the contrary the sodium can be find mainly in whites. The same holds for potassium. Magnesium is loaded in approximately equal amounts in whites and yolks.

Notwithstanding the above findings, caution is required in interpreting the data, since it is well known that minerals content of the eggs is mainly related to the diet (*Naber*, 1979; *Verga*, 1999). Little effects have so far been found due to the housing system (*Verga*, 1999). Regarding obtained results for minerals content are our results consistent with results published elsewhere (*Dobrzanski et al*., 1999; *Cook* and *Briggs*, 1990; *Scherz* and *Senser*, 1994; *Holland et al*., 1992) although the latter five authors specified neither origin of eggs nor the system of rearing, number of analysed samples and methods of determination the elements.

CONCLUSIONS

In the past a couple of experiments have been conducted to estimate content of some elements in eggs coming from free range and commercial farms respectively. Different housing systems did have statistically significant influence on potassium and magnesium content in whites and yolks, on sodium content in whites and on phosphorus and zinc content in yolks. Free range eggs were normally very similar in terms of calcium content to those from birds kept in indoor systems.

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