The influence of halloysite supplementation in laying hens feeding on egg yolk lipid fraction

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Summary

The aim of the study was to observe the effect of the addition of halloysite to a laying hens fodder, on the content of some egg yolk components. Hens were divided into three experimental groups and fed with standard diet or with fodder enriched with halloysite (with 2% HAV or 2% HSD addition).

The results showed the ratio of n6/n3 polyunsaturated fatty acids was more beneficial in eggs from hens feeding with diet enriched with HSD addition (17:1), but with HAV addition higher ratio was obtained (21:1). Moreover, halloysite supplementation caused a slightly increase of palmitic acid and palmitooleic acid content in relation to control group. Cholesterol content was strongly influenced by the level of HAV addition to the birds diet. Implementation of halloysite to layers fodder increased the quantity of cholesterol from 10.93 mg/1g yolk for control group up to 12.25 mg/1g yolk for experimental group fed with HAV addition. The feeding supplement had a positive effect on vitamin A content; a growth from 3.99 µg/1g yolk in control to 4.75 µg/1g yolk in experimental group was noticed.

Keywords: halloysite, egg yolk, fatty acids, cholesterol, vitamin A

Introduction

The use of natural and synthetic aluminosilicates in animal production is a subject of numerous interdisciplinary research. The substances are characterised by the ability to prevent the growth of fungi, including toxigenic fungi (Kolacz *et al*., 2004), decrease the bioaccumulation of heavy metals in animal organisms (Dobrzanski, 2004) and enrich the diet with trace elements (Yablonska, 2003). They may influence the processes of digesting and bonding of metabolites, which decreases the emission of toxic gases from bedding (Tymczyna, 1993).

Natural and synthetic aluminosilicates are a porous, negatively charged material. Their chemosorptive and ion-exchanging qualities depend on their structure, degree of the polarisation of particles and the diameter of the pores. Zeolites, kaolins, bentonites, saponite and halloysite are the best known aluminosilicates. Sorption properties of halloysite were presented in the work of Hoffmann *et al.* (2004) and the composition of halloysite was different in comparison to other aluminosilicates (Dobrzanski *et al.*, 2003).

Positive effect of some aluminosilicates used in animal feeding has been proved by different authors (Dobrzanski *et al*., 1994; Rudzik, 1998). Kulok *et al*. (2005) indicated high decontaminating efficiency of halloysite towards bacteria, fungi and aflatoxin B_1, which proves that aluminosilicates may be used to reduce the contamination of feed mixtures. The aim of the present research was to study the effect of using halloysite as a feed additive on the profile of fatty acids, cholesterol and vitamin A content in hen's egg yolk.

Materials and methods

The halloysite used in the study was obtained from „Dunino" deposit in Lower Silesia (Poland). The chemical characteristic of halloysite is: formula $Al_2Si_2O_5(OH)_4$, molecular weight 258.1 g, and the chemical composition:

Al – 20.90 % mass (39.50 % mass Al_2O_3);

Si - 21.76 % mass (46.55 % mass SiO_2);

H – 1.56 % mass (13.95 % mass H_2O_2) (Hoffmann *et al*., 2004).

Halloysite used in feed mixture for laying hens had two forms:

HAV – halloysite activated in a sulphuric acid, and HSD – raw fine-grained halloysite.

Research was conducted in 12 weeks time, on the group of 60 birds (20 birds in one group) in controlled conditions. Laying hens ISA Shaver were kept in a battery three-storey system (Specht). The fodder was delievered daily in an amount of 125 g per animal.

Hens were fed as follows:

control group I – conventional feed mixture (Dolpasz Extra N),

experimental group II - feed mixture with 2% HAV addition, and

experimental group III - feed mixture with 2% HSD addition.

The eggs were broken and separated into egg white and yolk. Lipids were extracted from egg yolks with standard procedure (Folch *et al*., 1957) using methylene chloride and methanol (2:1). After methylation (14% BF_3 in ethanol), the analysis of fatty acid profile was performed in a gas chromatograph with a spectroscopy mass detector (Agilent Technologies 6890N SC System, 5973 MS Detector). The separation of fatty acids was carried out in a column DB-225 MS. Cholesterol content was analysed using High Performance Liquid Chromatography (Agilent 1100 Series) in a column XDB-C18. The vitamin A (retinol) concentration was determined and performed in HPLC and the absorbance was monitored at 292 nm.

External (egg weight, shell strength) and internal egg quality (yolk weight, yolk colour, yolk pH, yolk diameter, yolk height) were also analysed.

The collected data of the experiment were subjected to statistical analysis as Duncan test ($p \leq 0.05$) using Statistica ver. 8.0.

Results and discussion

Scientific data verifies that zeolites' dietary use will contribute to the improvement of animals' health status, also implying a potential improvement in dairy products quality (Papaioannou, 2005).

In our investigation, the chemical analysis of egg constituents revealed an increase in dry matter and total lipids contents in eggs from hens fed with a mixture with halloysite addition (HAV and HSD), however it caused a reduction of egg total proteins content.

Feeding with HSD had positive influence on higher vitamin A concentration (4.75 µg/ 1g of egg yolk) in relation to control group (3.99 µg/ 1g of egg yolk). Analyses of cholesterol level showed the highest increase in a group with HAV addition of 12.25 mg/ 1g of egg yolk comparing to control eggs (Table 1), but there was any significant differences between groups.

Table 1. Vitamin A and cholesterol content in egg yolk

Group	Vitamin A	Cholesterol
	[µg/g yolk]	[mg/g yolk]
I - Control	3.99^{a}	10.93
II - HAV	4.10	12.25
III - HSD	4.75^{b}	10.47

a - b – $p \leq 0.05$

In estimation of nutritive value of egg lipids the special attention should be put on the fatty acids profile. In experiment the ratio of n-6/n-3 fatty acids also was determined. More efficient ratio of n-6/n-3 (17:1) was calculated for eggs collected from hens fed with fodder contained HSD. But from nutritive point of view, the satisfactory level of n-6/n-3 ratio is 4:1, which confirmed the study of Kazmierska *et al.* (2007). HAV addition caused the increase in n-6/n-3 ratio (21:1).

Higher sum of polyunsaturated fatty acids PUFA (n-6 + n-3) was analysed for egg yolk lipids when HAV was inserted to hens fodder and reached 14.28% (Table 2). Moreover, halloysite supplementation of HSD caused an increase of palmitic acid and palmitooleic acid content in relation to control group.

Table 2. The profile of fatty acids in egg yolk (%)

Fatty acid	Symbol	Group		
		I Control	II HAV	III HSD
Myristic	C14:0	0.287	0.281	0.289
Pentadecanoic	C15:0	0.053	0.048	0.045
Palmitic	C16:0	26.052	26.292	26.963
Palmitooleic	C16:1	2.867	3.130	3.484
Heptadecanoic	C17:0	0.165	0.166	0.158
Stearic	C18:0	8.921	8.867	8.839
Oleic	C18:1	47.194	46.748	47.117
Linoleic (n-6)	C18:2	12.052	12.032	10.545
Linolenic (n-3)	C18:3	0.250	0.198	0.212
Eicosenoic	C20:1	0.230	0.186	0.198
Eicosatrienoic (n-6)	C20:3	0.073	0.039	0.063
Arachidonic (n-6)	C20:4	1.379	1.563	1.584
Docosahexaenoic (n-3)	C22:6	0.477	0.450	0.503
n-6/n-3 ratio		18	21	17

It has been proved that diet containing zeolites improves average daily gain and/or feed conversion in broilers (Fethiere *et al.*, 1994). Zeolites also enhance the egg production of laying hens and have beneficial effects on egg weight and the interior egg characteristics (Tserveni-Gousi *et al.*, 1997; Olver, 1997). That confirms also a study by Yannakopoulos *et al.* (1998) which showed that dietary natural zeolite increased egg weight and albumen weight, while yolk weight was not significantly affected. The yolk:albumen ratio was less (more albumen) in eggs laid by hens on zeolite treatments. Conclusion was that by feeding natural zeolite it is possible to alter the yolk:albumen ratio. Our experiment also modified this ratio, but significantly more yolk concentration was assessed (Table 3). However the enhancement effect is related to the type of used aluminiumsilicate, its purity and physicochemical properties, as well as the supplementation level in the diet.

Table 3. Physicochemical parameters of hen's eggs

Parameter	Group		
	I Control	II HAV	III HSD
Egg weight [g]	60.01	61.30	62.41
Albumen weight [g]	36.62	36.86	37.20
Yolk weight [g]	15.39[a]	16.24[b]	16.83[b]
Yolk height [mm]	18.03[a]	19.17[b]	19.49[b]
Yolk diameter [mm]	38.81[a]	41.41[b]	41.51[b]
Yolk colour [Roche]	12.6	12.3	12.4
Yolk pH	6.01	6.00	6.02
Shell strength [N]	18.83	19.21	19.77
Shell weight [g]	7.99	8.20	8.37
Shell thickness [mm]	0.385	0.384	0.389

a - b – $p \leq 0.05$

Korniewicz *et al.* (2006b) found that the halloysite used as an additive in feed mixture for fatteners in the amount of 2% had an advantageous effect on the microbiological quality of the mixture during storage. Fatteners fed with diets containing this aluminosilicate, assimilated protein, fat, fiber and mineral components, such as calcium, magnesium, zinc and copper more effectively.

Kolacz *et al*. (2005) reported that in blood serum of fatteners fed with the mixture containing 2% halloysite, significant increase of concentration of total protein and decrease triglycerides and HDL content when compared with the control group was observed.

Halloysite dietary had positive effect on the fatty acids profile in muscles, liver and backfat of finishing pigs (Korniewicz *et al*. 2006a).

In conclusion, the supplementary feeding of halloysite increased significantly the concentration of yolk in egg. That implied a higher amount of polyunsaturated fatty acids, but generally the analysis did not reveal any differences regarding the profile of fatty acids. The n-6/n-3 ratio was negatively high. Enriched eggs were characterized by cholesterol content remained on the stable level and relevant amount of vitamin A.

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