JERUSALEM ARTICHOKE (*HELIANTHUS TUBEROSUS L.*) INFLUENCE ON LAYING HEN'S EGGS' QUALITY CHARACTERISTICS

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Summary. Twenty Lohmann brown laying hens were used to determinate how Jerusalem artichoke aditive in laying hens feed influence quality of laying hen's eggs'. Hens were randomly distributed into 2 treatment groups, with 10 hens per replicate. Treatment groups were fed basal diet (control) and basal diet plus 2 pct. Jerusalem artichoke. The feeding experiment was performed for 56 days, egg quality parameters were evaluated in 14 days intervals: egg weight, yolk weight, albumen height, Hough unit (HU), albumin pH, yolk pH, shell weight, shell thickness, shell breaking strenght, yolk color were measured. Visual evaluation of eggs during sensory analysis reveals some differences in albumen color homogeneity. Egg weight, yolk weight, were not significantly ($P > 0.05$) affected by the feed supplementation of Jarusalem artichoke. The experimental treatments had significant effects on egg shell quality traits. The shell breaking strenght were higher 6.86 ($p<0.05$) in compare with control group and eggs shell weight with coat were biger 6.39 pct. ($p<0.05$) than control group eggs shell weight in the end of experiment. The results of this study demonstrate that the addition of Jarusalem artichoke into a laying hen's diet can impruve same egg's shell quality parameters, albumen height and Haught unit.

Keywords: Jerusalem artichoke, laying hen's, egg's quality

Introduction. Evaluation of the external and internal quality of chicken eggs is important because its affect consumer acceptability and preference. The quality of the egg, sensory properties and chemical composition, strongly depends on feed's composition and quality (Zaheer, 2015).

Jerusalem artichoke are rich in inulin, fructooligosaccharides (FOS), and a small amount of polyphenols (Takeuchi et al., 2011;. Towviriyakul et al., 2012). Fructooligosaccharides which composed of short chains of fructose and considered as a prebiotic which stimulating the growth of bacteria in the lower gut and block the adhesion of pathogenic bacteria in the intestinal mucosa (Poeikhampha et al., 2013). Administration of FOS or inulin can increase the number of bifidobacteria, lactobacilli and certain butyrate-producing bacteria (Hold et al., 2003). Experimental studies have shown that fructans modulate the hormonal level of insulin and glucagon, thereby regulating carbohydrate and lipid metabolism by lowering the blood glucose levels; they are also effective in lowering the blood urea and uric acid levels, thereby maintaining the nitrogen balance (Kaur et al., 2002). Prebiotic additions, such as oligofructose, inulin, galacto-oligosaccharides, resistant starches, and lactulose, in particular, seem to have a positive influence on calcium metabolism (Cesari et al., 2014).

Several studies have demonstrated that dietary supplementation of prebiotics to laying hens results in improved production, increased egg shell thickness and egg shell density, and enhanced calcium retention (Li et al., 2007; Abdelqader et al., 2013). Due to combined positive effects inulin and fructooligosaccharides in laying hens diet can lead improwed egg quality characteristics, but the researches in this area are still very spare.

The aim of this research was to evaluate how Jerusalem artichoke aditive in laying hens feed influence quality of laying hen's eggs'.

Material and methods

Feeding experiment

The feeding experiment was performed in Institute of Animal Rearing Technologies, Lithuanian University of Health Sciences, Veterinary Academy. The research was carried out complying with "Law on welfare and protection of animals" (2012-10-03 No. XI–2271). The trial was performed in accordance with EU Directive 2010/63/EEC on the protection of animals used for scientific purposes and the EC recommendation 2007/526 EC on guidelines for Animal use and storage for xperiments and other purposes.

The feeding experiment was performed for 56 days with Lohmann Brown lines laying hens. Hens were randomly distributed into 2 treatment groups, with 10 hens per replicate. Treatment groups were fed basal diet (control) and basal diet plus 2 pct. Jerusalem artichoke (JA).

Table 1. **Analysed values of the diet used in the experiment with laying hens (%)**

Diet	Dry matter	Crude protein	Crude fibre	Crude ash	Starch	Crude fat	P/Phosphorus	Na/Sodium
Control	89.75	19.23	4.53	5.50	39.21	6.52	0.63	0.15
JA	90.10	19.80	4.41	5.82	38.93	6.51	0.63	0.15

Egg quality analysis

Egg quality parameters were evaluated in 14 days intervals: egg weight, yolk weight, albumen height, Hough unit (HU), albumin pH, yolk pH, shell weight, shell thickness, shell breaking strenght, yolk color were measured.

Egg weight, yolk weight, shell weight without and with coat were measured by an electronic scale "Scaltec SB C22" (Germany). pH of eggs albumen and yolk analysed by Inolab 730 equipment (Germany). Albumen high, Haugh unit, intensity of egg yolk color were established by multifunctional automatic egg characteristics analyzer "Robotmation Egg Multi-Tester EMT-5200"(Japan), eggshell breaking strenght – by "Robotmation co., LTD Egg Shell Force Gauge MODEL–II" device (Japan) and thickness of eggshell – by electronic micrometer MITUTOYO Digimatic Micrometer". The colour of egg yolk was determined instrumentally by Minolta Chroma-meter (CR-410, Konica Minolta, Osaka, Japan).

Sensory analysis

The samples of eggs for sensory analysis were boiled in water bath for 10 min. Then they were removed from heat, cooled by cold running water to temperature 35 ºC, shelled, cut in half, and served to a sensory panel, along with room temperature water, tea and unsalted crackers. Each assessor received sample of yolk and sample of albumen, separately. A sensory panel for the quantitative descriptive analysis consisted of 6 assessors experienced in evaluation of eggs sensory quality. The assessors were selected and trained according to the ISO 8586. A structured numerical scale was used for evaluation of the intensity of each attribute. The left side of scale corresponding to the lowest intensity of attribute was given value of 1, and the right side corresponding to the highest intensity was given value of 9. All sessions were conducted in a climate-controlled sensory analysis laboratory equipped with individual booths. The assessors were instructed to clean the palate with water or tea between evaluations of each sample. The samples were presented to the assessors monadically. A data collection system for automatic acquisition of the assessor scores and data analysis was used (FIZZ, Biosystems, France).

Intensity of egg yolk and albumen attributes, such as overall odor, non typical odor, hardness, taste of yolk or albumen, non-typical taste, yolk color intensity, granularity of yolk was determined. Non typical odor or taste was evaluated as any acceptable or not acceptible odor or taste not typical for hard boiled egg (Parpinello, 2006). On the basis of the profile, it was possible to compare products according to separate characteristics and their intensity and to establish relationships between sensory quality and separate characteristics.

Data analysis

SPSS software, version 15.0 (SPSS, Chicago, IL, USA) was used for statistical analysis. The one –way ANOVA was performed to determine the effect of the laying hens feed composition on the sensory quality of eggs. Differences were classified by Duncan multiple comparison test.

Results and discussions

Taste and health are important quality issues for both producers and consumers. Egg is an important source of nutrients for human and its composition can be modified to obtain a more functional food through the manipulation of laying hen diet (Parpinello et al., 2006). Changes in laying hen's diet composition had no effect on sensory properties of hard boiled eggs yolk (Table 2). Diet composition JA had no significant effect on hardness of albumen and overall odour. Visual evaluation of eggs during sensory analysis reveals some differencs in albumen color homogeneity, but yolk color intensity was not affected. Albumen samples from control group had more homogenous colour than samples from JA group ($P<0.05$). The texture of the heat coagulated egg albumen gel is important e.g. in industrial processing of whole shell eggs for producing hard-boiled peeled eggs. In the shell egg pH, protein content and composition and other factors important for gel texture. Mainly the ovalbumin, ovotransferrin, and lysozyme are responsible for gelation by heat denaturation (Hammershishij et al., 2000).

Table 2. **Diet effect on mean values of intensity of sensory properties of fresh eggs, after 56 days**

Parameter	Sample	
	Control	JA
Albumen		
Overall odour	7.67^{a}	7.83^{ab}
Non-typical odour	1.17	1,67
Color homogeneity	8.00^{b}	7.67^{a}
Hardness	5.00	6.33^{ab}
Overall taste	7.83	6.67
Nontypical taste	1.00	1.17
Acceptability	8.00	6.50
Yolk		
Overall odour	6.33	6.67
Non-typical odour	1.00	1.00
Color intensity	5.83	6.17
Hardness	5.17	4.67
Granularity	2.83	3.00
Overall taste	7.00	7.17
Nontypical taste	1.17	1.20
Aftertaste	4.17	4.67
Acceptability	8.17	7.83
$^{a, b}$ -Means within a row with different superscript differ ($P < 0.05$)		

Interior egg quality characteristics content are given in Table 3. Egg weight, yolk weight, were not significantly ($P > 0.05$) affected by the feed supplementation of JA. These results agree with the reports of Chen et al. (2005) reported that dietary oligofructose and inulin increased egg production and feed efficiency of layers without impairing egg quality. After 28 days trail period albumen height (mm) was higher 0.60 pct. ($P < 0.05$), Haught units was higher on 3.00 pct. ($P < 0.05$) in the treatment groups compared to the control, these results matches with Karpinska et al. (2001), Poeikhampha T. et al, (2013) which reported that supplementation of oligosaccharide improved the albumen height and Hugh unit.

Table 3. **Diet effect on laying hens' internal egg quality**

Parameter	Trail period	Group	
		Control	JA
Egg weight, g	after 14 days	65.74±3.03	64.70±5.42
	after 28 days	63.66±4.18	62.61±6.75
	after 42 days	65.02±4.93	63.66±4.10
	after 56 days	66.71±3.46	62.86±5.11
Yolk weight. g	after 14 days	13.72±1.36	16.16±1.52
	after 28 days	15.91±1.73	16.06±1.32
	after 42 days	15.97±1.28	15.73±1.07
	after 56 days	17.03±0.88	16.15±1.54
Albumen height (mm)	after 14 days	7.13±1.94	7.07±0.85
	after 28 days	6.67±1.11[a]	6.71±1.01[b]
	after 42 days	6.51±1.10	7.44±1.18
	after 56 days	5.71±1.25	6.12±1.43
Haught units	after 14 days	81.31±12.72	82.32±6.92
	after 28 days	79.86±7.77[a]	82.26±8.31[b]
	after 42 days	77.00±9.28	85.01±6.63
	after 56 days	71.71±10.26	75.64±11.00
Albumin pH	after 14 days	8.24±0.28	8.45±0.27
	after 28 days	8.48±0.25[a]	8.59±0.23[b]
	after 42 days	8.55±0.19	8.54±0.19
	after 56 days	8.61±0.31	8.74±0.14
Yolk pH	after 14 days	6.26±0.21	6.28±0.05
	after 28 days	6.23±0.14	6.33±0.21
	after 42 days	6.39±0.20	6.25±0.10
	after 56 days	5.94±0.10[a]	6.13±0.19[b]
Yolk color intensity	after 14 days	3.00±0.98[a]	3.23±1.34[b]
	after 28 days	3.67±0.50	4.14±0.38
	after 42 days	3.09±0.68	3.24±1.07
	after 56 days	4.00±0.00	3.44±0.53
L^*	after 14 days	74.82±1.90	76.14±1.03
	after 28 days	73.96±1.30	74.57±2.73
	after 42 days	62.18±1.28	64.45±1.78
	after 56 days	65.5±1.39	64.84±2.49
a^*	after 14 days	-7.08±1.39	-6.74±1.04
	after 28 days	-8.22±1.38[a]	-7.61±2.34[b]
	after 42 days	-7.14±1.99	-6.78±1.73
	after 56 days	-7.19±0.75	-7.39±1.06
b^*	after 14 days	50.30±6.33	52.58±2.71
	after 28 days	34.76±11.32	34.42±11.83
	after 42 days	38.97±8.75	41.28±11.12
	after 56 days	42.27±6.71	43.59±4.36

[a, b] -Means within a row with different superscript differ ($P < 0.05$)

The experimental treatments had significant effects on egg shell quality traits (Table 4) Shell breaking strenght were higher 6.86-11.70 pct. ($p<0.05$) in compare with control group after 42 and 56 days trail period and eggs shell weight with coat were biger 6.39-7. 55 pct. ($p<0.05$) than control group eggs shell weight (after 28 and 56 days of trail). These results matches with Świątkiewicz at al., (2010) which reported that a significant improvement in shell quality was obtained by the use of inulin, oligofructose, volatile fatty acids and medium-chain fatty acids.

Table 4. **Diet effect on laying hens'egg shell quality**

Parameter	Trail period	Group	
		Control	JA
Shell breaking strenght (kg/cm^2)	after 14 days	3.57±1.00	3.15±0.59
	after 28 days	3.09±0.60	3.63±0.71
	after 42 days	3.42±0.57[a]	3.53±0.77[b]
	after 56 days	3.50±0.92[a]	3.74±0.49[b]
Shell thickness (mm)	after 14 days	0.37±0.07	0.34±0.03
	after 28 days	0.36±0.04	0.38±0.03
	after 42 days	0.36±0.05	0.37±0.05
	after 56 days	0.36±0.04	0.36±0.03
Shell weight without coat (g)	after 14 days	5.68±0.67	5.49±0.64
	after 28 days	5.29±0.73	6.33±1.69
	after 42 days	5.76±0.78	5.39±0.83
	after 56 days	6.00±0.87	5.69±0.38
Shell weight with coat (g)	after 14 days	8.33±0.76	8.20±0.63
	after 28 days	7.95±0.90[a]	8.55±0.31[b]
	after 42 days	8.57±1.04	8.53±1.18
	after 56 days	8.62±0.78[a]	8.69±0.54[b]
[a, b] -Means within a row with different superscript differ ($P < 0.05$)			

Other reseaches estimated that eggshell thickness and eggshell breaking strength are higher in the inulin addition group (250 mg inulin kg/diet) than in the control group because of the increased absorption rate of nutrients of inulin and minerals such as calcium, a main component of egg's shells (Park, et al., 2012).

Conclusions

The results of this study demonstrate that the addition of Jarusalem artichoke into a laying hen's diet can impruve egg shell quality, albumen height and Haught unit. After 28 days trail period albumen height (mm) was higher on 0.60 pct. ($P < 0.05$), Haught units was higher on 3.00 pct. ($P < 0.05$) in the treatment groups compared to the control. The shell breaking strenght were higher 6.86 ($p<0.05$) in compare with control group and eggs shell weight with coat were biger 6.39 pct. ($p<0.05$) than control group eggs shell weight in the end of experiment.

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