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Effect of artichoke (*Cynara scolimus* L.) on the egg productivity and biochemical parameters in laying hens

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Abstract

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The objective of the research was to investigate the effects of artichoke (*Cynara scolumus* L.) on the egg productivity and some biochemical parameters in laying hens from ISA Brown and Lohman Brown breeds. Two experiments were carried out with different doses of artichoke in the diet (2.2 g/kg and 3 g/kg). The analysis of the egg productivity was done. The following some biochemical parameters were analyzed: total protein, albumin, urea, glucose, alkaline phosphatase (ALP), aspartat amino transferase (AST), alanin amino transferase (ALT) and elements as potassium, sodium and calcium. Artichoke supplementation to the laying hens' diet for a period about of 5 weeks had not significant effect on the final body weight and egg productivity during both experiments. However, the glucose level as well as ALP and AST contents significantly decreased ($P < 0.05$). Artichoke supplementation lead to an increase of potassium (K) and calcium (Ca) in the blood serum of laying hens ($P < 0.05$).

Keywords: laying hens; artichoke; *Cynara scolumus*; egg productivity; biochemical parameters

Introduction

A number of feed additives, including antibiotics and synthetic hormones, have been widely used in the poultry industry for several decades (Edens, 2003). Approximately 80% of domestic animals have been fed synthetic compounds for the purpose of either medication or growth promotion (Lee et al., 2001). Recently, the concerns about possible residual amounts of nutritional antibiotics and synthetic hormones in animal products (meat, milk, eggs) have caused great caution in their use in the animal industry (Rahimi et al., 2011). Herbs, spices and essential oils are an alternative of nutritional antibiotics in livestock farming (Wenk, 2003). These plants are very important for the improvement of the poultry industry, because they are feed alternatives with positive effects to improve animal performance, quality and shelf life of meat products (Nedeva et al., 2014) or antioxidant activities (Jimenez-Escrig et al., 2003).

Artichoke (*Cynara scolymus* L.) is widely used in culinary and pharmaceutical industries (Sekara et al., 2015). This plant and its extracts are rich in biologically active substances (BAS), flavonoids (cynarin, luteolin, apigenin), tannins, inulin, pectin ect. (Wang et al., 2003; Abbasi & Samadi, 2014) and are also of interest to the feed industry (Grigorova et al., 2017). The main polyphenolic compounds of *Cynara scolymus* (caffeic acid and its derivatives; flavonoids cynarin, apigenin and luteolin; tannins) have antioxidant properties. The above-mentioned polyphenolic compounds affect cholesterolemia in two different biochemical mechanisms: on the one hand, they modulate cholesterol absorption and,

on the other hand, delay the synthesis of endogenous cholesterol by inhibiting HMG-CoA reductase. In addition, these substances may also increase the production of bile acids and exhibit antioxidant activity in the liver and blood serum (Nazni et al., 2006). Artichoke active compounds decrease blood glucose (Gouveia & Castilho, 2012).

Over the past two decades, a number of studies have been conducted to determine the effect of *Cynara scolymus* and its extracts on growth, egg production and reproduction in poultry (broiler, hens, duck, Guinea fowl**,** Japanese quail)**.** The artichoke extract had a beneficial effect when was administered to birds challenged with mycotoxins in the diet (Stoev et al., 2004). Mariani (1998) reported that the use of artichoke extract during the first weeks of life may increase productive response of broilers.

Several research have shown that the artichoke extract had some beneficial effects such as improving the growth rate and skin color of broilers and the egg production of laying hens (Bonomi, 2001), protection the hepatotoxicity in broiler chickens (Nateghi et al., 2013), modulating the oxidative stability and meat quality of Japanese quail (Abbasi & Samadi, 2014) and enhancing the immune functions in broiler chickens (Tajodini et al., 2015). Although the enlarged use of artichoke, very little biological investigations have been done. Therefore the aim of the present study was to analyze the chemical composition and the antioxidant capacity of dried artichoke (*Cynara scolymus* L.) supplementation on the egg productivity and some biochemical parameters in laying hens.

Materials and Methods

Experimental design and animal management

Two experiments were carried out at the Experimental Poultry Breeding Center of Institute of Animal Science, Kostinbrod, Bulgaria. The first (I) one was conducted with ISA Brown laying hens at the initial age of 38 weeks (n = 40). The second experiment (II) was carried out with hens from Lohman Klassik Brown breed at the initial age of 42 weeks (n = 40). Both experiments had the control groups (n = 20). The poultry were randomly divided into control and experimental groups in separate boxes (20 birds in each). They were raised on a deep litter pen on a 16 h lighting schedule, temperature of 21–24°C and relative humidity 70-85%. Water was supplied via nipple drinkers. The first experiment lasted 48 days (16 preparatory and 32 experimental periods) and the second one – 50 days (10 preparatory and 40 experimental periods). In both experiments the poultry received 130 g/day compound feed for layers. Composition and nutritive value of the diets are presented in Table 1. Feed nutritive value was determined by the conventional Weende

Table 1. Composition and nutritive value of the compound feed for laying hens

Ingredients, g/kg^{-1}	I experiment		II experiment	
	Control 1	Group 1	Control 2	Group 2
Maize	50	50	–	–
Wheat	571.40	569.2	643.4	640.4
Sunflower meal	120	120	140	140
Soybean meal	130	130	90	90
Sunflower oil	25	25	20	20
Artichoke	-	2.2	–	3
Limestone	85	85	90	90
Monocalcium phosphate	6	6	4	4
Complex premix 6015*	12.5	12.5	12.5	12.5
Antioxidant	0.1	0.1	0.1	0.1
Nutritive value				
Metabolizable energy, Kcal/kg	2560	2560	2710.23	2710.23
Crude protein (%)	176.40	176.20	164.76	164.43
Crude fat (%)	40.80	40.36	33.19	32.98
Crude fiber (%)	50.80	50.95	45.81	46.18
Lysine (%)	8.90	8.90	7.94	7.90
Methionine (%)	4.80	4.80	4.39	4.40
Ca (%)	36.50	36.61	37.27	37.33
P (%)	5.60	5.51	4.93	4.89

*Complex premix 6015 contains: sodium bicarbonate, lysine, methionine, threonine, necessary vitamins and minerals for laying hens, choline chloride. It does not contain nutritive antibiotics, synthetic dyes and carotenoids or other stimulants.

analysis. The metabolizable energy was calculated according to WPSA (1989). The diet for experimental hens was supplemented with 2.2 g/kg (I experiment) and 3 g/kg (II experiments) of dried and milled artichoke.

The tested product, originated in Poland, is a dry mass of the above-ground part of the artichoke (*Cynara scolumus* L.). The following analysis of this product was made: crude protein, crude fat and crude fiber (by Weende analysis); the content of Ca (BSS 11 374-86, 1990) and P (BSS 4336-73, 1990); total polyphenols content by the Folin-Ciocalteu method described by Blainski et al. (2013) and total antioxidant activity by the DPPH method described by Petrova et al. (2016).

Performance parameters

The body weight of the hens was measured at the beginning and at the end of the experiments. On daily basis, the following parameters were controlled: laying capacity (eggs number/group), laying intensity (%/group) and mortality (number of dead hens). Also the feed intake and feed conversion were calculated for each group.

Hematological parameters

At the end of both experiments 15 birds from each group were chosen at random and blood samples were taken from the *Vena cutanea ulnaris* (3 ml/hen) by using syringe needle assemblies that had been flushed with heparin (15 µL of heparin per 3 mL of blood). Serum was separated by centrifugation at 3000 rpm for 10 minutes. Total protein, albumine, urea, glucose, alkaline phosphatase (ALP), aspartate amino transferase (AST), alanine amino transferase (ALT), potassium (K), sodium (Na) and calcium (Ca) were measured by commercial kits (BioSystems S.A., Costa Brava, Spain), using an Eppendorf D30 biochemical analyzer (San Diego C.A.).

Statistical analysis

The statistical analysis of the data was performed using SPSS 15.0 software. The statistical significance between groups was determined by one-way analysis of variance (ANOVA). The measure of statistical significance was a P value below 0.05 ($P < 0.05$). The results obtained are presented as means with their standard errors.

Results and Discussion

The chemical composition and antioxidative properties of the tested product are presented in Table 2. Similar data are reported by other authors (Ceccarelli et al., 2010; Tajodini et al., 2015). Despite that tested artichoke had a higher total content of polyphenols than described by Gouvei and Castilho (2012) (546.6 mg GAE/100 g against 233.6 mg GAE/100 g), its total antioxidant activity was lower (2928.7 µmol TE/100 g against 3770 µmol TE/100 g by Gouvei and Castilho (2012).

Table 2. Chemical composition and total antioxidant activity of dried artichoke

Chemical composition	
Dry matter, g/100g product	89.56
Crude protein, g/100g product	10.77
Crude fats, g/100g product	1.99
Crude fibers, g/100g product	14.58
Ca, g/100g product	1.01
P, g/100g product	0.18
Total polyphenols, mg GAE (gallic acid equivalent)/100g	546.6
Antioxidant activity, µmol TE (Trolox equivalents)/100g	2928.7

Regarding the determination of the phenolic compounds, Vamanu et al. (2011) demonstrated that the EtOH extract from the leaves of *Cynara scolymus* had the highest amount of these compounds. In opposite, Oliveira et al. (2014) proved that aqueous extract of *Cynara scolymus* is the most abundant of phenolic compounds. The difference in the antioxidant capacity of artichoke must be related to the wide variety of phenolic compounds present in the different subspecies of the plant (Gouvei & Castilho, 2012).

During the whole experimental periods of the both trials, the poultry from all the groups consumed the diets willingly. The hens were in good health, very lively, and with good looks and feathering. The physiological and productive parameters of the hens are shown in Table 4. No mortality was observed during the both trials. The addition of 2.2 g and 3 g/kg of the tested product to compound feed did not affect negatively the hens' body weight. The total number of eggs in the group had a tendency to be higher in the experimental groups, especially in the group receiving 3 g/kg of artichoke, however, the difference between groups in both experiments were not significant. Our results are in agreement with these reported by Abbasi and Samadi (2014), who did not find significant effect of artichoke leaf powder on growth performance in Japanese quails. Also the experimental hens with 3g/kg additive had the best feed conversion compared to the other groups: only 141.88 g of diet were spent for obtaining one egg (Table 3).

Figure 1 shows the dynamics of laying intensity in hens throughout the both experiments. At the beginning of the I experiment there were not differences between both groups, but at the end, the poultry from the experimental group in-

Table 3. Body weight, feed intake and mortality of the investigated hens (mean±SE)

Parameters	I experiment		II experiment	
	Control 1 (n = 20)	Group 1 (n = 20)	Control 2 (n = 20)	Group 2 (n = 20)
Initial body weight (g)	1796.5±37.72	1785±37.19	1846.5±27.65	1841±32.33
Final body weight (g)	1865±31.27	1879.4±29.83	1936±28.34	1917±33.91
Total eggs number/group	566	569	715	733
Feed intake during the whole experimental period, kg	83.200	83.200	104.00	104.00
Feed intake per one egg, g	146.99	146.22	145.45	141.88
Mortality of hens, number	0	0	0	0

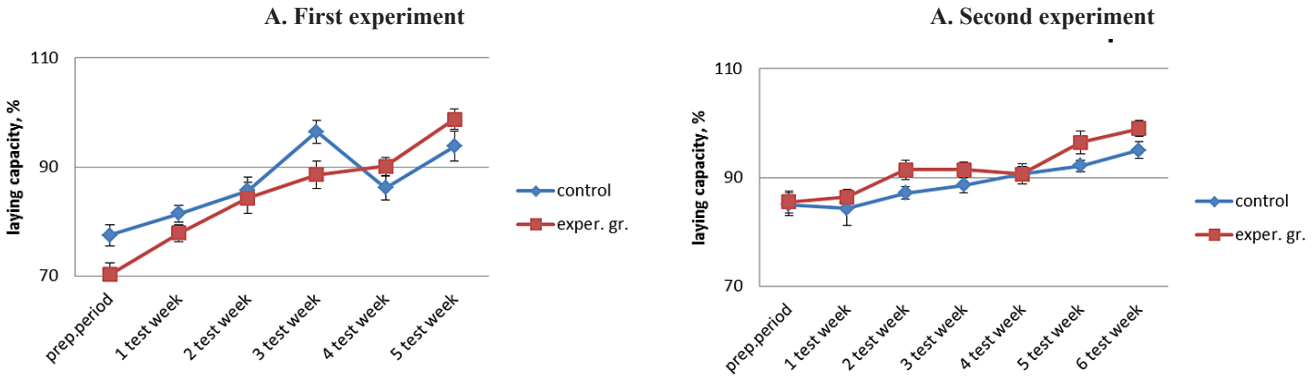

Fig. 1. Laying intensity of the hens from control and experimental groups

creased their egg production (Fig. 1, A). Similar results were observed during the II experiment (Fig. 1, B). The hens receiving 3g dried artichoke per kg compound feed increased significantly their egg intensity at the last two weeks of the trial. Radwan et al. (2007) also did not find significant differences in the egg production when adding 50, 75 and 100g/t artichoke extract, as well as 2%, 3%, 6% artichoke leaves meal to the diet of mandarah hens. However, Bonomi (2001) reported that the replacement of lucerne meal with meal from dehydrated artichoke leaves at a rate of 4% in the diet of laying hens improved the egg productivity.

Significant differences were found in some important blood biochemical parameters (Table 4). The hens, receiving 2.2 g or 3 g artichoke per kg compound feed had a significantly lower level of glucose, ALP and AST in blood serum ($P < 0.05$) compared to the control group (Table 4).

The hypoglycemic properties of artichoke can be explained by the action of fructans (inulin and oligofructose)

Table 4. Biochemical parametrs of laying hens from control and experimental groups

Parameters	I experiment		II experiment	
	Control 1 (n = 15)	Group 1 (n = 15)	Control 2 (n = 10)	Group 2 (n = 10)
Total protein, g/L	49.14±4.5	46.99±1.58	49.80±5.5	43.62±6.8
Albumin, g/L	24.32±1.28	22.95±2.42	18.7±2.3	18.3±2.0
Urea, mmol/L	1.45±0.54	1.79±0.50	1.21±0.63	0.94±0.15
Glucose, mmol/L	8.63±0.75	5.99±1.12*	10.05±1.57	8.84±0.98*
Alkaline phosphatase (ALP), U/L	336±81	192±52*	277±55	183±31*
Aspartate amino transferase (AST), U/L	347±57	180±61*	182±13	160±24*
Alanine amino transferase (ALT), U/L	12.17±3.82	13.60±4.90	11.9±8.82	10.9±4.45
Potassium (K), mmol/L	3.84±0.40	5.47±0.36*	4.02±0.21	6.27±0.46*
Calcium (Ca), mmol/L	1.49±0.28	2.75±0.38*	1.14±0.22	3.0±0.38*
Sodium (Na), mmol/L	150±1.06	142.20±2.67	148.78±85.05	145.66±74.41

*$P < 0.05$

contained in the plant. They modulate the level of hormone insulin and glucagon, thus regulating carbohydrate and lipid metabolism by lowering the blood glucose levels (Blumenthal et al., 2000; Nazni et al., 2006). Regarding ALP and AST, it is widely known that layers show a changeable activity as result of the continued metabolic load of the poultry (Gyenis et al., 2006). Additionally, the observed by us decreasing level of the liver enzymes may reflect the decreased level of glucose. The scientific data showed that elevated concentrations of liver enzymes have been associated with higher glycaemia (Noordam et al., 2017).

From the viewpoint of egg production, calcium, potassium and phosphorus are of major importance in the laying hens' nutrition. Artichoke is rich in K, Ca and Na (Ben Salem et al., 2017). The serum calcium and potassium concentration were relatively balanced in both control groups. Including of the artichoke to the layers' diet, lead to significant increase of Ca and K ($P < 0.05$), corresponding with intensification of the egg production in treated hens. Sodium (Na) concentration in the blood serum showed a decreasing tendency in the experimental groups compared to the controls ($P>0.05$).

Conclusions

The present study established that the tested artichoke contained: crude protein – 10.77 g/100 g product; crude fats – 1.99 g/100 g product; crude fibers – 14.58 g/100 g product; Ca – 1.01 g/100 g product; P – 0.18 g/100 g products; total polyphenols – 546.6 mg GAE (gallic acid equivalent)/100 g product. Its total antioxidant activity was 2928.7 mmoL TE (Trolox equivalents)/100 g product. Supplementation of this artichoke to the laying hens diet in doses of 2.2 g/kg and 3g/kg compound feed during about of 5 weeks lead to a decrease of the glucose level as well as alkaline phosphatase and aspartate amino transferase ($P < 0.05$) and to an increase of potassium (K) and calcium (Ca) contents in the blood serum of laying hens ($P < 0.05$). Although the miss of a significant effect on the final body weight and total eggs number per group, the increase of the laying intensity during the two last weeks of the experimental period was observed ($P < 0.05$).

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