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Effect of Jerusalem Artichoke (*Helianthus tuberosus* L.) Supplementation on Production Performances, Egg Quality Characteristics and Intestinal Microflora of Laying Hens

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Abstract: Three-hundred and twenty-four days of 24 weeks hens were used to examine the Jerusalem artichoke (*Helianthus tuberosus* L.) supplementation as dietary prebiotic in feed on performances, egg quality characteristics and intestinal microflora of laying hens. The dietary treatments were divided into 4 groups and each group consisted of 6 replications with 18 hens. The study were divided into one control (without Jerusalem artichoke) and 2 treatment groups; (1) supplementing 50 ppm of dried Jerusalem artichoke in diet and (2) supplementing 100 ppm of dried Jerusalem artichoke in diet. At the end of feeding trial (8 weeks), supplementing Jerusalem artichoke in feed did not influence feed intake, final body weight, egg production, egg weight and egg mass ($p>0.05$), however 100 ppm of dried Jerusalem artichoke significantly increased albumen ratio, yolk:albumen ratio and albumen height of eggs ($p<0.05$). Furthermore, 100 ppm of Jerusalem artichoke significantly increased lactic acid bacteria population in the caecum of hens ($p<0.05$). On the other hand, yolk weight ratio, shell weight ratio and shell eggs thickness of eggs did not influence by Jerusalem artichoke. It can be concluded that Jerusalem artichoke useful as dietary prebiotic to accomplish egg quality characteristics and intestinal lactic acid bacteria population of laying hens.

Key words: Jerusalem artichoke, prebiotic, feed additive, feed, intestinal microflora, egg quality, hens

INTRODUCTION

In the modern or intensive of layer farming system, hens are usually susceptible to pathogenic microorganism and risk to diseases outbreak by various factors, these results decline the egg production and side effects on the egg quality. Using antibiotics clearly prevents the diseases in layer production system. However, the using antibiotic growth promoter is trendy withdraw in laying diet and has completely banned in some country (Phillips *et al*., 2004). Therefore, non-antibiotics growth promoters have intensively considered, especially, the natural growth promoter or phytogenic probiotic.

Prebiotics is non digestible oligosaccharide which stimulating the growth of bacteria in the lower gut (Poeikhampha and Bunchasak, 2011a; Gibson and Roberfroid, 1995) and block the adhesion of pathogenic bacteria such as *Streptococcus*, *Haemophilus* and *Escherichia coli* K99 (*E. coli*) in the intestinal mucosa (Mouricout *et al*., 1990). In addition, prebiotics induce the immune response through a direct effect on cell receptors or via change in the intestinal microorganisms (Buddington *et al*., 2002).

Jerusalem artichoke is a root vegetable from temperate zone. It can serve as fructooligosaccharides which composed of short chains of fructose molecules (Roberfroid, 1993) and considered as a prebiotic and possible substitutes for antibiotics growth promoter (Poeikhampha and Bunchasak, 2010). In addition, several investigators reported that Jerusalem artichoke improved performance, feed utilization and improved egg production in poultry (Yildiz *et al*., 2006; Kaya *et al*., 2003). In addition, it has been indicated that Jerusalem artichoke increase the number of bifidobacteria, lactobacilli and butyrate-producing bacteria (Hold *et al*., 2003) and at the same time reduces the population of intestinal phatogenic bacteria (Gibson and Roberfroid, 1995). Therefore, this research was carried out to determine the effect of Jerusalem artichoke (as a source of prebiotics) on performance, egg quality characteristics and intestinal microflora in laying hens.

MATERIALS AND METHODS

The study was conducted at Animal Research Farm, Department of Animal Science, Faculty of Agriculture, Kasetsart University, Thailand in January to March, 2012. The experimental animals were kept, maintained and treated in adherence to accepted standards for the humane treatment of animals.

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Animals and managements: Three-hundred and twenty-four of 24 weeks of age laying hens H and N "Brown Nick" were used in the study. During 8 week of feeding trial, three birds were grouped in 40.5×40 cm (equaling 1,620 cm^2 total floor space) in wire cage (each hen had approximately 540 cm of floor space) and raised in evaporative cooling houses and temperature was maintained 26±3°C. Hen subjected to a photoperiod of 16 h light/day from 05:00 to 21:00 daily. House was cleaned two days interval, while the feces of hens were removed every day.

Experimental design and diets: The Completely Randomized Design (CRD) was used as the experimental design. The study was divided into one control and two treatment groups and each group consisted of 6 replications with 18 hens. Three experimental diets were provided as follows; (1) basal diet (control), (2) basal diet+50 ppm of dried Jerusalem artichoke and (3) basal diet+100 ppm of dried Jerusalem artichoke. The basal diets were formulated to provide the same amount of nutrients and met the requirement as commercial recommendation without antimicrobial agent and were analyzed for Proximate Analysis according to the AOAC (2000) methods. Feed (mash form) and water were provided *ad libitum* throughout the trial. Body weight and feed intake were recorded two weeks interval.

Parameters

Performances: The initial body weight of each hens was recorded and at the end of feeding trial (8 weeks) the body weight, body weight gain and feed intake were recorded two weeks interval in order to calculation of body weight gain, average daily feed intake. The morbidity and mortality of hens were observed. Hen-day egg production was recorded daily whereas egg weights were determined 2 weeks interval (4 periods). Egg mass was calculated by multiplying egg weight by hen-day egg production. Feed Conversion Ratio (FCR) was calculated as gram feed consumption per day per hen divided by gram egg mass per day per hen. During 3 days of the end of each period, 36 eggs from each group were randomly taken in order to determine egg weight, egg component (percentage of egg yolk, egg albumen and eggshell) and albumen high as well as eggshell thickness.

Preparation of bacterial counts in the digestal content: At the end of the feeding trial, 6 hens per treatment were putdown. The samples of caecal digesta were kept in order to count the lactic acid bacterial population and. The samples for bacterial counts were immediately pooled and kept in a sealed plastic bag at 39°C.

Bacterial counts: Ten grams of sample was diluted with 90 mL of 1% peptone solution and homogenized by Stomacher (Stomacher Lab Blender 400, Seward Medical, West Sussex, United Kingdom); the peptone was kept in a sealed plastic bag which filled by CO_2. The bacterial population was determined by using serial 10-fold dilutions with 1% peptone solution onto the Sharpe (MRS) agar (DifcoTM; Becton and Dickinson, Argentina) for determinations of lactic acid bacteria and Mac Conkey Agar (Laboratorios Britania, Mendoza, Argentina) for determinations of *Escherichia coil*. To determine population of microorganisms, Sharpe (MRS) agar plates were incubated under anaerobic conditions at 37.0°C for 24 h, while MacConkey agar plates was incubated under aerobic conditions for 24 h at 35.0 and the population of *Escherichia coil* in MacConkey Agar were identified by the presence of pink-red colonies according to Yousef and Carlstrom (2003) and Delost (1997).

Statistical analysis: All data were statistically analyzed using Analysis of Variance (ANOVA) of SAS (1988). The differences between the means of groups were separated by Duncan's New Multiple Range Test (Duncan, 1955) according to the following model:

$$Y_{ij} = \mu + A_i + \epsilon_{ij}$$

where, Y_{ij} is the observed response, A_i is the effect of diet and ϵ_{ij} is experimental error; ϵ_{ij} ~NID $(0,\delta^2)$. Statements of statistical significance were based on $p<0.05$. All statistical analyses were done in accordance with the method of Steel and Torrie (1980).

RESULTS AND DISCUSSION

Performances: Effects of Jerusalem artichoke on production performance of laying hens are shown in Table 1. The results indicated that supplementing Jerusalem artichoke 50 and 100 ppm in diet not influenced final body weight and body weight gain and averaged 1.84 kg hen^{-1}. In this study, 100 ppm of dried Jerusalem

Table 1: Effect of Jerusalem artichoke on production performance of laying hens during 24-32 weeks of age

		Jerusalem artichoke			
Item	Control group	50 ppm	100 ppm	SEM	p-value
Initial body weight (g)	1.73	1.71	1.70	0.02	0.36
Final body weight (kg)	1.85	1.83	1.85	0.04	0.60
Weight gain (g)	0.13	0.12	0.15	0.02	1.00
Egg production (%)	92.64	93.07	93.68	0.89	0.35
Feed intake (g/hen/day)	114.40	114.79	113.07	1.57	0.54
Eggs weight (g)	63.69	63.78	64.41	0.90	0.35
Eggs mass	59.00	59.35	60.34	0.38	0.11
FCR	1.80	1.80	1.76	0.83	0.33

artichoke slightly increased egg production, there was 93.68% compared to 92.64% in control group, however the statically difference was not found ($p>0.05$). Feed intake was not affected by Jerusalem artichoke and averaged 114.08 g/hen/day. However, the egg mass was slightly increased and feed conversion ratio was slightly improved by 100 ppm of Jerusalem artichoke supplementation, there were 60.34 and 1.76 compared to 59.00 and 1.80 in control; respectably however the statically differences were not founded ($p>0.05$).

It can be believed that supplementation of 100 ppm of Jerusalem artichoke may improve nutrients utilization (digestion and absorption), since FCR was slightly improved 2.22 % compared to control. Jerusalem artichoke can be a dietary prebiotic due to consists oligosaccharides which commonly use as purified prebiotic (Roberfroid, 1993). In addition, Chen *et al.* (2005) reported that the supplementation of oligofructose to laying hen rations did not influence feed consumption but the hens that received oligofructose produced more eggs than the birds fed a control diet. Therefore, in this study the feed conversion ratio possibly improved by oligofructose addition.

Egg quality characteristics: At the end of feeding trial, supplementation 100 ppm Jerusalem artichoke in diet significantly decreased albumen weight ratio although the albumen height was increased ($p<0.05$), the ratio of albumen weight was 51.95% compared to 55.83% in control group. The albumen height in the 100 ppm Jerusalem artichoke supplementation was 12.06 mm compared to 10.78 mm in control group. The Yolk: Albumen ratio was increased by 100 ppm of dried Jerusalem artichoke, there was 0.65 compared to 0.56 in control group. In this study, Jerusalem artichoke did not influence the yolk weight ratio, shell weight ratio and shell eggs thickness ($p>0.05$) and averaged 32.14, 13.77% and 0.03 mm, respectively. Effects of Jerusalem artichoke on eggs quality of laying hens during 24-32 weeks of age are shown in Table 2.

Table 2: Effect of Jerusalem artichoke on eggs quality of laying hens during 24-32 weeks of age

		Jerusalem artichoke			
Item	Control group	50 ppm	100 ppm	SEM	p-value
Albumen height (mm)	10.78^{b}	11.64^{b}	12.06^{a}	1.19	0.04
Yolk weight ratio (%)	31.03	31.56	33.57	0.47	0.14
Albumen weight ratio (%)	55.83^{a}	54.74^{a}	51.95^{b}	1.19	0.04
Shell weight ratio (%)	13.14	13.70	14.49	0.09	0.20
Houng unit	79.23^{b}	80.96^{b}	83.15^{a}	0.82	0.03
Yolk:albumen ratio	0.56^{b}	0.58^{b}	0.65^{a}	0.65	0.01
Shell eggs thickness (mm)	0.03	0.03	0.03	0.01	0.06

Means in the same row with different superscripts are different significantly at $p<0.05$

The study of Yildiz *et al.* (2006) reported that supplementation of Jerusalem artichoke in layer diet tended to increase hen-day production that higher than control group. In addition, the study of Kahraman *et al.* (2006) reported that supplementation of prebiotic in layer diet tended to improve egg production egg quality and increase yolk:albumen ratio, these results are in agreement with Chen *et al.* (2005) who found that oligosaccharide supplementation in layer diet improved body weight and egg quality.

Egg quality is identified by egg shell, albumen and yolk (Kul and Seker, 2004). The albumen height is related with Hugh unit which is a parameter of albumen quality and fresh egg (Keener *et al.*, 2006). The old eggs decrease albumen height which giving the lower Hugh unit (Toussant and Latshaw, 1999). The study of Karpinska *et al.* (2001) reported that supplementation of oligosaccharide improved the albumen height and Hugh unit. This consequence may come from Jerusalem artichoke increased the intestinal mucosa which results in increase the absorption of mineral in gastrointestinal tract that affected to increase absorption of water and mineral to egg (Coudray *et al.*, 2003).

Intestinal microorganisms: At the end of feeding trial, supplementation of 50 and 100 ppm of dried Jerusalem artichoke in diet significantly increased the population of Lactic acid bacteria in the caecum of layer hens ($p<0.05$), there were 4.03 log CFU g^{-1} digesta in dried Jerusalem artichoke supplementation groups and 3.04 log CFU g^{-1} digesta in control group. In this study, the population of *E. coil* did not influenced by Jerusalem artichoke and averaged 1.97 log CFU g^{-1} digesta (Table 3).

Growth of lactic acid bacteria can be promoted by supplementation of prebiotics (Crittenden, 1999 and Gibson, 1998) and lactic acid can inhibit growth of pathogenic bacteria and prevent intestinal disorders (Poeikhampha and Bunchasak, 2011a, b; Crittenden, 1999). Dietary prebiotic in Jerusalem artichoke may poorly digest and absorb in the small intestine and it is utilized by lactic acid bacteria in large intestine, these bacteria are support and balance microorganisms in gastrointestinal tract (Lampromsuk *et al.*, 2012; Gibson and Roberfroid, 1995). Similarly, the study of Park and Park (2012) reported that

Table 3: Effect of Jerusalem artichoke on *E. coli* and lactic acid bacteria population (log CFU g^{-1}) in the caecum of laying hens

		Dried Jerusalem artichoke			
Item	Control group	50 ppm	100 ppm	SEM	p-value
E. coli	2.01	1.96	1.96	0.72	0.11
Lactic acid bacteria	3.04^{b}	4.03^{a}	4.03^{a}	0.19	0.01

Means in the same row with different superscripts are different significantly at $p<0.05$

supplementation oligosaccharides in feed increase beneficial bifidobacterium and Lactobacillus growth and inhibition of harmful bacteria in the cecum. The reduction of photogenic bacteria by dietary prebiotics is due to the significant increase of Lactobacillus population in the cecum (Poeikhampha and Bunchasak, 2011a, b; Ahn *et al*., 2007; Park, 2008). However in this study Jerusalem artichoke supplementation in feed did not affect to *E. coil* population this may be due to under well managed conditions, the expression of Jerusalem artichoke on intestinal microorganisms are limit and/or involved with mechanism of gastrointestinal tract that maintained proper pH for enzyme therefore *E. coil* population was not affected (Djouvinov *et al*., 2005).

CONCLUSION

It was concluded that the supplementation of Jerusalem artichoke had no adverse effect on laying hen performance but had adverse effect on egg quality characteristics and may inhibit growth and destroy pathogenic microorganisms. The results implied that Jerusalem artichoke supplementation may be useful as a prebiotic to accomplish the egg quality in layer hens.

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