Research Article

Effects of Asparagus Trims By-Product Supplementation in Laying Hens Diets on Nutrient Digestibility and Productive Performance

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Abstract

An experiment was conducted to examine the utilization of asparagus trims by-product as alternative feedstuffs in laying hen diets. Two hundred and forty laying hens (ISA-Brown strain), 40 weeks of age were raised under ambient temperature and assigned in a completely randomized design (CRD) with four dietary treatments and three replications per treatment. Each treatment contains different levels of asparagus trims by-product (0, 1, 2 and 3% TAP). All birds were fed with diets containing 18% CP and 11.9 MJ/kg (ME) of laying hens diet to meet nutrient requirements of poultry according to NRC (1994). Diets were restricted (110 g/h/d) throughout the study (42 days) and drinking water was offered *ad libitum* to the bird. Results showed that total hen-day egg production, egg mass, feed conversion ratio per one dozen of egg (FCR, feed:gain) and feed cost per gain (FCG) per one dozen of egg were not significantly different ($P>0.05$) among treatments. The average egg weight values differ significantly among levels of asparagus trims ($P < 0.01$) (58.29, 60.28, 59.94 and 60.72 g, respectively). In addition, egg from different treatment shows significant different on whole egg weight, yolk weight and albumen weight ($P<0.01$). Nutrients digestibility were not significantly different ($P>0.05$) among levels of asparagus trims by-products. However, fiber digestibility of birds fed with 3% of asparagus trims were higher than those with 2% asparagus trim, and significantly higher than those in control groups and 1% of asparagus trims ($P<0.01$) (44.80, 48.77, 51.50 and 56.69%, respectively). Furthermore, results also shows that four levels of asparagus trims has no effect on lipid oxidation (TBARs) ($P>0.05$). Nevertheless, asparagus trims by-product is suitable alternative feedstuffs in laying hen diets.

***Key Words*:** Asparagus trims; Laying hen; Hen-day egg production; Egg weight; Digestibility

Introduction

Agriculture by-products are widely used as feed for livestock in the developing countries because of their availability and affordable price. Western Thailand produces asparagus for local and export markets especially to Japan and Taiwan. In 2012, approximately 6,650 ton of asparagus were produced, which is 7% lower compared to the production in year 2011. Asparagus trim, a by-product from the processing of asparagus prior to export, contains moderate protein (15-23%) and high crude fiber (>50%) (Fuentes-Alventosa et al., 2013). Green asparagus stem contains 32.7% crude protein, 18.5% crude fiber, 3.4% crude fat and 16.08 MJ/kg gross energy (Aberoumand and Deokule, 2010). At least 10% of asparagus is loss from stem cutting (Eveli et al., 2013). In addition, Asparagus contains fructooligosaccharides (FOS) (Yamamori et al., 2002). The use of FOS as prebiotics has attracted considerable interest, primarily because they can act as a modulator of colonic bacterial population and fermentation end-products (Czarneki-Maulden, 2000). This includes the reduction of pathogenic bacteria population (Barley et al., 1991) and increasing beneficial micro-flora population (*bifidobacteria* and *lactobacilli*) in large intestine (Williums et al., 1994), which can effectively improve health and performance of poultry (Juskiewicz et al., 2006; Fuguta et al., 1999). FOS is not digested in small intestine by endogenous enzymes which will then enters the large intestine, eventually will be fermented by beneficial micro-flora to produce volatile fatty acid (VFA), lactate and gases (Twomey et al., 2003). The health benefits are mainly due to an antibacterial effect on potentially pathogenic bacteria through the production of acid which cause a reduction in intestinal pH, reduction of ammonia level through protonation of NH_4^+, production of B group vitamins, and immunomodulation in the gut mucosa (Gibson and Roberfroid, 1995).

Therefore, aim of this study was to investigate the dietary effect of asparagus trims as alternative feedstuffs on productive performance, nutrient digestibility, egg quality trait and storage time of eggs in laying hens.

Material and Methods

Animal and Feeding Management

Asparagus trims collected from Hup-krapong, Phetchaburi province under the His Majestic King of Thailand royal project, the asparagus trims were sliced, spread on plastic sheet and sun dried for three days followed by oven dried at 60°C for three days. The dried asparagus trims were ground to uniform size about of 2 mm for use in this experiment. In addition, the dried asparagus trims were analyzed for chemical composition.

The asparagus trims were used to substitute yellow corn in the diets at 3 levels (1, 2 and 3%) on dry basis and diets with no asparagus trims as control. One hundred and eighty ISA-Brown laying hens of 40 weeks of age were randomly assigned to control or experimental diets, with three replicates per treatment. The birds were housed in individual battery cage (50 x 40 x 40 cm) under photoperiod throughout the 28 days experiment. All of birds were kept under ambient temperature and were fed with corn-soybean based diet (Table 1) formulated to achieve 18% crude protein and 11.9 MJ/kg for laying hens to meet their nutrients requirement according to NRC (1994). During the 28 days experimental period, all hens were given 110 g/h/d of experimental diets and clean drinking water was offered *ad-libitum*. Limitation on the experimental diets given was because heavy weight might affect egg production.

Egg production, egg weight and feed intake were recorded daily. Hen-day egg production, average egg weight, egg mass [(Average Egg Weight

x Hen-day production) / 100] were calculated according to the method of Uuganbayar et al. (2005) whereas the cost per egg production (FCR x Cost 1 kg of feed) were calculated as described by Chinrasri (2003). FCR (kg of feed needed to produce a kg of eggs) was calculated according to Yang et al. (2006).

Egg Quality Analysis

During the last five days of the experimental period, eggs were collected daily and five eggs were randomly selected from each treatment to determine egg characteristic. Egg weight was measured after washing and drying with cool air to remove contaminants from shell. Egg yolk was separated from the albumen and weighed. Shell weight was measured after removal of remaining albumen with water. The weight of albumen was calculated by subtracting the weights of yolk and shell from the weight of whole egg. Thickness of the shell was obtained by averaging measurement from three areas; blunt end, pointed end and middle part of the egg using a digit meter as described by Hatice and Muhlis (2012). The thickness of the albumen was measured on glass plate with an auto tri-pod micrometer (Chatcharee, 2003). Haugh unit was calculated from the thickness albumen and weight of egg using the following formula proposed by Haugh (1937); H.U. = 100 log [Albumen height in millimeter + 7.57 x 1.7 Weight of egg in gram$^{0.37}$] according to the method described by Ragabe et al. (2012) using the Eggware software program.

Nutrient Digestibility Analysis:

To determine nutrient digestibility, each treatment consisted of 3 replications and 15 birds per replicate making up a total of 45 birds per treatment, were transferred to battery cages. Chromic oxide (0.30%) was added to the experimental diets as external marker and was fed to the birds for 10 days with the first seven days as adaptation period, and the last three days were the test period. Fecal sample were collected daily and sample from same treatment group were pooled and stored immediately at -20 ˚C until analysis. The fecal samples were later dried in oven at 60 ˚C and ground for later use. Samples of experimental diet and feces were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and gross energy (GE) according to AOAC (2000). Apparent digestibility of nutrients was calculated using method as described by Fenton and Fenton (1979). Chromium concentration was estimated by the absorbance readings in spectrophotometer (CE 3021, Cecil, England) at 390 nm.

Oxidative Stability Analysis

At day 28, six eggs per replicate were randomly collected and stored at room temperature. For lipid oxidation, two eggs were analyzed weekly using thiobabituric acid reaction substance (TBARs) according to the method described by Buege and Aust (1978). Butylated hydroxytoluene (0.03% by weight) was used to prevent oxidation prior to homogenization with 25 ml of TBARs solutions (0.375% TBA, 15% TCA and 0.25 N HCl) at 11,000 rpm for 1 min. The mixture was heated at 90 ^{o}C for 10 min to develop a pink color, which is then cooled in ice water bath. The absorbance of the solutions was measured in a spectrophotometer (CE 3021, Cecil, England) at 538 nm. The TBARs value was calculated from the standard curve of malondialdehyde (MDA) and expressed as mg MDA/kg sample according to the method described by Marshell et al. (1994) and Atchariya et al. (2011).

Statistical Analysis

The experimental data were subjected to analysis of variance (ANOVA) using the general liner models procedure (Monchai, 2001). Differences among treatment means were compared using Duncan's multiple range test (DMRT) as described by Steel and Torrie (1992). A significance levels $P<0.05$ was used to differentiate between means.

Table 1 Ingredients and chemical composition of experimental diets

Ingredients (%)	Levels of asparagus trims			
	0%	1%	2%	3%
Corn	35.15	34.15	33.15	32.15
Soybean meal 44%	14.38	14.38	14.38	14.38
Asparagus trims	-	1.00	2.00	3.00
Rice bran meal	10.00	10.00	10.00	10.00
Canola meal	12.50	12.50	12.50	12.50
Corn-DDGS	15.00	15.00	15.00	15.00
Rice bran oil	1.84	1.84	1.84	1.84
$CaCo_3$ (Fine)	2.73	2.73	2.73	2.73
$CaCo_3$ (Flake)	6.38	6.38	6.38	6.38
MCP (P21)	0.78	0.78	0.78	0.78
NaCl	0.28	0.28	0.28	0.28
Choline-Choride	0.01	0.01	0.01	0.01
DL-Methionine 99%	0.27	0.27	0.27	0.27
L-Lysine	0.22	0.22	0.22	0.22
Premix[1]	0.46	0.46	0.46	0.46
Total	100.00	100.00	100.00	100.00
Analysis nutrient content				
Dry matter (%)	91.22	91.06	91.08	91.36
Crude Protein (%)	18.78	18.31	18.41	18.79
Ether Extract (%)	2.17	2.03	2.06	2.01
Crude fiber (%)	5.31	5.89	6.20	6.93
Ash (%)	5.73	5.24	5.90	5.71
Ca (%)	4.39	4.51	4.44	4.76
P (%)	0.93	0.91	0.97	0.94
Gross Energy (MJ/kg)	15.22	15.94	15.72	15.81

[1]Each one kilogram of vitamin-mineral premix contained 22.75 MIU of retinal palmitate, 5.46 MIU of cholecalciferol, 54.60 g of DL-3-tocophyryl acetate, 5.46 g of phylloquinone, 1.82 g of thiamine, 7.28 g of riboflavin, 27.30 g of Ca-D-pantothenate, 10.92 g of pyridoxine, 72.80 g of niacin, 2.184 g of folic acid, 36.40 mg of cobalamin, 455 mg of D-biotin, 800 g of manganese, 2 g of selenium, 800 g of zinc, 2.5 g of cobalt, 150 g of copper, 700 g of ferrous, 10 g of iodine.

Results

Laying Performance

Chemical composition analysis of dried asparagus trims sample shows that dried asparagus trims contains 90.26% dry mater, 13.59% crude protein, 4.47% ether extract, 32.41% crude fiber, 9.45% crude ash, 0.79% calcium and 1.08% phosphorus. Average egg weight of chicken fed with asparagus trims diet was significantly higher than (60.28, 59.94 and 60.72 g, for 1, 2 and 3% supplementation, respectively) the control diet (58.29%) ($P<0.01$). In addition, FCR of chicken fed with 3% asparagus trims diet was the lowest (2.02) as compared with other treatments (2.16, 2.06 and 2.15 for 0, 1 and 2% supplementation, respectively (Table 2). However, hen-day egg production and egg mass were not significantly different among treatments ($P>0.05$).

Egg Quality

Egg quality parameters were not significantly different among treatments ($P>0.05$) except for whole egg, yolk weight and albumin weight (Table 3). Whole egg weight, yolk weight and albumin weight of chicken fed asparagus trims diet were significantly higher than asparagus trims free diet (control) ($P<0.01$). The average whole egg weight of each treatment was 59.33, 62.03, 62.38 and 62.19 g, respectively.

Nutrient Digestibility

Nutrient digestibility of asparagus trims diets are shown in Table 4. Nutrient digestibility was not significantly different among treatments ($P>0.05$), except CF digestibility. The CF digestibility of chicken fed asparagus trims diets at 2 and 3% were significantly higher than asparagus trims free diet, and asparagus trims diet at 1% ($P<0.01$). They were 44.80, 48.77, 51.50 and 56.69%, respectively.

Oxidative Stability

Oxidation stability of egg from different storage times are shown in Table 5. TBARs values were not significantly different among treatments ($P>0.05$). However, the TBARs values of egg from asparagus trims diets group were slightly higher than asparagus trims free diet.

Discussion

Asparagus trim is a by-product from the processing of asparagus for export. It contains moderate crude protein (13.59%) and abundant crude fiber (32.41%). Up to date, only a few studies reported the use of asparagus trims as feedstuffs substitute. Thus, there is a limited amount of information regarding its use as feedstuffs.

For productivity performance, the increase in average egg weight, egg mass, yolk and albumin weight may be due to the high energy in asparagus diets (average 15 MJ/kg) (Table 1, 2 and 3). Furthermore, the improve in FCR was due to the high CF digestibility of asparagus trim diet which the soluble fiber content of asparagus trim is mainly in the form of FOS. Asparagus is a food rich in prebiotics such as FOS and inulin. FOS and mannooligosaccharides (MOS) are prebiotic oligosaccharides which help to promote beneficial micro-flora (*Bifidobacteria* and *Lactobacilli*) in large intestine (Williums et al., 1994). *Bifidobacteria* are able to use FOS as an energy source owing to its ability to hydrolyze β-2,1-glycosidic bond (Berg et al., 2005). Moreover, the *Bifidobacteria* produces volatile fatty acid and lactic acid that tends to lower pH in large intestine, which in turn will inhibits the growth of pathogenic bacteria (Berg et al., 2005). A previous study by Kalavathy et al. (2003) found that *Lactobacilli* can increase weight gain and feed conversion in broiler chicken. Similarly, it has been reported that prebiotic could improve the egg production when 0.025 to 0.05% of prebiotics were included into layer hen's diets (Woo et al., 2007; Kim et al., 2011).

Table 2 The effect of asparagus trims supplementation on productive performance of in laying hens

Productive performance	Levels of asparagus trims				SEM[1]
	0%	1%	2%	3%	
Feed intake (g/d)	110.00	110.00	110.00	110.00	-
Hen-day production %	87.32	88.40	85.35	89.3	83.47
Average egg weight (g)	58.29[b]	60.28[a]	59.94[a]	60.72[a]	0.65
Egg mass (g)	50.90	53.30	51.14	54.28	2.14
FCR (Feed intake/Egg mass)	2.16[b]	2.06[ab]	2.15[b]	2.02[a]	0.06
FCG per 1 Kg of egg (Bath)	33.48	31.93	33.33	31.31	0.91

1USD = 30.509 of Thai bath,

[1] pool standard error of means, [a, b, c] Mean values on the same row with different superscripts differ significantly ($P < 0.01$).

Table 3 The effect of asparagus trims supplementation on egg quality of in laying hens

Egg quality	Levels of asparagus trims				SEM[1]
	0%	1%	2%	3%	
Whole egg weight (g)	59.33[b]	62.03[a]	62.38[a]	62.19[a]	0.19
Shell weight (g)	7.8	17.90	7.79	8.05	0.28
Yolk weight (g)	15.53[b]	16.04[a]	15.76[ab]	15.99[a]	0.57
Albumen weight (g)	35.99[b]	38.09[a]	38.83[a]	38.15[a]	0.41
Albumen height (mm)	7.26	7.44	7.41	7.26	0.34
Haugh unit	84.32	84.69	84.62	84.71	2.05
Egg york color	11.76	11.83	11.84	11.66	0.11
Egg shell thickness (mm)	0.344	0.333	0.32	00.337	0.013

[1] pool standard error of mean, [a, b, c] Mean values on the same row with different superscripts differ significantly ($P < 0.01$).

For nutrients digestibility, although most of nutrients digestibility were not significantly different but CF digestibility had increased in asparagus trims diet. One of the reasons for high CF digestibility was might be due to mostly is soluble fiber.

Conclusion

Asparagus trims by-product could be used as alternative feedstuffs in laying hen diets based on the increased average egg weight, yolk and albumin weight in laying hen shown in this study. In addition, asparagus trims had improved feed conversion ratio and no adverse effect on other performance parameter, nutrients digestibility, egg quality and oxidative stability.

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Table 4 The effect of asparagus trims supplementation on nutrients digestibility in laying hens

Nutrients digestibility (%)	Levels of asparagus trims				SEM[1]
	0%	1%	2%	3%	
Dry matter	83.02	82.56	82.68	82.62	0.87
Crude fiber	44.80[b]	48.77[b]	51.50[ab]	56.69[a]	3.82
Ether extract	78.99	74.08	77.59	77.65	3.46
Gross energy	82.73	82.35	81.70	81.54	0.72
Crude protein	80.06	83.30	86.49	83.97	4.90

[1] pool standard error of mean, [a, b, c] Mean values on the same row with different superscripts differ significantly ($P < 0.01$).

Table 5 The effect of asparagus trims supplementation on oxidative stability of egg from different storage times

TBARs (mg/kg)	Levels of asparagus trims				SEM[1]
	0%	1%	2%	3%	
0 day	1.19	1.27	1.81	1.26	0.032
7 day	4.77	4.98	4.47	5.02	0.041
14 day	5.14	5.38	5.44	5.29	0.017

[1] pool standard error of mean

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References

Aberoumand, A., and Deokule, S. S. (2010) Preliminary studies on proximate and mineral composition of marchubeh stem (*Asparagus officinalis*) vegetable consumed in the Behbahan of Iran. *World Applied Sciences Journal* 9(2): 127-130.

AOAC. (2000) *Official Methods of Analysis of AOAC International*. 17th ed., Associate of Analysis Chemistry, Gaithersburg, MD.

Atchariya, C., Wattanachant, S., and Benjakul, S. (2011) Quality characteristics of raw and cooking spent hen *Pectoralis major* muscle during chilled storage: Effect of tea catechins. *International Journal of Poultry Sciences* 10(1): 12-18.

Baley, J. S., Blankenship, L. C., and Cox, N. A. (1991) Effects of fructooligosaccharide on *salmonella* colonization of chicken intestine. *Poultry Science* 70: 2433-2438.

Berge, E. L., Fu, C. J., Porter, J. H., and Kerley, M. S. (2005) Fructooligo-saccharide supplementation in the yearling horse: Effect on fecal pH, microbial content, and volatile fatty acid concentrations. *Journal of Animal Science* 83: 1549-1553.

Buege, J. A. and Aust, S. D. (1978) Microsomal lipid peroxidation. *Method Enzymol* 52: 302-304.

Chatcharee, H. (2003) *QCD/EQM and QCM+ Eggware Software Manual,* 1st ed., p. 31. Bangkok.

Chinrasri, O. (2003) *Poultry production technology,*

1st ed., p. 206. Mahasarakham University Mahasarakham, Thailand.

Czarnacki-maulden, G. (2000) The use of prebiotic in prepared pet food. *Veterinary Internaional* 12: 19-23.

Eveli, S., Paul, L., and Gabriele, W. B. (2013) *Food waste in the supply chain-impacts on the product carbon footprint.* The 6th International conference on life cycle management in Gothenburg, Sweden.

Fukata, T., Sasai, K., Miyamoto T., and Baba, E. (1999) Inhibitory effects of competitive exclusion and fructooligosacharide, singly and in combination, on *Salmonella* colonize of chicks. *Journal of food Protection* 62: 229-233.

Fenton, T. W., and Fenton, M. (1979) An improved method for chromic oxide determination in feed and feces. *Canadian Journal of Animal Science* 59: 631-634.

Fuentes-Alventosa, J. M., Jaramillo-Carmona, S., Rodrìguez-Gutiérrez, G., Guillén-Bejarano, R., Jiménez-Araujo, A., Fernández-Bolaños, J., and Rodríguez-Arcos, R. (2013) Preparation of bioactive extracts from asparagus by-product. *Food and Bioproducts Processing* 91: 74-82.

Gibson, G. R. and Roberfroid, M. S. (1995) Dietary modulation of the human colonic microbiota: introducing the concept of prebiotics. *Journal of Nutrition* 125: 1401-1412.

Hatice, K. and Muhlis, M. (2012) Effect of inclusion of garlic (*Allium sativum*) powder at different level and copper into diets of hens on performance egg quality traits and yolk cholesterol content. *International Journal of Poultry Science* 10(1): 12-18.

Haugh, R. R. (1937). The Haugh unit for measuring egg quality. U.S. Egg and Poultry Magazine 43: 552-572.

Juskiewicz, J., Jankoski, J., Zdunczyk, Z., and Mikulski, D. (2006) Performance and gastrointestinal tract metabolism of turkeys fed diet with difference contents of fructooligosacchride. *Poultry Science* 85: 886-891.

Kalavathy, R., Abdullah, N., and Ho. Y. W. (2003). Effect of *Lactobacillus cultures* on growth performance, abdominal fat deposition, serum lipid and weight of organs of broiler chickens. *British Poultry Science* 44: 139-144.

Kim, G. B., Seo, Y. M., Kim, C. H., and Paik, I. K. (2011) Effect of dietary prebiotic supplementation on the performance, intestinal microflora and immune response of broilers. *Poultry Science* 90: 75-82.

Marshell, A. C., Sams, A. R., and Van Elswyk, M. E. (1994) Oxidative stability and sensory quality of stored egg from hen fed 1.5 % menhaden oil. *Journal of Food Science* 59: 561-563.

Monchai D. (2001). *SAS Enterprise Guide for Analysis.* Nanawittaya publishing company, Khon Kaen.

NRC. (1994) *National Reseach Council, Nutrient Requirement of Poutry,* 9th ed., pp.11-19. National Academy Press, Washington, D. C. Ragab, H. I., Abdel Ati, K. A., Kijora C., and Ibrahim, S. (2012) Effect of difference level of the processed *Lablab purpureus* seed on laying performance, egg quality and serum paramaters. *International Journal of Poultry Science* 11(2): 131-137.

Steel, R. G. D. and Torrie, J. H. (1992) *Principles and Rocedure Statistic,* 2nd ed., McGrew-Hill Book, Singapore.

Twomey L. N., Pluske J. R., Rowe J. B., Choct, M., Brown W., and Pethick, D. W. (2003) The effect of added fructooligosaccharide (Raftilose® P95) and inulinase on feacal quality and digestibility in dogs. *Animal Feed*

Science Technology Technology 108: 83-93.

Uuganbayar, D., Bea I. H., Choi K. S., Shin I. S., Firman J. D., and Yang, C. J. (2005) Effect of green tea powder on laying performance and egg quality in laying hens. *Asian Australasian Journal Animal Science* 18: 1769-1774.

Williums, C. H., Witherly S. A., and Buddington, R. K. (1994) Influence of dietary neosugar on selected bacterial groups of the human fecal microbiota. *Microbial Ecology* 7: 91-97.

Woo, K. C., Kim, C. H., and Paik, I. K. (2007) Effects of supplementary immune modulator (MOS, Lectin) and organic acid mixture (organic acid F, organic acid G) on the performance, profile of leukocytes and erythrocytes, small intestinal microflora and immune response in laying hens. *Korean Journal of Animal Science Technology* 49: 481-490.

Yamamori, A., Onodera, S., Kikuchi M., and Shiomi N. (2002) Two novel oligo-saccharide formed by 1 ^{F} - fructo-syltransferase purified fom root of asparagus (*Asparagus officinalis* L.). *Bioscience Biotechnology Biochemistry* 66(6): 1419-1422.

Yang, Y. X., Kim, Y. J., Jin, Z., Lohakare, J. D., Kim, C. H., Ohh S. H., Lee, S. H., Choi, J. Y., and Chae, B. J. (2006) Effects of dietary supplementation of astaxanthin on production performance, egg quality in layers and meat quality in finishing pigs. *Australasian Journal Animal Science* 7: 1019 - 1025.