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Effect of extruded amaranth grains on performance, egg traits, fatty acids composition, and selected blood characteristics of laying hens

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ABSTRACT

The aim of the study was to evaluate the effect of extruded amaranth grains (AMG) in laying hen diets on performance, egg traits, egg yolk fatty acids composition, as well as selected blood characteristics. A total of 60 Lohmann Brown laying hens, 24 wk of age, were randomly distributed into 3 dietary treatments and fed for 10 wk. The AMG was used at the levels of 0%, 5%, and 10% in the diets of the control and 2 treatment groups, respectively. Each dietary treatment was divided into 4 replicates, comprising of 5 hens each. Hens were housed in a 3-tier battery system. Feed and water were provided ad libitum. Blood samples and eggs were collected after 5 wk and at the end of the experiment. Amaranth grain supplementation increased body weight (1.64, 1.66, and 1.72 kg for diets containing 0%, 5%, and 10% AMG, respectively; linear, $P<0.01$). Although hens responded to AMG supplementation linear and quadratically ($P<0.01$), the greatest egg production and the lowest feed conversion ratio were observed with 5% AMG. No differences in the mean egg weight, eggshell weight, yolk and albumen weight, thick albumen height, Haugh units and breaking strength of eggshells were observed in hens fed AMG-supplemented diets. Also, sensory analysis of eggs did not reveal any differences among hens fed different diets. Fatty acids content of egg yolk was similar in all treatments, although in hens fed 5% AMG, the polyunsaturated fatty acid (n-6), especially linoleic acid, level was slightly greater and the n-6/n-3 acid ratio was decreased. The concentrations of alanine aminotransferase, aspartate aminotransferase, and glucose level were reduced linearly after 5 wk ($P=0.01$–0.03) by increasing AMG supplementation. The quadratic effect on alanine aminotransferase at wk 5 ($P=0.02$) and 10 ($P<0.01$) was also observed. The results showed that dietary inclusion of AMG at the level of 5% increased hen performance and did not negatively influence the hens' health conditions and also quality and sensory traits of eggs.

1. Introduction

Extensive studies that used diets enriched in plant-derived products to improve animal performance, health, or the quality of feed, and food of animal origins have been conducted for many years. The Andean crop amaranth is a pseudo cereal that has been the focus of attention in many scientific studies during the last 2 decades, mainly on its nutritional, functional, agricultural, and technological potentials (Bartkowiak et al., 2007; Berghofer and Schoenlechner, 2002; Czerwińska et al., 2004; Ferreira

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and Arêas, 2010; Króliczewska et al., 2008; Lehmann, 1996; Plate and Arêas, 2002; Zralý et al., 2006).

The advantages of amaranth grains, compared to conventional cereals, are a relatively high content of proteins and better balanced composition of amino acids (Pisarikova et al., 2006). Amaranth grain is also rich in lysine and sulfur amino acids, which makes an attractive source of protein if consumed along with other cereals (Bressani, 1994). Moreover, the content of lysine and tryptophan, together with low content of leucine, makes amaranth grain a high-quality supplement for cereals rich in leucine but poor in lysine and tryptophan (Gorinstein et al., 2002).

Additionally, amaranth's oil fraction is rich in unsaturated fatty acids, especially linoleic and oleic acids, and the high content of some unsaponifiable components, such as squalene, phytosterols, tocopherols, and tocotrienols, is responsible for its beneficial hypercholesterolemic effects (Mendonça et al., 2009; Odhav et al., 2007). However, some recent reports have shown that amaranth free of the lipid moiety is more effective in inducing the reduction of blood cholesterol levels, and these reports concluded that other components, possibly the protein fraction, are responsible for these benefits (Berger et al., 2003a; Plate and Arêas, 2002).

The amaranth plant has a great potential to be integrated into the traditional and modern agricultural system in many regions of the world. Moreover, because of its easy cultivation and nutritional aspects, it can play an important role in the animal and human food system (Lehmann, 1996; Saunders and Becker, 1984; Teutônico and Knorr, 1985). Amaranth grain has not been widely used in laying hen feeding mainly because its application in their diets has not been established yet (Bartkowiak et al., 2007; Króliczewska et al., 2008; Pavlík et al., 2007; Pisarikova et al., 2006; Vishtakalyuk et al., 2001).

There are still some questions on the influence of amaranth grains on poultry physiology and productivity. Determination of blood indicators is one of the methods evaluating the effect of amaranth grain feeding on health and production. Among several possible processing methods, extrusion is the most interesting from the nutritional and economic point of view because it produces a stable product with all nutritive components preserved or enhanced (Bressani, 1994; Chávez-Jáuregui et al., 2010; Mendoza and Bressani, 1987). Therefore, the present study was conducted to evaluate the effect of extruded amaranth seeds on performance, egg traits, fatty acid composition, and selected blood characteristics.

2. Materials and method

2.1. Animals and experimental diets

A total of 60 Lohmann Brown laying hens 24 wk of age were used for the study. Hens were allocated into 12 cages (three-tier battery system) and divided into 3 dietary treatments with 4 replicates, each comprising 5 hens each. The experiment was conducted in an environmentally controlled room (temperature $=20\pm2$ °C and relative humidity $=65\pm5\%$) with light regimen of 16 h light:8 h dark. Feed and water were provided ad libitum during the 10 wk experimental period. The study was conducted in accordance with the protocol approved by the Second Wroclaw Ethics Commitee for Animal Experimentation at the Wroclaw University of Environmental and Life Sciences (Wrocław, Poland).

The ingredients and chemical composition of the diets are presented in Table 1. Both control and treatment diets were formulated to be isocaloric (11.6 MJ/kg) and isonitrogenous (16.5% crude protein). Nutrient composition of diets was determined according to the standard procedures (AOAC, 2000). The extruded amaranth grains (AMG) used in the experiment was obtained from a commercial company (P.P.H.U. Szarłat S.C., Łomża, Poland) and produced in the process of cold extrusion without using any organic solvents. The grains were used at the level of 0%, 5%, and 10% in the diets of the control (0% AMG) and 2 treatment groups (5% and 10% AMG), respectively. The nutrient profile of the extruded grains was as follows: 3790 kcal/kg; 16.4% crude protein; 66.4% carbohydrate; and 5.3%, 4.5%, and 1.82% fat, ash, and vitamin B_{12}, respectively.

2.2. Performance traits

During the whole experiment, the egg production was monitored. Eggs were collected daily and egg production

Table 1
Ingredients and chemical composition of the diets.

Item	Diet[a]		
	0% AMG	5% AMG	10% AMG
Ingredients, %			
Corn	13.0	12.6	12.1
Soybean meal	16.0	15.3	14.6
Wheat	36.0	32.8	30.5
Wheat mix	15.6	14.9	13.4
Sunflower meal	2.7	2.7	2.9
Wheat bran	2.8	2.8	2.8
AMG	0.0	5.0	10.0
Soybean oil	3.5	3.5	3.4
Limestone	8.3	8.3	8.3
Sodium carbonate	0.1	0.1	0.1
Dicalcium phosphate	1.2	1.2	1.2
DL-Methionine	0.15	0.15	0.15
Threonine	0.08	0.08	0.08
L-Lysine	0.07	0.07	0.07
Salt	0.25	0.25	0.25
Vitamin mineral premix[b]	0.25	0.25	0.25
Total	100.00	100.00	100.00
Chemical composition[c]			
Metabolizable energy, MJ/kg	11.6	11.6	11.6
Crude protein, %	16.5	16.5	16.5
Ca, %	3.38	3.39	3.40
Available P, %	0.31	0.31	0.31

[a] 0% AMG: control diet+0% extruded amaranth grains; 5% AMG: control diet+5% AMG; and 10% AMG: control diet+10% AMG.

[b] Composition per kilogram of diet: vitamin A, 10,000 IU; vitamin D_3, 2500 IU; vitamin E, 10 mg; vitamin K_3, 1 mg; vitamin B_1, 1 mg; vitamin B_2, 3 mg; vitamin B_6, 1.5 mg; vitamin B_{12}, 0.02 mg; Ca pantothenate, 8 mg; folic acid, 0.5 mg; choline chloride, 250 mg; Mn, 80 mg; Zn, 50 mg; Fe, 45 mg; Cu, 6 mg; I, 0.7 mg; and Se, 0.15 mg.

[c] Calculated Janssen (1989).