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Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

The effect of amaranth seed added to the standard diet upon selected meat quality traits in the quail

Małgorzata Jakubowska[1]*, Józefa Gardzielewska[1], Zofia Tarasewicz[2], Danuta Szczerbińska[2], Tadeusz Karamucki[1], Kinga Rybak[1], Ewa Poławska[3], Justyna Garczewska[1]

[1] Institute of Food Commodity Sciences, Department of Biotechnology and Animal Breeding, West Pomeranian University of Technology, Doktora Judyma 24, 70-466 Szczecin, Poland

[2] Department of Poultry Breeding, Department of Biotechnology and Animal Breeding, West Pomeranian University of Technology, Doktora Judyma 20, 70-466 Szczecin, Poland

[3] Polish Academy of Sciences, Institute of Genetics and Animal Breeding, Jastrzębiec, Postępu 36A, 05-552 Magdalenka, Poland

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The study was conducted on 36 female Pharaoh quails (3 groups, 12 birds per group). The experiment covered the 7th to the 20th weeks of birds' lives. The control group (I) received standard feed formulated for adult quails. Groups II and III received standard feed with 4% and 7% of amaranth seeds, respectively. All feeds were isoproteinous and isocaloric. At the age of weeks 20, 12 females were randomly selected from each group and slaughtered. In the isolated breast and leg muscles water-holding capacity, thermal drip, colour, basic chemical composition, fatty acids profile were determined and sensory evaluation performed. Amaranth seed supplementation showed no effect on the basic chemical composition of breast and legs muscles and fatty acids profile. Deterioration in the flavor of cooked quail breast muscle was observed with the higher dosage of the seeds in the diet. Improved muscle tenderness was observed in birds receiving 4% of amaranth seeds in the diet.

KEY WORDS: amaranth seeds / fatty acid profile / meat quality / quail

Long-chain n-3 and n-6 polyunsaturated fatty acids are essential components of healthy diets for humans and animals [Sales and Horbanczuk 1998, Zralŷ *et al.* 2006, Polawska *et al.* 2011]. However, they must be provided in a diet as humans and

*Corresponding autor: malgorzata-jakubowska@zut.edu.pl

animals cannot synthesize their native forms (linoleic and linolenic acid) and may only convert them within the same omega-6 or omega-3 fatty acids family [Mieczkowska *et al*. 1999]. These essential fatty acids can be provided by oil seed supplementation [Poławska *et al*. 2013], for example with amaranth seed.

Beneficial effect of amaranth seed supplementation on blood lipid parameters has been reported in laying hens [Króliczewska *et al.* 2008]. An amaranth seeds supplementation showed no effect on the protein content in muscles of broiler chickens [Roučkova *et al*. 2004]. Finally, the feed mix containing from 2% to 10% amaranth seeds increased the content of polyunsaturated fatty acids n-6 and in particular linoleic acid in chicken egg yolk [Bartkowiak *et al*. 2007]. These results suggest the possibility of obtaining positive changes in the fatty acids profile of meat of poultry using a feed mixture containing amaranth seeds.

The aim of the study was to determine the influence of amaranth seeds supplementation to quails diet on the physicochemical parameters of meat. The intended purpose of the study was to assess the resultant sensory attractiveness and physicochemical characteristics of quail meat.

Material and methods

The study was conducted on female Pharaoh quails (three groups, 12 quails per group), lasted 14 weeks and covered a period from week 7 to week 20 of the quails' age. In the control group (I) quails were fed the feed mix assigned for adult quails, formulated according to the standards accepted for this species [NRC – National Resarch Council 1994] In the experimental groups (II and III) the standard feed mix was supplemented with amaranth seeds – at 4% and 7% in the diet.

At the end of experiment 12 females were randomly selected from each group and after 12 hours of fasting were slaughtered by decapitation with a sharp knife. After exsanguination, plucking and gutting, the carcasses were kept at about 6°C for 24 hours. Then superficial pectoral muscle and leg muscles were isolated from the carcasses. In the obtained meat the following determinations were made:

1. pH using a pX-processor PM-600 pH meter with a ESAgP-307 glass electrode.
2. Water-holding capacity based on the percentage of free water in meat according to Grau and Hamm [1953] with Pohja and Niinivaara modifications [1957]. 300 mg meat samples (weighed to 1 mg) were placed on Whatmann filter paper and subjected to pressure of 2 kg between two glass plates for 5 min. A planimeter was used to determine the area (cm^2) of the two patches formed by the pressed meat juices and of the meat. In order to determine the percentage of free water in the meat, the drip area (cm^2) resulting from the difference between the two patches was divided by the mass of the weighed sample.
3. Measurement of colour – determined after placing meat samples in measurement dishes and storing them for 20 minutes in a refrigerator at 4°C to allow oxygenation of myoglobin in the surface layer of the meat. Colour was

measured using a MiniScan XE Plus 45/0 with a port hole diameter measuring 31.8 mm adapted to measure the colour of minced meat, using a scale of CIE L*a*b* according to CIE [CIE, 1976], and the illuminant D65 and standard observer 10°. Calibration of the apparatus was made using black and white reference standards with coordinates X = 78.5, Y = 83.3 and Z = 87.8.

4. Basic chemical composition of muscle by AOAC [2003].
5. Fatty acid profile of breast muscles. Lipids were extracted according to the method of Folch *et al*. [1957]. Fatty acid were analyzed using gas chromatograph/ mass spectrometer (GCMS) CLARUS 600 (PERKIN ELMER, USA), equipped with a 60 m capillary column (ELITE-5 ms, PERKIN ELMER, USA) with 0.25 mm inner diameter and 0.20 μm film thickness. A 2 μl sample was injected at a split ratio of 1:50. Helium 6,0 was used as a carrier gas at a flow rate of 55 mL.min-1. The injector, transfer line and ions source in MS were maintained at 260°C. Column oven temperature was programmed to increase from 120°C (held for 4 min) at a rate of 5°C · min^{-1} to 180°C (held for 10 min) and then to 290°C at a rate 5°C · min^{-1} (held for 5 min). Individual fatty acids were identified by comparison of retention times and with library mass spectrograms (NIST) to those of a standard FAME mixture (Supelco 37 Component FAME Mix, 47885-U – 10 mg · ml^{-1} in isooctane, analytical standard, Sigma-Aldrich Co.) and expressed as a percentage of total fatty acids.
6. For the sensory evaluation, muscle samples were placed in 300 ml glass jars and covered with 100 ml of water. The jars were then closed, placed in a hot water bath until reaching a temperature of 85°C inside the muscle, according to Baryłko-Pikielna [1964]. The sensory characteristics of the meat and broth were evaluated using a 5-point scale, where 1 point meant the worst score, and 5 points the best. This assessment was conducted by a team of five according to specified norms [Polish Standard PN-ISO 4121, 1998].
7. The difference between the weight of the meat sample before cooking and after cooking was measured to determine thermal drip, expressed as a percentage of the weight of samples before cooking.

The results were analysed statistically using a univariate analysis of variance. The significance of differences was determined using Duncan's test and Statistica 7.0 software.

Results and discussion

The use of amaranth seed in feed formulated for adult quails showed no effect on the chemical composition of meat from breast and legs muscles at the age of 20 weeks old quails (Tab. 1).

Analysing the data obtained from the determinations of physicochemical properties of quail breast muscle, it can be concluded that the muscle pH (Tab. 2) was typical

Table 1. Mean values and standard deviations for the chemical composition of breast and thigh muscles of quails

Item	Control	Amaranth seed 4%	Amaranth seed 7%	Mean	SEM
Breast muscles					
dry matter (%)	27.97	28.10	27.67	27.91	0.218
total protein (%)	23.91	23.76	23.96	23.88	0.128
raw fat (%)	2.53	3.06	2.45	2.68	0.222
ash (%)	1.22	1.27	1.26	1.25	0.014
Leg muscles					
dry matter (%)	25.93	25.52	25.27	25.57	0.383
total protein (%)	20.66	20.23	20.20	20.37	0.160
raw fat (%)	4.25	4.35	4.10	4.24	0.303
ash (%)	0.96	0.92	0.97	0.95	0.045

Table 2. Mean values and standard deviations for the physicochemical characteristics of quail breast muscle

Item	Control	Amaranth seed 4%	Amaranth seed 7%	Mean	SEM
pH	5.83	5.85	5.90	5.86	0.040
Meat lightness (L*)	32.80	32.78	30.73	32.10	0.616
Redness (a*)	11.10	10.22	10.53	10.62	0.236
Yellowness (b*)	9.00	8.51	8.05	8.52	0.324
Free water (%)	3.65	3.66	3.63	3.65	0.288
Thermal drip (%)	35.60	36.00	35.27	35.62	0.903

Table 3. Mean values and standard deviations for the sensory evaluation of cooked breast and leg muscles (in points)

Item	Control	Amaranth seed 4%	Amaranth seed 7%	Mean	SEM
Breast muscles					
flavour	5.00	5.00	5.00	5.00	0.000
tenderness	4.10^{A}	5.00^{B}	4.60^{AB}	4.57	0.137
juiciness	3.70	4.00	4.00	3.90	0.108
palatability	4.40^{A}	4.00^{A}	2.60^{B}	3.67	0.257
Leg muscles					
flavour	5.00	5.00	5.00	5.00	0.001
tenderness	5.00	5.00	5.00	5.00	0.000
juiciness	5.00	5.00	5.00	5.00	0.001
palatability	5.00	5.00	5.00	5.00	0.000

^{AB}Means in rows bearing different superscripts differ significantly at $P<0.01$.

for this meat – from 5.75 to 5.90 [Daszkiewicz *et al*. 1998, Genschev *et al*. 2008, Gardzielewska *et al.* 2010].

Breast muscle colour parameters, namely brightness (L*), redness (a*) and yellowness (b*), were similar in all examined quail groups. Similar values of colour parameters of breast muscle were found by Genschev *et a*l. [2008].

Sensory evaluation, conducted separately for breast and leg muscles, showed a positive effect of amaranth seed on breast muscle tenderness in the group receiving lower seed additive (group II). The breast muscle of quails receiving higher doses of amaranth seed (group III) showed a deteriorated palatability. Leg muscles showed no significant differences in sensory evaluation between experimental and control groups (Tab. 3).

Amaranth seed supplementation did not affect significantly the sensory characteristics of broth obtained from cooking the breast and leg muscles (Tab. 4).

Table 4. Mean values and standard deviations for the sensory evaluation of broth cooked from breast and leg muscles (in points)

Item	Control	Amaranth seed 4%	Amaranth seed 7%	Mean	SEM
Breast muscles					
Flavour	5.00	5.00	5.00	5.00	0.000
Clarity	5.00	5.00	5.00	5.00	0.001
Colour	4.75	4.70	4.70	4.72	0.065
Palatability	4.70	4.50	5.00	4.73	0.145
Leg muscles					
Flavour	4.50	4.00	3.50	4.00	0.129
Clarity	5.00	5.00	5.00	5.00	0.000
Colour	4.10	4.00	4.00	4.03	0.033
Palatability	4.95	4.70	4.70	4.78	0.067

The fatty acid profile of quail meat is presented in Table 5. Regardless of the dosage of amaranth seeds, palmitic acid was predominant saturated fatty acid C16:0 (24%). Among the unsaturated acids, oleic acid C18:1 (approx. 40%) and linoleic acid C18:2 (about 18%) were predominant. Similar values were found by Tarasewicz *et al*. [2001] and Genschev *et al*. [2008]. There were no differences observed in the content of fatty acids in meat from the breasts of quails between control and experimental groups. In an experiment conducted on porkers fed with a feed containing amaranth seed (10% and 20%) [Bobiel and Sokół 1999]. There were also no changes found in the content of individual fatty acids in meat.

It is concluded that amaranth seed supplementation did not change basic chemical composition of breast and leg muscles in quails and did not change physicochemical characteristics of quail meat. No significant effect on fatty acid profile of quail meat was found. A greater dosage of amaranth seeds deteriorated the palatability of cooked breast muscle, and smaller doses of amaranth seeds improved the tenderness of breast muscle.

Table 5. Mean values and standard deviations for the saturated fatty acids (% total fatty acids)

Item	Control	Amaranth seed 4%	Amaranth seed 7%	Mean	SEM
			Saturated fatty acids		
C 12:0	0.06	0.06	0.06	0.06	0.000
C 14:0	0.80	0.80	0.80	0.80	0.001
C 15:0	0.10	0.10	0.10	0.10	0.000
C 16:0	24.25	24.30	24.14	24.23	0.012
C 17:0	0.02	0.02	0.02	0.02	0.000
C 18:0	5.13	5.16	5.13	5.14	0.010
C 20:0	0.15	0.15	0.15	0.15	0.000
C 22:0	0.02	0.02	0.02	0.02	0.001
Σ SFA	**30.53**	**30.62**	**30.42**	30.52	0.017
			Monounsaturated fatty acids		
C 14:1	0.29	0.30	0.29	0.29	0.001
C16:1c	8.54	8.52	8.56	8.54	0.013
C16:1 t	0.03	0.03	0.03	0.03	0.000
C 18:1 n-9 c	39.94	39.86	40.07	39.95	0.050
C 18:1 n-9 t	0.90	0.90	0.89	0.90	0.001
C 20:1	0.35	0.35	0.35	0.35	0.001
C 22:1 n-9	0.10	0.10	0.10	0.10	0.000
Σ MUFA	**50.16**	**50.06**	**50.30**	50.17	0.062
			Polyunsaturated fatty acids		
C 18:2 n-6 c	17.80	17.80	17.75	17.78	0.008
C 18:3 n-3	0.90	0.90	0.90	0.90	0.001
C 18:3 n-6	0.01	0.01	0.01	0.01	0.000
C 20:2 n-6	0.06	0.06	0.06	0.06	0.000
C 20:3 n-6	0.06	0.06	0.06	0.06	0.000
C 20:4 n-6	0.28	0.29	0.29	0.29	0.001
C 20:5 n-3	0.20	0.20	0.20	0.20	0.001
C 22:5 n-6	0.002	0.002	0.002	0.002	0.000
C 22:6 n-3	0.001	0.001	0.001	0.001	0.000
Σ PUFA	**19.32**	**19.32**	**19.28**	19.31	0.009
UFA	69.47	69.38	69.58	69.48	0.067
PUFA/MUFA	0.38	0.38	0.38	0.38	0.001
PUFA/SFA	0.63	0.63	0.63	0.63	0.001
UFA/SFA	2.27	2.27	2.29	2.28	0.003
n-6/n-3	16.55	16.59	16.49	16.54	0.025

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