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Influence of feeding colored wheat varieties on selected quality parameters of broiler chicken's meat

Ondřej Šťastník, Eva Mrkvicová, Leoš Pavlata, Miroslav Jůzl, Andrea Roztočilová, Roman Pytel, Tomáš Vyhnánek, Petr Martinek

ABSTRACT
The effect of feeding colored wheat varieties (PS Karkulka and Skorpion) on chicken´s performance and texture, color and sensory characteristics of broiler chicken´s meat were evaluated in this study. The experiment was performed with 66 of Ross 308 cockerels. Cockerels were divided into three equal groups. The two experimental groups received feed mixtures containing 40% of wheats with different grain colour: groups PS Karkulka (n = 22) with PS Karkulka wheat cultivar and Skorpion (n = 22) with Skorpion cultivar. The third group (n = 22) had 40% of common wheat Vánek cultivar (Control). The live weight of broilers between all three groups was not significant different, as well as carcass yield and chemical composition of breast and thigh meat of chickens. In the parameter Razor Shear Force was found statistically significant higher breast meat tenderness in PS Karkulka against Control and Skorpion groups. In parameters L* and b* of colour of the meat samples was found statistically significant higher value in L* parameter in Skorpion group and b* parameter was higher in Control group. The total colour change was 2.25 and 2.53 for PS Karkulka and Skorpion group, respectively. In sensory analysis of broilers breast muscle was found statistically significant differences in odour, colour, fibreness, chewiness, juiciness and flavour parameter. The fatty taste parameter was non-significant. The odour parameter of chicken´s breast muscle was significantly lower in Skorpion group against PS Karkulka and Control groups. The significantly most intense colour of breast muscle was found in Control group versus Skorpion and PS Karkulka groups (91.71 mm, 79.71 mm and 71.15 mm, respectively). The fibreness parameter was significantly higher for Control group, as well. Significantly higher chewiness of breast meat was in Control (68.49 mm) than PS Karkulka (52.02 mm) and Skorpion (43.32 mm) group. The feeding of wheat cultivars with different grain pigmentation had no effect on performance parameters of broiler chicken´s as well as to it´s body and chemical composition of breast and thigh meat in this study.

Keywords: poultry nutrition, purple pericarp, blue aleurone, meat quality, sensory traits

INTRODUCTION
Anthocyanins are found in plants in glycosylated forms, generally linked with glucose, galactose, arabinose, rhamnose, xylose and fructose **(Choi et al., 2007; Hosseinian and Beta, 2007).** Cyanidin is the most common anthocyanidin (aglycone) followed by delphinidin, peonidin, pelargonidin, petunidin and malvidin **(Oomah and Mazza, 1999)**. Anthocyanins have evoked the interest of many researchers. Anthocyanins are common constituents in colored fruits and vegetables. These substances can act as antioxidants and help in prevention of cardiovascular diseases **(Kris-Etherton et al., 2004)**, diabetes **(Patel et al., 2013)**, inflammation, cancer **(Arts and Hollman, 2005)**, obesity **(Tsuda et al., 2003)** and aging **(Chen et al., 2013)**.

The colour in wheat grain is mainly due to natural pigments (such as anthocyanins). These substances accumulate in the aleurone layer or pericarp of wheat and provide the blue, purple and red colours of the grain **(Ficco et al., 2014)**. Common wheat cultivars across the world are white (amber) in color. The colored wheat, rich in anthocyanin is quite uncommon. Black wheat resulted by the combination of genes for both purple and blue colors. Colored wheat has attracted the attention of many breeders across the world but these lines exhibit low yield compared to conventional varieties **(Martinek et al., 2014)**.

Modern bird hybrids grow very fast due to genetic selection, improved nutrition and efficient production systems. Broiler chicken´s meat have high breast meat yields due to the high demand for breast meat. Selection for fast growth and high yield chickens may have negative impact to the sensory and functional parameters of the meat **(Dransfield and Sosnicki, 1999**; **Fanatico et al., 2007)**. A range of natural substances such as propolis may positively affects the sensory quality of Ross 308 chickens meat, which is one of the most important parts for use in human food chain **(Haščík et al., 2012)**. Chickens meat from our previous study with colored wheat varieties was characterized by steady overall quality between Konini wheat and UC66049 wheat. The effect of various wheat feeding did not affect meat quality of broiler chicken´s **(Šťastník et al., 2017)**. In the previous study were evaluated a genetic resources but not a registered varieties in the Czech Republic. This study already carried out on registered varieties, thereby increasing the relevance of the study for practice.

The effect of feeding colored wheat varieties (PS Karkulka and Skorpion) on chicken´s performance and texture, color and sensory characteristics of broiler chicken´s meat were evaluated in this study.

Scientific hypothesis

The inclusion of non-traditional colored wheat varieties containing anthocyanins will influence selected quality parameters of chicken´s meat.

MATERIAL AND METHODOLOGY

The animal procedures were reviewed and approved by the Animal Care Committee of the Mendel University in Brno.

Animals and nutrition

The experiment was performed with 66 of Ross 308 cockerels. Chickens were fed with starter feed mixture until seventh day of age. From the seventh to the tenth day of the chickens a preparatory period was carried out. Chickens were fed with experimental and control feed mixtures in this period. The trial was performed from day 10 to day 36 of chick’s age. Cockerels were divided into three equal groups. The two experimental groups received feed mixtures containing 40% of wheats with different grain colour: groups PS Karkulka (n = 22) with PS Karkulka wheat cultivar and Skorpion (n = 22) with Skorpion cultivar, respectively. The third group (n = 22) had 40% of common wheat Vánek cultivar (Control). Table 1 shows proximate analyses of used wheat varieties and Table 2 shows nutrient composition of experimental diets. The rations were calculated according to the Broiler nutrition specifications **(Aviagen group, 2014a)**. The chickens were fed *ad-libitum*. Table 3 shows chemical composition of used feed mixtures.

The conventional deep litter system with wood shavings were used. Room temperature, humidity and lighting regime were controlled according to requirement for actual age of chickens in **Aviagen group (2014b)**. Health status was evaluated daily and live weight measured every week during the trial.

The chemical composition of nutrient content of diets were determined for dry matter, crude protein, ether extract, crude fibre, and ash according to Commission Regulation (EC) **(Commission Regulation, 152/2009)**. The total content of anthocyanins was measured by previous published methods **Varga et al. (2013)** and

Table 1 Chemical analysis of used wheat varieties (in dry matter).

	Control	PS Karkulka	Skorpion
Crude Protein (%)	13.40	13.68	16.76
Ether extract (%)	1.43	1.57	1.60
Crude fibre (%)	2.88	2.92	2.44
Ash (%)	1.46	1.79	1.81
Cyanidin 3-glucoside (mg.kg^{-1})	3.64	37.24	37.93

Table 2 Nutrient composition of diets (g.kg^{-1}).

Component	Control	PS Karkulka	Skorpion
Wheat	400	400	400
Soybean meal	260	260	260
Maize	205	207.5	223.7
Rapeseed oil	40.5	40.5	40.5
Wheat gluten	31	28	12.2
Premix*	30	30	30
Maize starch	20	20	20
Monocalciumphosphate	7.5	7.5	7.5
$CaCO_3$	3	3	3
L-Lysine	1.5	2.1	1.7
DL-Methionine	1.5	1.5	1.5

Note: *Premix contains (per kg): lysine 60 g; methionine 75 g; threonine 34 g; calcium 200 g; phosphorus 65 g; sodium 42 g; copper 500 mg; iron 2,500 mg; zinc 3,400 mg; manganese 4,000 mg; cobalt 7 mg; iodine 30 mg; selenium 6 mg; tocopherol 450,000 mg; calciferol 166,700 IU; phylloquinone 50 mg; thiamine 140 mg; riboflavin 230 mg; cobalamin 1,000 mg; biotin 7 mg; niaciamid 1,200 mg; folic acid 57 mg, calcium pantothenate 450 mg; choline chloride 6,000 mg; salinomycin sodium 2,333 mg.

Table 3 Proximate analysis of used diets in dry matter.

	Control	PS Karkulka	Skorpion
AME ($MJ.kg^{-1}$)*	12.61	12.61	12.62
Crude Protein (%)	23.57	23.22	23.55
Ether extract (%)	6.66	6.37	6.41
Crude fibre (%)	5.31	5.17	5.38
Ash (%)	6.41	6.23	6.10

Note: *Apparent Metabolisable Energy, calculated value.

expressed as the cyanidine-3-glucoside content.

Meat samples preparation

At the end of the experiment fifteen birds were selected randomly from each group, weighed and slaughtered. Feathers were removed, and chickens were eviscerated.

Table 4 Live weight (g) of broilers at 36th day of age.

Group	n	Mean ±standard error
Control	22	2,218 ±42.95
PS Karkulka	21	2,048 ±78.15
Skorpion	22	2,033 ±48.40

Note: Differences between groups are not statisticaly significant (*p* >0.05).

Carcass yield was calculated. Breast and leg meats without skin were separated from carcasses after cooling. All visible external fat was removed from sample meats. The breast and leg meat were weighed, and their percentage of live body weight was calculated.

The left part of breast and the left of thigh were pack up in aluminium foil, marked and stored at -20 °C until sensory analyses. Meat from the right half of breast and deboned right thigh meat were milled (in machine Moulinex Moulinette; France). Dry matter content of meat was determined by a method with sea sand and the total nitrogen according to Kjeldahl using OPSIS Liquid Line (KjelROC Analyser; KD 310-A-1015; Sweden). The crude protein content was calculated using the factor 6.0 (N*6) pertinent to meat. The content of total fat was determined gravimetrically after extraction with diethylether under reflux for 6 hours.

Texture and colour of meat

The tenderness of the raw fillets (breast muscle) was determined through the application of the Meullenet–Owens razor shear (MORS) test, using a texture analyser TIRATEST 27025 (TIRA Maschinenbau GmbH, Germany) as described by **Meullenet et al. (2004)** and **Cavitt et al. (2005)** during which Razor Shear Force (N) was recorded. Tests using the MORS blade are conducted on whole intact right fillets with 5 replicates 1-hour post mortem. The sharp blade was replaced every 80 measurements for optimum shearing performance. Test Settings: test speed 10 $mm.s^{-1}$, penetration depth was 20mm.

Colour measurement was performed by CIE L*a*b* colour space. L* (lightness), a* (redness) and b* (yellowness) values from the breast meat sample surface on the dorsal side were measured using a Spectrophotometer CM-3500d (Konica Minolta Sensing Inc., Japan) in SCE mode (specular component excluded), angle 8°, 8 mm slot. Each sample was measured at three places 1-hour post-mortem. Average value was taken as the final result. ΔE*ab **(CIE, 2007)** was calculated according next formulas **(Valous et al., 2009)**:

$$\Delta E*_{ab} = \sqrt{(L*_{control} - L*_{group})^2 + (a*_{control} - a*_{group})^2 + (b*_{control} - b*_{group})^2}$$

Sensory analysis

Sensory analysis of breast (n = 6) and leg meat (n = 6)

Table 5 Body composition of chickens.

Group	n	Carcass (%)	Breast meat (%)	Thigh meat (%)
		Mean ±standard error		
Control	15	69.4 ±0.40	21.5 ±0.55	14.7 ±0.28
PS Karkulka	15	68.0 ±0.69	20.0 ±0.69	15.1 ±0.32
Skorpion	15	66.5 ±0.31	18.6 ±0.56	14.6 ±0.22

Note: Differences between the groups are not significant (*p* >0.05).

Table 6 Chemical analysis of breast and thigh meat (%) of broilers chickens.

		n	Control	PS Karkulka	Skorpion
			Mean ±standard error		
Dry matter	Breast meat	6	24.44 ±0.40	24.31 ±0.59	24.90 ±0.26
	Thigh meat	6	24.12 ±0.33	23.42 ±0.31	24.45 ±0.16
Crude protein	Breast meat	6	22.10 ±0.61	21.89 ±0.52	21.83 ±0.29
	Thigh meat	6	17.86 ±0.33	17.65 ±0.20	17.38 ±0.21
Total fat	Breast meat	6	1.19 ±0.12	1.13 ±0.17	0.95 ±0.12
	Thigh meat	6	4.93 ±0.32	4.62 ±0.23	5.16 ±0.27

Note: Differences between the groups are not significant (*p* >0.05).

samples were evaluated by 10 panellists in special sensory laboratory (Department of Food Technology, Mendel University) according to **ISO 8589**. Each sample (breast and thigh) was packed into plastic case and frozen (-18 °C). After two weeks was thawed (cold storage room, 4 °C) and boiled in convection oven (200 °C, 60% humidity, 1 hour). Professional evaluation group was represented by a panel of trained panellists under **ISO 8586-1**. We used a graphic non-structured scale (100 mm, 0 = the worst, 100 = the best) to compare experimental group of descriptors (odour, colour, fibriness, chewiness, juiciness, flavour, fatty taste) with control group.

Statisic analysis

Data were processed by Microsoft Excel (USA) and Statistica version 12.0 (USA). One-way analysis (ANOVA) was used. To ensure evidential differences Scheffe´s test was applied and p <0.05 was regarded as statistically significant difference.

RESULTS AND DISCUSSION

Performance and body composition of chickens

Live weight of chickens was without statistically significant differences (p >0.05) among groups at the end of experiment (Table 4). This is consistent with results in chickens live weight in another study **(Šťastník et al., 2017)**.

Table 5 presents mean percentage of chicken´s body composition. There was not observed any significant differences (p >0.05). Our results of average crude protein content in breast muscle was found 22.10% for control group. No statistically significant differences (p >0.05) were found in the chemical analysis of the breast and thigh muscles (Table 6).

Table 7 Effect of feeding wheat varieties with different grain pigmentation on texture and colour of breast meat (Mean ±standard error).

Parameter	n	**Control**	**PS Karkulka**	**Skorpion**
Razor Shear Force (N)	30	5.91 ±0.17[a]	7.26 ±0.26[b]	6.03 ±0.24[a]
L*	12	65.89 ±0.54[ab]	64.97 ±1.05[a]	67.87 ±0.65[b]
a*	12	5.46 ±0.26[a]	4.53 ±0.44[a]	4.40 ±0.22[a]
b*	12	12.01 ±0.58[b]	10.18 ±0.47[a]	10.85 ±0.22[ab]
ΔE^*_{ab}		0	2.25	2.53

Note: ΔE^*_{ab} is compared with control group. [a,b] Means in a row within effect with no common superscript differ significantly (p <0.05).

Table 8 Sensory analysis of breast meat of chickens (mm in 100 mm scale).

Group		**Control**	**PS Karkulka**	**Skorpion**
		Mean ±standard error		
Sensory trait	n	60	60	60
Odour		90.49 ±1.12[b]	88.62 ±0.95[b]	84.81 ±0.92[a]
Colour		91.71 ±0.54[c]	71.15 ±1.61[a]	79.71 ±1.49[b]
Fibriness		91.54 ±0.86[b]	78.87 ±1.16[a]	80.00 ±1.13[a]
Chewiness		68.49 ±2.10[c]	52.02 ±1.42[b]	43.32 ±1.25[a]
Juiciness		43.20 ±1.44[ab]	47.33 ±1.20[b]	38.75 ±1.19[a]
Flavour		88.07 ±1.35[b]	82.70 ±1.26[a]	81.80 ±1.08[a]
Fatty taste		98.38 ±0.89[a]	99.88 ±0.08[a]	99.92 ±0.06[a]

Note: [a, b, c] – different letters in one line means statistically significant differences (p <0.05).

Table 9 Sensory analysis of broilers thigh meat (mm in 100 mm scale).

Group		**Control**	**PS Karkulka**	**Skorpion**
		Mean ±standard error		
Sensory trait	n	60	60	60
Odour		88.18 ±1.30[c]	74.78 ±1.46[a]	82.00 ±1.31[b]
Colour		89.21 ±0.87[b]	80.77 ±1.16[a]	85.52 ±1.20[b]
Fibriness		88.12 ±1.33[c]	80.52 ±0.96[b]	74.62 ±1.37[a]
Chewiness		79.42 ±1.64[b]	69.20 ±1.34[a]	69.30 ±1.69[a]
Juiciness		71.06 ±1.80[a]	68.52 ±1.36[a]	66.44 ±1.61[a]
Flavour		87.00 ±1.16[b]	80.48 ±0.90[a]	85.28 ±1.10[b]
Fatty taste		97.66 ±0.78[a]	99.65 ±0.17[b]	99.37 ±0.26[b]

Note: [a, b, c] – different letters in one line - statistically significant differences (p <0.05).

Texture and colour of chicken´s meat

Table 7 presents effect of feeding different wheat varieties with different grain pigmentation on texture and colour of chicken´s breast meat. In the parameter Razor Shear Force (N) was found statistically significant differences (p <0.05). It was found higher breast meat tenderness in PS Karkulka against Control and Skorpion groups. Between Control and Skorpion groups was not found significant differences (p >0.05).

The meat color is one of the first characteristics noticed by consumers when buying meat products **(Fanatico et al., 2007)**. In parameters L* and b* of colour of the meat samples was found statistically significant differences (p <0.05). L* parameter was higher value in Skorpion group and b* parameter was higher in Control group. Parameter a* was not statistically different (p >0.05) among experimental groups (Table 7). The total colour change was 2.25 and 2.53 for PS Karkulka and Skorpion group, respectively.

Sensory analysis

In sensory analysis of broilers breast muscle was found statistically significant differences (p <0.05) in odour, colour, fibreness, chewiness, juiciness and flavour parameter. The fatty taste parameter was non-significant (p >0.05). The odour parameter of chicken´s breast muscle was significantly lower in Skorpion group against PS Karkulka and Control groups. The significantly most intense colour of breast muscle was found in Control group versus Skorpion and PS Karkulka groups (91.71 mm, 79.71 mm and 71.15 mm, respectively). The fibreness parameter was significantly higher for Control group, as well.

Significantly higher chewiness of breast meat was in Control (68.49 mm) than PS Karkulka (52.02 mm) and Skorpion (43.32 mm) group. Results of higher chewiness of Control group breast was confirmed with the content of total fat in chicken breast meat. The amount of total fat in chicken breast influenced the sensory analysis especially odour and flavour these chicken breast. Breast meat was better evaluated with the higher content of total fat.

The lowest Razor Shear Force (N) was measured in a sample of chicken’s breast from the Control group (5.91 N), which corresponds to a sensory analysis (0 = the worst, 100 = the best), especially color (91.71 mm) and fibriness (91.54 mm) of chicken breasts. The higher Razor Shear Force (N) was measured in the Skorpion group (6.03 N) and the highest in the PS Karkulka group (7.26 N). With the higher Razor Shear Force was chicken breast evaluated as the breast with the worse color and coarse fiberness. The PS Karkulka group was significantly (p <0.05) rated as the best juiciness parameter against Skorpion group. Differences in this parameter in Control group was not significant against PS Karkulka and Skorpion groups. In flavor parameter of breast meat was found significantly better value for Control group against PS Karkulka and Skorpion group. Among PS Karkulka and Skorpion groups was non-significant differences.

The results of sensory analysis of chicken´s thigh meat shows statistically significant differences (p <0.05) in almost all monitored parameters except juiciness parameter. Odour parameter of broilers thigh meat was significantly rated as the best in Control group versus Skorpion and PS Karkulka groups. The thigh meat of PS Karkulka group was rated significantly lower for colour parameter beside Skorpion and Control groups. On the basis of evaluators, the Control group was significantly higher colour of thigh meat. The thigh muscle fibreness parameter was significantly higher in Control group against other experimental groups. In chewiness parameter was found significantly higher value for Control group. The lowest value of flavour parameter was rated in PS Karkulka thigh meat (p <0.05) against Control and Skorpion groups. In thigh meat of broiler chicken´s was found significantly lower fatty taste in the Control group versus PS Karkulka and Skorpion groups.

CONCLUSION

The feeding of wheat cultivars with different grain pigmentation had no effect on performance parameters of broiler chicken´s as well as to it´s body and chemical composition of breast and thigh meat in this study.

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Contact address:

Ondřej Šťastník, Mendel University in Brno, Faculty of AgriSciences, Department of Animal Nutrition and Forage Production, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: ondrej.stastnik@mendelu.cz.

Eva Mrkvicová, Mendel University in Brno, Faculty of AgriSciences, Department of Animal Nutrition and Forage Production, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: eva.mrkvicova@mendelu.cz.

Leoš Pavlata, Mendel University in Brno, Faculty of AgriSciences, Department of Animal Nutrition and Forage Production, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: leos.pavlata@mendelu.cz.

Andrea Roztočilová, Mendel University in Brno, Faculty of AgriSciences, Department of Animal Nutrition and Forage Production, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: xroztoc@mendelu.cz.

Miroslav Jůzl, Mendel University in Brno, Faculty of AgriSciences, Department of Food Technology, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: miroslav.juzl@mendelu.cz.

Roman Pytel, Mendel University in Brno, Faculty of AgriSciences, Department of Food Technology, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: roman.pytel@mendelu.cz.

Tomáš Vyhnánek, Mendel University in Brno, Faculty of AgriSciences, Department of Plant Biology, Zemědělská 1, 613 00 Brno, Czech Republic, E-mail: tomas.vyhnanek@mendelu.cz.

Petr Martinek, Agrotest fyto, s.r.o., Havlíčkova 2787/121, 767 01 Kroměříž, Czech Republic, E-mail: martinek@vukrom.cz