

The influence of baical skullcap root (*Scutellaria baicalensis radix*) in the diet of broiler chickens on the chemical composition of the muscles, selected performance traits of the animals and the sensory characteristics of the meat

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ABSTRACT: The aim of this study was to evaluate the effect of the baical skullcap root (*Scutellaria baicalensis radix*) on the performance, chemical composition of the muscles and sensory characteristics of the meat of broiler chickens. 120 one-day old Hubbard Hi-Y broiler hybrids were assigned to four groups of 30 each and fed either a basal diet (control) or a basal diet supplemented with 0.5%, 1.0% or 1.5% ground root of skullcap. The body weight, weight gain, feed consumption and feed : gain ratio were calculated after 42 days. The addition of the ground baical skullcap root to the fodder had no effect on the quality or chemical composition of the breast and leg muscles of the broiler chickens. However, it positively influenced some of the performance characteristics of the chickens.

Keywords: chemical composition; meat quality; skullcap root

There is a growing interest in the use of natural products like herbs, spices and plant extracts in the human food and animal feed industries. Herbs and spices are classified as flavours and appetizers under current EU legislation. The use of plant additives is not without risks, either because the cumulative amount of the active ingredients may reach harmful levels, or due to side effects of one or more of the intrinsic ingredients. At high levels, some active ingredients, such as tannins, hemagglutinins, saponins, and cyanogenic substances, may exert an antinutritional effect in animals (Jamroz et al., 2003).

On the other hand, supplementing the diet with plant material that is rich in active substances with beneficial effects for general health and for the im-

mune system has been used as an alternative to antibiotic growth promoters. It has also been reported to have some positive effects on production traits and the environment, as well as satisfying consumer demand for safe food (Cross et al., 2002; Hernandez et al., 2004).

In the cases of the diets of hens and broiler chickens, the addition of plant material, especially herbs, can have a positive influence on some physiological characteristics, on egg production and quality, and on carcass and meat quality (Wezyk et al., 2000; Kroliczewska et al., 2004;). However, not all consumers accept the use of such herbal additives, because some, including rosemary, sage, oregano and thyme, may give a new odour, taste and/or colour to the produced food.

Dry root of *Scutellaria baicalensis* Georgi (Labiatae) is officially listed in the Chinese Pharmacopoeia. It is a perennial herb that has long been used in official and traditional medicine, mainly in Russia, Japan, Korea, and Mongolia. Although it is a little-known plant in Poland, it grows perfectly well in our climate. It has a particularly high content of compounds that serve as modifiers of inflammatory processes, e.g. against bacterial infections, and also has antiviral, antitumor, antioxidative and hepatoprotective properties (Gao et al., 1999; Chan et al., 2000; Bochorakova et al., 2003; Shen et al., 2003; Wozniak et al., 2004).

The principal active compounds determining skullcap's pharmacological properties are found in its roots and short rhizomes. The high level of physiological and therapeutic activities of skullcap root extracts is due to the presence of almost 70 flavonoids: chalcones, flavanones, flavones, flavanonols, flavonols, and anthocyanidines. Flavones (wogonin, baicalein, and baicalin) and their glycosides (mainly glucuronides) are the most abundant (Figure 1). The total content of flavonoids in the roots of wild-grown skullcap varies from 15 to 20% of the dry weight (12–17% is baicalin, a flavone glucuronide, and 3–4% is wogonin), with glycosides predominating. At harvest, the dry weight of roots is 10–15 g per plant (Tang and Eisenbrandt, 1992; Oszmianski, 2002).

The aim of this study was to evaluate the effect of supplementary skullcap root in the diet of broiler chickens on the animals' performance traits, the chemical composition of their muscles, and the sensorial characteristics of the meat.

MATERIAL AND METHODS

Plant material and growth conditions

Scutellaria baicalensis plants were grown from authenticated seeds obtained from the Botanical

Garden of the Medicinal Plant Herbarium at the Medical University in Wroclaw, Poland, with cultivation in the University's experimental field. The seeds were sowed in sandy soil in the spring of 2000, and roots from the plants were harvested the following September. Voucher specimens were deposited at the herbarium. The collected roots were washed in distilled water, and dried under controlled humidity at room temperature until a moisture content of 5% was reached. The dried roots were then crushed using a laboratory mill and stored at -20°C .

Animals, diets and experimental design

120 one-day old Hubbard Hi-Y male broiler hybrids were randomly allocated into four treatment groups. Each treatment was replicated 5 times with six birds per replicate pen in a battery brooder. All the pens were equipped with feeders and water. The birds were fed either a basal diet or that diet supplemented with ground dried root of skullcap.

The birds were fed a starter diet for 21 days, followed by a finishing (grower) diet from Day 21 to 42. The basal diets were formulated using NRC (1994) guidelines, and contained 18.50–20.10% crude protein and 12.13–12.55 MJ/kg metabolizable energy. The ingredients and chemical compositions of the starter and grower basal diets are shown in Table 1.

The dietary treatments consisted of the basal diet supplemented with 0 (control), 0.5%, 1.0% and 1.5% ground dried baical skullcap root (BSR) (*Scutellaria baicalensis radix*). Small amounts of the basal diets were first mixed with the respective amounts of BSR and then with a larger amount of the basal diet until the total amount of the respective diets were homogeneously mixed. The diets and fresh water were provided *ad libitum*. The chicks were housed in electrically heated battery pens.

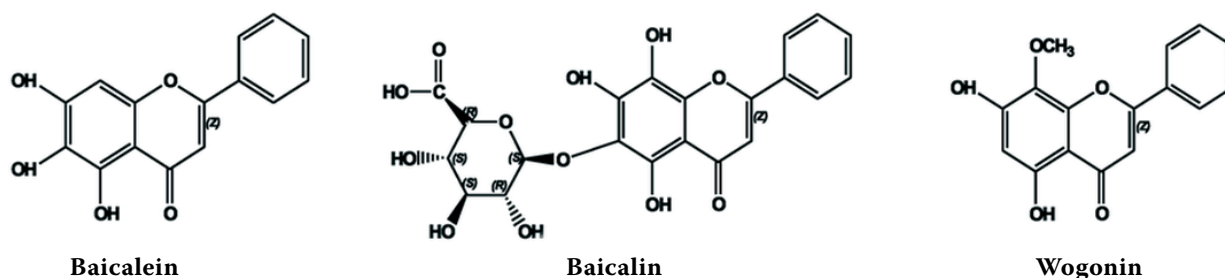


Figure 1. The structures of the major flavones isolated from skullcap roots

Table 1. Composition of the basal diets for the broiler chickens (in g/kg DM)

Ingredients	Starter (1–21 days)	Grower (22–42 days)	Chemical and calculated analyses	Starter (1–21 days)	Grower (22–42 days)
Maize	375.0	510.0	Metabolizable energy (MJ/kg)	12.13	12.55
Wheat	220.0	150.0	Crude protein	201.0	181.5
Soybean meal	285.0	230.0	Crude fibre (max.)	40.0	40.0
Meat meal	33.6	46.6	Ash	56.2	57.1
Plant oil	50.0	30.0	Crude fat	53.1	49.8
Calcium carbonate	2.0	3.0	Lysine	12.3	11.4
Dicalcium phosphate	19.5	15.0	Methionine + cystine	9.2	8.6
NaCl	3.0	3.0	Tryptophan	2.1	2.0
DL-methionine	2.6	2.6	Calcium	9.5	8.5
Vitamin and mineral premix*	10.0	10.0	Phosphorus	6.9	7.1
			Available phosphorus**	4.0	4.0

*Vitamin and mineral premix provided per kilogram of diet: vitamin A (retinol), 10 000 IU; vitamin D3 (cholecalciferol), 2 500 IU; vitamin E (α -tocopheryl acetate), 35 mg; pantothenic acid, 10 mg; B1, 3 mg; B2, 7 mg; B12, 0.01 mg; niacin, 25 mg; folic acid, 1.5 mg; choline, 950 mg; vitamin K, 1 mg; biotin, 0.15 mg; Mn, 60 mg; Zn, 50 mg; Fe, 40 mg; Cu, 6 mg; Se, 0.15 mg

**Calculated on the basis of P-availability from Nutrient Requirements (1996)

Sample and laboratory analysis

The chemical compositions of the diets were determined according to standard methods (AOAC, 1990). The phosphorus content in the diets was analyzed after previous mineralization by the ammonium vanadomolybdate method using a Beckman DU 800 Spectrophotometer at a wavelength of 470 nm. The calcium content in the diets was determined using inductively coupled atomic emission spectroscopy, as described by McQuaker et al. (1979).

All the chickens in each pen were weighed in groups at the beginning and at the end of the experiment. Weight gain was calculated from this data. The feed which was consumed per pen was recorded and the feed:gain ratio was calculated. At the end of the experiment, ten chickens per group

were taken randomly as a representative sample and were slaughtered. The carcasses were dissected manually and the breast and leg meat (thigh and shank) was saved for further analysis.

The basic chemical analysis of the muscles was determined using standard methods: the crude protein content (CP) by the Kjeldahl method, acc. to Polish Standard PN-75/A-04018 (1975); dry matter (DM) by the thermal method (105°C), acc. to Polish Standard PN-ISO 1442 (2000); crude ash (CA) acc. to Polish Standard PN-72/A-82245 (1972); crude fat (CF) by the Soxhlet method, acc. to Polish Standard PN-ISO 1444 (2000); and the pH value acc. to Polish Standard PN-ISO 2917 (2001).

The colour of the muscles was determined by the colorimetric method according to accepted standards using a tristimulus analyser (Minolta ChromaMeter CR-200). The results were presented

Table 2. Growth performance of chickens fed experimental diets from 1 to 42 days of age

Parameter	Dietary treatments			
	Control	0.5%	1.0%	1.5%
Final body weights (g)	1 741 ^a ± 22	1 783 ^b ± 132	1 773 ^b ± 112	1 855 ^c ± 102
Weight gain (g)	1 702 ^a ± 82	1 744 ^b ± 18	1 733 ^a ± 29	1 816 ^c ± 24
Feed consumption (g)	3 055 ^b ± 29	2 942 ^a ± 21	2 986 ^a ± 24	3 138 ^b ± 19
Feed : gain ratio (g : g)	1.79 ± 0.04	1.68 ± 0.02	1.72 ± 0.02	1.72 ± 0.02

Means in the same column with different superscripts are significantly different ($P < 0.05$)

in the “Hunter Lab” scale, as L^* , a^* , b^* , respectively corresponding to lightness, redness, and yellowness (Commission Internationale de l’Eclairage, 1976; Uijttenboogaart et al., 1993).

Subjective traits of meat quality were assessed in a sensoric evaluation of roasted samples of breast and leg meat from 10 chickens per group: a test panel consisting of five people judged the meat samples for their colour, flavour, taste, tenderness, juiciness and overall acceptability. Whole samples of breast and leg meat without any additives (salt or spice) were placed in an electric oven preheated to 180°C, until an internal temperature of 80°C was reached. Samples were served individually to each of the trained panelists in hermetic plastic containers immediately after roasting. A 5-point scale was used: 1 = very disagreeable; 2 = moderately disagreeable; 3 = slightly agreeable; 4 = agreeable; 5 = very agreeable (Cross et al., 1986).

Statistical analysis

The results obtained were processed using the program STATISTICA for Windows ver. 7.0. All of the numerical data was analyzed by one-way ANOVA to test for the effects of the dietary treatments. The treatment effects were considered at $P < 0.05$. The statistical evaluation of the obtained data is given in the tables as the mean (\bar{x}) and standard deviation (SD). For factors that showed significant P -values in the ANOVA table and that do not interact with other factors, a further analysis was performed via the Multiple Range Tests with the Fisher’s least significant difference (LSD) procedure. With this method, there is a 5.0% risk of calling each pair of means significantly different when the actual difference equals 0. The differences in treatment effects between muscles were included in a GLM model. The estimated least squares mean (LS mean) and the estimated standard error of the

least squares mean (LS Sigma) were calculated. The model included the dietary BSR concentration and the chemical composition of the leg and breast muscles as the main effects and their interaction.

RESULTS AND DISCUSSION

The results for the production traits of chickens fed with and without the addition of the ground baical skullcap root are presented in Table 2. The addition of baical skullcap root to the chicken fodder affected the final body weight of the birds. On the 42nd day of breeding, the final weights of the chickens in the three experimental groups were higher than the final weight of the control group chickens by 4.5% for the group with a 0.5% supplement, 4.0% for the 1.0% group, and 6.1% for the 1.5% group ($P < 0.05$). Also, the increase in fodder consumption was up to 6% higher in the experimental groups/in the group receiving the fodder with the highest concentration of additives.

The presented results concerning chicken feeding with supplementary baical skullcap were positive with regard to bird breeding parameters. Hernandez et al. (2004) obtained similar results in their studies of the influence of supplementary plant extracts of the *Labiatae* family to broiler chicken fodder. About 3% body weight growth in comparison to the control group was observed after 42 days on the diet. Jamroz et al. (2005) studied Hubbard Hi-Y broiler hybrids chickens fed with a diet based on maize or wheat or barley with added plant extracts containing capsaicin, cinnamaldehyde and carvacrol, and demonstrated that the body weight of the birds was not relatively higher, but that fodder utilization increased by 4.2% in the case of a maize-based diet and by 2.0% in the case of wheat- and barley-based diets. In earlier studies, Jamroz et al. (2003) demonstrated that, in comparison to the control group, the birds’ body weight had increased

Table 3. The chemical composition of the breast muscles of broiler chickens ($n = 10$, mean \pm SD)

Dietary treatments	DM (%)	CP (%)	CF (%)	CA (%)	pH
Control	26.78 ^a \pm 0.31	22.82 ^a \pm 0.15	2.46 ^b \pm 0.20	1.17 \pm 0.10	5.73 \pm 0.01
0.5%	27.21 ^b \pm 0.30	23.45 ^b \pm 0.26	2.32 ^a \pm 0.18	1.23 \pm 0.08	5.67 \pm 0.02
1.0%	26.95 ^a \pm 0.42	23.20 ^b \pm 0.14	2.28 ^a \pm 0.26	1.18 \pm 0.09	5.71 \pm 0.03
1.5%	27.34 ^b \pm 0.11	23.28 ^b \pm 0.23	2.48 ^b \pm 0.15	1.28 \pm 0.11	5.68 \pm 0.02

DM = dry matter, CP = crude protein, CF = crude fat, CA = crude ash

Means in the same column with different superscripts are significantly different ($P < 0.05$)

Table 4. The chemical composition of the leg muscles of broiler chickens ($n = 10$, mean \pm SD)

Dietary treatments	DM (%)	CP (%)	CF (%)	CA (%)	pH
Control	27.16 ^b \pm 0.41	19.82 \pm 0.14	6.00 ^c \pm 0.42	1.1 ^c \pm 0.09	6.18 \pm 0.03
0.5%	26.40 ^a \pm 0.25	19.72 \pm 0.66	5.72 ^b \pm 0.42	0.80 ^a \pm 0.06	6.26 \pm 0.02
1.0%	26.26 ^a \pm 0.28	19.73 \pm 0.23	5.60 ^a \pm 0.18	0.98 ^b \pm 0.03	6.24 \pm 0.04
1.5%	27.02 ^b \pm 0.20	19.99 \pm 0.31	5.88 ^c \pm 0.31	0.95 ^b \pm 0.08	6.22 \pm 0.01

DM = dry matter, CP = crude protein, CF = crude fat, CA = crude ash

Means in the same column with different superscripts are significantly different ($P < 0.05$)

by Day 21 of the experiment, by 5.4 and 8.1% ($P < 0.01$), respectively with the application of 150 and 300 ppm of herbal extract. Also, fodder utilization respectively increased by 3.1 and 7.1% ($P < 0.05$).

Horton et al. (1991) and Freitas et al. (2001) showed that, in broiler chickens fed a diet supplemented with a commercial garlic product, body weight gain and the feed : gain ratio were not affected. However, Lewis et al. (2003) and Demir et al. (2003) reported a trend towards improved body weight gain and a higher feed : gain ratio in broiler chickens given low concentrations of a commercial garlic product. The data from this study also indicates a trend towards improved body weight gain and a higher feed : gain ratio in broiler chickens receiving the skullcap root extract in their diet.

The production results of poultry breeding and the quality of the carcasses and meat depend to a high degree on feeding, including the antioxidant level included in the fodder (Kang et al., 2001). Dry root of *Scutellaria baicalensis* has a high content of flavonoids, which are natural antioxidants. Natural dietary antioxidants may be a better alternative to post-slaughter stabilization, because intact poultry meat is non-homogenous and may prevent an even distribution of antioxidants. Natural antioxidants may also supplement the antioxidant effects at the cellular level. Therefore, incorporating natural plant antioxidants by dietary means may be more effective and economical in controlling post-slaughter lipid peroxidation, and may be an alternative way of adding more of these health-enhancing nutrients to human diets (Asghar et al., 1990; Kang et al., 2001).

The supplementation of dietary mixtures for poultry with medicinal plants has been practiced for some time. However, due to consumer requirements, the physico-chemical and sensory characteristics of the meat should also be considered, not just the production effects on breeding. Chicken meat is very important in the human food industry. The alimentary value of poultry meat is higher

than that of large slaughter animals' meat, since it includes less cholesterol, collagen and total fat. Obtaining proper quality poultry meat depends not only on genetic potential but also on alimentary factors (Kang et al., 2001).

The results of the physico-chemical tests of the breast and leg muscles are presented in Tables 3 and 4. The dry matter content in the breast muscle of the chickens given the 1.5% supplement was significantly higher than in the chickens fed the control diet (0.6%, $P < 0.05$; Table 3). However, in the leg muscle, we observed a smaller amount of dry matter with 0.5 and 1.0% supplementation, and no effect with 1.5% supplementation in comparison to the chickens on the control diet.

The protein content was higher in the breast muscle of the chickens that had the baical skullcap root supplement in their diet than in that of the control group ($P < 0.05$), whereas in the leg muscle, no significant effects were seen.

The breast muscles contained only half the amount of fat that was detected in the leg muscle. Supplementation with 1.0% BSR led to significantly lower values of fat in both breast and leg muscles, but 1.5% supplementation apparently had no effect on the fat content in the muscles. Supplementation with BSR had no effect on the ash content in the breast muscle, whereas in the leg muscle, a significantly lower ash content was observed at all values of supplementation (Tables 3 and 4). The data from this study also demonstrates a different influence of BSR supplementation on the chemical characteristics of the leg and breast muscles (Tables 3, 4 and 5). The effect on leg muscle is significantly higher probably due to the metabolic levels. Table 5 shows the results of the multiple comparison procedure of DM, CF, CP and CA. All the data was subjected to analysis by ANOVA using the GLM procedure to determine which means are significantly different from which others. The estimated difference between the pairs of leg and breast

Table 5. This table applies a multiple comparison procedure to determine which means are significantly different from which others, and shows the estimated difference between leg and breast pairs of means

Parameter	Muscle	LS mean	LS sigma	Difference	+/- Limits
DM	leg	26.7096	0.198483	0.107917	0.893307
	breast	26.8175			
CP*	leg	19.8154	0.075998	3.12208	0.224196
	breast	22.9375			
CF*	leg	5.72417	0.062433	-3.35167	0.184178
	breast	2.3725			
CA*	leg	0.95625	0.0208737	0.260417	0.0615775
	breast	1.21667			

DM = dry matter, CP = crude protein, CF = crude fat, CA = crude ash

*There are statistically significant differences between any pair of means at the 95.0% confidence level

means is also shown. In this experiment, supplementation decreased the level of CF and increased the CP content in the broiler chickens' breast muscles. Wezyk et al. (2000) also demonstrated a decreased fat content in the breast muscles of Arbor Acres chickens given a herbal supplement; however, they found that this characteristic depended on the birds' origin.

Generally, pH is a direct reflection of muscle acid content, which affects shear force, drip loss and meat colour. Low pH reduces the importance of myoglobin absorption of green light, resulting in a meat colour that appears less red and more yellow. Muscle pH variation is also related to glycogenolysis, and increased catecholamine secretion in response to an acute stressor just prior to slaughter increases glycogen breakdown and the rate of pH decline post-slaughter while the carcass temperature is still high (Ji et al., 2006). The data from this study indicates that the addition of skullcap root to the

diets of broiler chickens had no effect on breast and leg muscle pH. BSR had no effect on the ultimate pH in either the breast muscle or in the leg muscle.

The conducted colour evaluation (Table 6) of the breast muscles of the chickens demonstrated that the addition of baical skullcap root to the diet had no effect on colour. At 1.5%, the supplement significantly influenced the leg muscle colour in comparison to the control group (Table 6) with regard to brightness L^* reduction; however, since the redness (index) increased, it was possible to speak about colour darkening. Adding plant supplements to dietary mixtures may not only influence breeding effectiveness, but also the colour of the birds' carcasses and their sensory value. Colour is a major criterion that can be used by consumers to judge meat quality. The L^* value is important in white muscles and correlates with drip loss and pH (Barbut, 1997; Roberts et al., 2001). However, in our own studies, we did not observe any influ-

Table 6. Colorimetric evaluation of muscle colour ($n = 30$, mean \pm SD)

Groups	Colour	Dietary treatments			
		Control	0.5%	1.0%	1.5%
Breast muscle	L	61.13 \pm 2.71	60.01 \pm 2.08	60.66 \pm 5.58	60.45 \pm 2.85
	a	4.20 \pm 1.01	3.51 \pm 0.53	4.46 \pm 0.98	4.93 \pm 1.94
	b	9.76 \pm 2.01	9.6 \pm 1.3	11.03 \pm 3.22	11.63 \pm 2.76
Leg muscle	L	59.5 ^b \pm 3.07	55.46 ^a \pm 4.83	58.65 ^b \pm 2.96	54.43 ^a \pm 1.25
	a	12.45 ^b \pm 2.79	10.56 ^a \pm 1.21	11.45 ^a \pm 2.32	13.46 ^c \pm 1.33
	b	10.85 \pm 2.75	9.36 \pm 1.29	10.28 \pm 1.61	10.48 \pm 0.99

L = lightness scale 0–100, a = redness, b = yellow

Means in the same row with different superscripts are significantly different ($P < 0.05$)

Table 7. Sensoric evaluation of breast and legs meat with grades from 1 (very disagreeable) to 5 (very agreeable), $n = 10$

Dietary treatments	Colour	Flavour	Taste	Tenderness	Juiciness	General impression
Control B	4.6	4.5	3.9	4.5	4.1	4.1
0.5% B	4.7	4.1	4.5	4.5	4.1	4.5
1.0% B	4.5	4.1	4.4	4.4	4.5	4.2
1.5% B	4.1	4.2	4.0	4.2	4.5	4.4
Control L	4.7	4.7	4.7	4.9	4.5	4.5
0.5% L	4.5	4.1	4.1	4.2	3.9	4.4
1.0% L	4.5	4.0	3.9	4.6	4.4	4.1
1.5% L	4.5	4.0	3.9	4.5	3.7	4.4

B = breast meat, L = leg meat

ence of baical skullcap on the breast muscle colour. Darkening of the leg muscles and redness increase was observed, which might indicate an increase in the hem pigments. The results of this study are in agreement with those in earlier reports by Fritz (1999) and Gornowicz (2004) where broiler Ross 308 chickens were given an oregano extract.

The sensory analysis, which included colour, flavour, taste, tenderness, juiciness and tout ensemble (general impression), showed that BSR supplementation had no effect on any of the estimated traits. It should be emphasized that the obtained evaluation results were very high in all cases, ranging from 4.1–4.7 for breast muscles to 3.7–4.7 for leg muscles on a 5-point scale (Table 7). In our experiments, there were no significant differences in the various characteristics of the subjective quality traits of breast and leg meat.

In summary, it can be said that the addition of the ground baical skullcap root to fodder did not worsen the quality or chemical composition of the breast and leg muscles of broiler chickens. It did positively influence the breeding parameters of the chickens.

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