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Growth performance, blood cell profiles, and meat quality properties of broilers fed with *Saposhnikovia divaricata*, *Lonicera japonica*, and *Chelidonium majus* extracts

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ABSTRACT

An experiment was conducted to evaluate the effect of 3 plant extracts, *Saposhnikovia divaricata* extract (SDE), *Lonicera japonica* extract (LJE), and *Chelidonium majus* extract (CME) on growth performance, blood cell profiles, and meat quality in broilers. Qualitative and quantitative analysis of the compounds of phenolic acids and flavonoids was performed by high performance liquid chromatography with diode-array detection for characterization of the selected extracts. Total amounts of phenolic acids and flavonoids in the extracts were in the order of LJE, CME, and SDE. These extracts were added at a rate of 0.2% to the starter and finisher basal diets of broilers, and a feeding study was conducted in battery cages for a period of 5 week. A total of 240, one-day-old male Arbor Acres broilers were allotted to 4 treatments with 4 replicate cages and 15 broilers per cage. The results indicated that daily weight gain was greater in the CME treatment groups and the plant extract treated groups (SDE+LJE+CME) than the control group ($P=0.044$, $P=0.036$, respectively), while feed intake was not different among the groups. The feed conversion of broilers fed the SDE-supplemented diets was lower than the control groups ($P=0.044$). White blood cells, neutrophils, lymphocytes, monocytes, and eosinophils in broilers fed the LJE, CME, and plant extract-supplemented diets (SDE+LJE+CME) were greater than those fed the control diets ($P<0.05$). In addition, red blood cells, hemoglobin, and hematocrit were also elevated in broilers fed the LJE diets. Volatile basic *N* and thiobarbituric acid reactive substance values of broiler breast meat was reduced by the addition of LJE or CME, respectively ($P=0.036$, $P=0.023$, respectively). No changes were observed in the meat color, pH, cooking loss, drip loss, fatty acid concentrations, and texture properties, except for the adhesiveness of broiler breast meat, which was increased by the addition of SDE, LJE, and plant extract-supplemented diets (SDE+LJE+CME) compared with the control ($P<0.001$). These results indicate that supplementation of these plant extracts in the broiler diet may potentially improve weight gain, blood cell profiles, and meat qualities.

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1. Introduction

Increasing trends of antibiotic resistant bacteria have led researchers to adopt natural alternative additives, such as probiotics, enzymes, organic acids, and various plant extracts, as a feed additive in animal production (Adil et al., 2011; Khan et al., 2012). Among them, plant extracts have been derived from various plant sources for use as a feed additive, and many have shown potential benefits for broilers (Chen et al., 2003; Hossain et al., 2012; Orengo et al., 2012). In recent years, many investigators have been testing the inclusion of plant extracts as a growth promoter or immune enhancer in poultry production, and they have demonstrated that the plant extracts have the potential as a suitable replacement to antibiotics, as well as an antioxidant (Cross et al., 2007; Hernandez et al., 2004; Windisch et al., 2008). Those active components in the plant are chemical compounds that are present in the entire plant or in specific parts of the plant, which may have a therapeutic activity or beneficial effects. These substances, which have low molecular weight and are derived from the plant's secondary metabolism, include flavonoids, phenolic compounds, tannins, isoprene, saponins, terpenoid, and essential oils (Cowan, 1999). These compounds are produced by a range of plants for defense against external factors, such as physiological stress, environmental factors, and pathogens (Huyghebaert, 2003).

Saposhnikovia divaricata have been traditionally used as medicine for anti-inflammatory, analgesic, diaphoretic, antipyretic, antibiotic, and antivirus purposes in eastern Asia, including Korea (Lee et al., 2003; Wang et al., 1999). Moreover, it has been reported that panaxynol extracted from *Saposhnikovia divaricata* inhibits the proliferation of cancer cells by inhibiting the cell cycle between the G1 phase and S phase (Wang et al., 2000). *Lonicera japonica* is native to eastern Asia, including Korea, and has been traditionally used as a medicinal plant with notable anti-inflammatory functions. This extract is also known for its other biological and pharmaceutical properties, including antibacterial, antiviral, antiangiogenic, antinociceptive activities, and liver protection (Xiang et al., 2001; Yoo et al., 2008). In addition, *Chelidonium majus* is a plant that is highly praised worldwide for its therapeutic potential, which has recently attracted attention for its pharmacologic actions, such as anti-inflammatory, antimicrobial, immunomodulatory, antitumoral, choleretic, hepatoprotective, analgesic, and anticancer (Yang et al., 2011).

Although the addition of medicinal plant extracts to animal diets is not a new idea, the effects of their addition (*Saposhnikovia divaricata, Lonicera japonica*, and *Chelidonium majus*) have not yet been widely confirmed in broilers or livestock. Therefore, the objective of this study was to investigate the effect of the dietary addition of 3 medicinal plant extracts on the growth performance and blood cell profiles of broilers, and their effect on the breast meat quality of broilers.

2. Materials and methods

2.1. Preparation of medicinal plant extracts

Medicinal plants (*Saposhnikovia divaricata, Lonicera japonica*, and *Chelidonium majus*), which were cultivated in Korea were purchased (Kumho Market, Seoul, Korea). The plant material was air dried at room temperature (26 °C) and in darkness for 30 d, and was then powdered with a mill (IKA M 20; IKA, Staufen, Germany). The dried sample was extracted with distilled water (1:10) at 80 °C, and was then refluxed for 6 h to obtain an initial extract (fraction I). The residues were extracted with distilled water (1:5) at 80 °C for 2 h to obtain fraction II. After cooling to room temperature and filtering (Whatman No. 2; Whatman Ltd., Kent, UK), the 2 fractions were combined, and dried under vacuum below 40 °C. Two kinds of extracts were completely dried in a freeze-drier and stored at −20 °C until further use.

2.2. Extraction and purification of phenolic acids and flavonoids

A 0.1-g extract was mixed with 50 mL of acidified 50% methanol (formic acid, pH 2.39). Then, the extract was centrifuged at 3000g for 10 min at 4 °C, and the supernatant was collected. The supernatant was evaporated in a rotary evaporator at 40 °C. The residue was then dissolved in 10 mL of solvent containing 0.01 mg/ml of *p*-coumarin, and was filtered through a 0.45-μm membrane filter, and 10 μL was injected for high performance liquid chromatography with diode-array detection (HPLC-DAD; Agilent 1100; Agilent Technologies, Santa Clara, CA) analysis.

2.3. Analytical condition of HPLC-DAD

Analysis of the compounds in the extract was performed using HPLC-DAD. Samples were separated on a column (Nucleosil 100-5 C18 Column: 250 mm × 4.0 mm i.d., 5 μm particle size; Macherey-Nagel, Dueren, Germany) which was protected by a 10 mm guard column with a gradient elution system. The mobile phase consisted of 2 solvents: solvent A was a mixture of water/formic acid (pH 3.29), and solvent B was 100% acetonitrile/formic acid (pH 3.29). Gradient elution was performed as follows: initially, 7% of solvent B, followed by 0–15% B in 25 min, 30% B at 35 min, 40% B at 50 min, 100% B at 45 min, and 100% B at 55 min. The flow rate was 1 mL/min, and the column temperature was 30 °C. The phenolic compounds in the samples were identified by comparing their retention times using standards. The injections of sample and standard were performed in triplicate.

2.4. Experimental design

A 5-week experiment with 240 one-day-old male Arbor Acres broilers (38.0 ± 0.1 g) was conducted. Broilers were individually weighed and were assigned to stainless steel battery cages (1.50 × 0.65 m^2) based on their body weights. There were 15 broilers per cage and 4 replicate cages per experimental treatment. The temperature in the poultry house was gradually reduced from 35 °C on day 1, to 18 °C on day 35, light was on continuously. Fresh feed and water were provided. The feeding program consisted of a standard starter diet until 21 d and a finisher diet until 35 d of age (Table 1). Broilers for the control group were given diets without additives (CON). The other 3 treatment groups were given the same diets supplemented with 0.2% *Saposhnikovia*

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