Effects of *Scutellaria baicalensis* and *Lonicera japonica* extract mixture supplementation on growth performance, nutrient digestibility, blood profiles and meat quality in finishing pigs

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**ABSTRACT**

A total of 135 [(Landrace × Yorkshire) × Duroc] finishing pigs with initial body weight (BW) of 44.2 ± 2.23 kg were used in this 12-wk trial to evaluate the effects of an herbal extract mixture (*Scutellaria baicalensis* and *Lonicera japonica*, HEM) supplementation on growth performance, nutrient digestibility, blood profiles and meat quality. The dietary treatments were supplemented with 0, 0.025% and 0.05% HEM, respectively. There were 9 replications per treatment with 5 pigs per pen. During 1–6 wk, the inclusion of HEM linearly increased (*p < 0.05) the final BW and average daily gain (ADG). During 7–12 wk, dietary HEM supplementation led to a greater (linear, *p < 0.05) final BW at the end of 12 wk. Throughout the experiment, the overall ADG and gain: feed ratio were increased (linear, *p < 0.05) in pigs fed HEM supplemental diet. The administration of HEM improved (linear, *p < 0.05) the nutrient digestibility of dry matter, nitrogen and energy. Providing HEM diet also reduced (linear, *p < 0.05) the serum cortisol concentration. Furthermore, the inclusion of graded levels of HEM linearly increased (*p < 0.01) the pH of meat, and the 2-thiobarbituric acid reactive substances (TBARS) were linearly decreased (*p < 0.05) by HEM supplementation. Taken together, administration of HEM (0.025% and 0.05%) could improve growth performance and nutrient digestibility, decrease serum cortisol levels, as well as benefit the meat quality in finishing pigs.

**Introduction**

Herbs and their extracts have been used in human and veterinary medicine for a long time (Costa et al. 2013). There is evidence to suggest that the herbs possess antimicrobial, anti-viral, anti-inflammatory and antioxidant properties, as well as the ability to improve digestibility and absorption of nutrients, modify intestinal microbiota and stimulate appetite and immune system (Dorman & Deans 2000; Namkung et al. 2004; Oetting et al. 2006; Utiyama et al. 2006). Considering the above benefits, the herbal extracts have been extensively tested in swine diets as potential alternatives to antibiotics growth promoters. For instance, Namkung et al. (2004) indicated that herbal extracts could reduce the proliferation of coliform bacteria in post-weaning pigs. Yan et al. (2012a) reported that a complex herbal extracts had beneficial effects on nutrient digestibility and gut microbial flora in weaning pigs. In addition, the positive effect of herbal extract has been observed in growing and finishing pigs (Wang et al. 2007; Yan et al. 2011a, 2011b). However, the inconsistent results of the experiments on various herbal materials have also been reported (Nofrarias et al. 2006; Oetting et al. 2006; Ao et al. 2011; Costa et al. 2011). This suggested that the health-related effects of herbs depend on their content of active principles.

*Scutellaria baicalensis* contains abundant flavones, mainly baicalein, baicalin, wogonin, oroxylin A (Table 1), which not only exert anti-inflammatory activity, but also provide antioxidative function (Li et al. 2004), this may benefit the meat quality. Another plant with similar properties is *Lonicera japonica*, which contains organic acids, flavones, iridoids and saponins (Shang et al. 2011). Previously, it has been suggested that a complex mixture of herbal extracts has more biological effective than each of the extract alone (Shoba et al. 1998; Wagner & Ulrich-Merzenich 2009). Thus, we hypothesise that the herbal extract mixture (HEM) made from *S. baicalensis* and *L. japonica* may exert positive effects on growth performance and meat quality in pigs. However, to the best of our
knowledge, no study has yet attempted to evaluate the use of S. baicalensis and L. japonica extract mixture in swine diets. Therefore, the objective of the herein study was to assess the effects of dietary HEM supplementation on growth performance, nutrient digestibility, blood profiles and meat quality in finishing pigs.

Materials and methods

Animal care and data collection procedures for the present study were approved by the Animal Care and Use Committee of Dankook University.

Preparation of herbal extract mixture

The dietary additive used in the present study was composed of two dried herbs including Scutellaria baicalensis and Lonicera japonica, which were bought from a local medicine market in Korea. In brief, the dried plant materials (whole plant, except the seeds of Lonicera japonica) were chopped and pulverised to pass 100 mesh (2 mm). Then, 100 kg of each powdered medicinal herb was extracted with 70% methanol (200 L) by a large-scale extractor (CoBiotech, Seoul, Korea) at room temperature for 24 h. The 70% methanol solution was filtered 2–3 times through cheese-cloth, and the filtrate was evaporated under vacuum, after which the evaporated filtrate was freeze-dried and crushed in the form of powder extract. Finally, a mixture of 55% Scutellaria baicalensis powder extract, 25% Lonicera japonica powder extract, and 20% carrier (wheat bran), was used as HEM for the pig diets.

Experiment design, animals, and housing

A total of 135 crossbred pigs [(Landrace × Yorkshire) × Duroc] with an average initial BW of 44.2 ± 2.23 kg were used in this 12-wk growth trial. Pigs were allotted to 3 dietary treatments based on their initial BW (9 replications; 5 pigs per pen). The experimental diets consisted of corn-soybean meal-based diets supplemented with 0, 0.025%, or 0.050% HEM. The diets were formulated to meet or exceed the NRC (2012) nutrient requirements (Table 2). Additive was added to the diet by replacing the same amount of corn. All the pigs were housed in an environmentally controlled room with a slatted plastic floor. Throughout all the experimental period, each pen was equipped with a 1-sided self-feeder and a nipple waterer to allow the pigs ad libitum access to feed and water.

Sampling and measurements

Individual pig BW was measured on the initial, at the end of 6 weeks, and the end of the experiment to monitor average daily gain (ADG), feed consumption was recorded on a pen basis during the experiment to calculate the average daily feed intake (ADFI) and gain:feed (G:F). One week before the end of experiment, pigs were fed diets mixed with chromic oxide

| Table 1. The main active components of Scutellaria baicalensis and Lonicera japonica. |
|---------------------------------|-----------------|---------------------------------|
| **Main active components**      | **Compounds**   | **Effect**                      |
| Scutellaria baicalensis         | Flavones        | Baicalin, baicalein, wogonin, oroxylin A | Anti-allergic, anti-tumour, anti-inflammatory, antioxidant |
| Lonicera japonica               | Organic acids   | Chlorogenic acid, isochlorogenic acid, caffeic acid | Antioxidant, anti-tumour, anti-inflammatory, antibacterial, antiviral |
|                                | Flavones        | Chrysoeriol, luteolin           | Anti-inflammatory |
|                                | Iridoids        | Loganin                        | Anti-inflammatory |
|                                | Saponins        | Lonicer oxide, hederagenin     | Anti-inflammatory |

Source: Li et al. (2004); Shang et al. (2011).

| Table 2. Ingredient composition of experimental diets (as-fed basis)a. |
|---------------------------------|-----------------|-----------------|
| **Items**                       | **Ingredient, %** | **Effect**      |
| Corn                            | 66.00           |                 |
| Soybean meal, 47.5% CP          | 23.06           |                 |
| Molasses                        | 3.00            |                 |
| Animal fat                      | 4.24            |                 |
| Dicalcium phosphate             | 1.26            |                 |
| Salt                            | 0.25            |                 |
| Limestone                       | 1.01            |                 |
| Ethoxyquin                      | 0.05            |                 |
| L-lysine-HCl                    | 0.01            |                 |
| Vitamin premixa                 | 0.12            |                 |
| Mineralpremixc                 | 0.10            |                 |
| **Calculated compositiond**     |                 |                 |
| ME, kcal/kg                     | 3350            |                 |
| CP, %                           | 18.00           |                 |
| Lys, %                          | 0.90            |                 |
| Met, %                          | 0.28            |                 |
| Ca, %                           | 0.70            |                 |
| P, %                            | 0.60            |                 |

aHEM was included in the diet by replacing the same amount of corn.
bProvided per kg of complete diet: 11,025 U vitamin A; 1103 U vitamin D3; 44 U vitamin E; 4.4 mg vitamin K; 8.3 mg riboflavin; 50 mg niacin; 4 mg thiamine; 29 mg d-pantothenic; 166 mg choline; 33 μg vitamin B12.
cProvided per kg of complete diet: 8 mg of Mn (as MnO2); 60 mg of Zn (as ZnSO4); 5 mg of Cu (as CuSO4·SH2O); 40 mg of Fe (as FeSO4·7H2O); 0.3 mg of Co (as CoSO4·SH2O); 1.5 mg of I (as KI); and 0.15 mg of Se (as Na2SeO3·SH2O).
dAccording to Sauvant et al. (2004).
(Cr₂O₃, 0.2% level) as an indigestible marker to calculate apparent total tract digestibility (ATTD) of dry matter (DM) and nitrogen (N), and gross energy (Ball & Aherne 1987). On the last two days of the experiment, fecal samples were collected from at least 2 pigs in each pen via rectal massage. All fecal samples, as well as feed samples, were stored at −20 °C until analysis. Before chemical analysis, fecal samples were thawed at 57 °C for 72 h, after which they were ground to pass through a 1-mm screen. All feed and fecal samples were analyzed for DM (method 930.15, AOAC 1995) and N (method 990.03, AOAC 1995). Chromium was analyzed using a Compensated Jacket Calorimeter 6100 (Parr Instrument Co., Moline, IL USA). The ATTD was then calculated using the following formula:

\[
\text{ATTD} = \frac{\left[1 - \frac{(\text{Nd} \times \text{Cd})}{\text{Nd} \times \text{Cd}}\right]}{\text{Nd}} \times 100
\]

where \(\text{Nd} = \) nutrient concentration in feces (% DM), \(\text{Cd} = \) chromium concentration in diet (% DM), and \(\text{Cd} = \) chromium concentration in feces (% DM).

At the end of the experiment, two pigs were randomly chosen from each pen (n = 54) and blood samples were taken by jugular venipuncture using vacuum tubes (Becton Dickinson Vacutainer Systems, Franklin Lakes, NJ). After collection, the serum samples from nonheparinised vacuum tubes were centrifuged (2000 × g) for 30 min at 4 °C. The blood aspartate transaminase (AST), alanine aminotransferase (ALT), \(\gamma\)-glutamyl transpeptidase (\(\gamma\)-GTP) concentrations and glucose levels were assessed using an automatic biochemistry analyzer (HITACHI 747, Japan). Anaplastic lymphoma kinase (ALK), triiodothyronine (T3), thyronine (T4), insulin-like growth factors-1 (IGF-1) and cortisol levels were determined by using a radioimmunoassay kit (Diagnostic Products Co., WH, CA). The adreno-cortico-tropic- hormoneurea (ACTH) was measured by Cobra 5010 Quantum (Diagnostic Products Co., WH, CA).

At the end of the trial, all pigs were transported to a local commercial slaughter house, pigs were firstly moved into the resting unit for 3 h rest and then were slaughtered. After chilling at 2 °C for at least 24 h, one 2.54-cm-thick longissimus muscle (LM) sample was removed at the 10th rib (right side of carcass). Sensory evaluation (colour, marbling, and firmness scores) was conducted according to the NPPC (1991) standards at an ambient temperature of 25 °C. Immediately after the subjective tests were determined, the lightness (L*), redness (a*), and yellowness (b*) values were measured at 3 locations on the surface of each sample using a chroma meter (Model CR-410; Konica Minolta Sensing, Inc., Osaka, Japan). At the same time, duplicate pH values of each sample were directly measured using a pH Meter (Model AR25, Fisher Scientific, Pittsburgh, PA). The LM area was measured by tracing the LM surface at the 10th rib, which was determined using the aforementioned sensor. Drip loss was measured using approximately 4.5 g of meat sample according to the plastic bag method described by Honikel (1998). Cook loss was determined as described previously by Sullivan et al. (2007). 2-thiobarbituric acid reactive substances (TBARS) were measured by the method of Witte et al. (1970) and expressed as mg of malonaldehyde (MDA) per kg of muscle. Trichloroacetic acid solution (20% wt/ vol) was used for the extraction. A UV absorption spectrophotometry (UV-1201, Shimadzu, Japan) was used for spectrophotometric analysis.

**Statistical analyses**

All experimental data were analyzed by using the GLM procedure of SAS (SAS 8.0, Inst. Inc., Cary, NC), the pen was served as the experimental unit. Polynomial contrasts were used to determine linear and quadratic effects of increasing HEM levels on all measurements. Probability values less than 0.05 were considered significant.

**Results**

**Growth performance**

As described in Table 3, pigs fed with HEM supplemental diets had greater final BW (linear, \(p < 0.05\)) than those fed with CON diets at the end of 6 wk and at the end of 12 wk, respectively. During 1–6 wk, the supplementation of HEM improved ADG (linear, \(p < 0.05\)), and tended to increase the G:F (linear, \(p = 0.051\)). During 7–12 wk, no difference (\(p > 0.05\)) was observed in the growth performance among the treatments. During the overall period, dietary HEM supplementation led to a greater ADG and G:F (linear, \(p < 0.05\)). Additionally, ADFI and backfat thickness were not altered (\(p > 0.05\)) by dietary treatment throughout the experiment.

**Nutrient digestibility**

At the end of the experiment, pigs fed diets supplemented with HEM led to a higher (linear, \(p < 0.05\)) ATTD of DM, N, and energy compared with those fed non-HEM supplemental diets (Table 4).
The TBARS was linearly decreased with graded levels of HEM linearly increased ($p < 0.05$). In the present study, pigs fed with HEM supplemental diets had a greater growth performance than those without supplementation. In agreement with our results, Grela (2000) and Paschma and Wawrzynski (2003) suggested that herbal extracts could be used to stimulate growth performance of finishing pigs. Yan et al. (2011b) also demonstrated that a complex herbal extract powder has a positive effect on BW, ADG and ADFI in finishing pigs. In contrast, lack of effects of herbs or their extract supplementation on growth performance in finishing pigs was observed by Wang et al. (2007) and Ao et al. (2011). These inconsistency results may be due to the selection of particular herb materials, forms of their administration (herbal plants, herbal extracts or oils), the amount of herbs, as well as the interactive of different herbs (Frankič et al. 2009).

### Blood profiles

No effect was observed on the blood profiles by HEM treatments except the cortisol concentration, and the cortisol concentration in the HEM supplemented groups was lower (linear, $p < 0.05$) than that in the non-HEM treatment group at the end of the trial (Table 5).

### Meat quality

There was no difference ($p > 0.05$) in the meat colour ($L^*$, $a^*$, $b^*$ values), sensory evaluation (colour, firmness, and marbling), cooking loss, drip loss, and LM area among dietary treatments (Table 6). The inclusion of graded levels of HEM linearly increased ($p < 0.01$) the pH of the LM. The TBARS was linearly decreased ($p < 0.05$) by dietary HEM supplementation.

### Discussion

#### Growth performance

In the present study, pigs fed with HEM supplemental diets had a greater growth performance than those reported by Park et al. (2014), who suggested that $0.2\%$ *L. japonica* extract could improve BW while not influenced the ADFI. Conversely, many previous studies demonstrated that the herbs or extracts could contribute to the desired organoleptic qualities of the diets and stimulate the appetite of the animals, accordingly, increased the feed intake and improved growth performance (Wenk 2003; Yan et al. 2011a, 2011b, 2012a). These inconsistent reports indicated that the mechanism of herbal products for enhancing growth performance can differ greatly due to the different herbal materials. It is well accepted that *S. baicalensis* and *L. japonica* have antimicrobial activity and are effective against many types of bacteria (Galina et al. 2009).

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**Table 3.** Effects of *Scutellaria baicalensis* and *Lonicera japonica* extract mixture supplementation on growth performance in finishing pigs.

| Level of HEM, % | $p$-Value |
|----------------|-----------|
| Items          |          |
| 0              | 0.025     |
| 0.05           | SEM       |
| Linear         | Quadratic |
| Initial BW, kg | 44.2      |
| 6 wk BW, kg    | 77.4      |
| 12 wk BW, kg   | 114.9     |
| 1 to 6 wk      | 791       |
| 7 to 12 wk     | 893       |
| ADG, g         | 2127      |
| ADFI, g        | 0.372     |
| G:F            | 0.329     |
| Overall        | 841.8     |
| ADG, g         | 2445      |
| ADFI, g        | 0.344     |
| Backfat thickness, mm |
| Initial       | 9.3       |
| 6 wk          | 15.8      |
| 12 wk         | 22.0      |

**Table 4.** Effects of *Scutellaria baicalensis* and *Lonicera japonica* extract mixture supplementation on nutrient digestibility in finishing pigs.

| Level of HEM, % | $p$-Value |
|----------------|-----------|
| Items          |          |
| 0              | 0.025     |
| 0.05           | SEM       |
| Linear         | Quadratic |
| Dry matter     | 70.88     |
| Nitrogen       | 70.03     |
| Energy         | 71.45     |

**Table 5.** Effects of *Scutellaria baicalensis* and *Lonicera japonica* extract mixture supplementation on blood profiles in finishing pigs.

| Level of HEM, % | $p$-Value |
|----------------|-----------|
| Items          |          |
| 0              | 0.025     |
| 0.05           | SEM       |
| Linear         | Quadratic |
| AST, U/L       | 47.00     |
| ALT, U/L       | 43.75     |
| γ-GTP, U/L     | 58.75     |
| ALK, U/L       | 118.25    |
| Glucose, mg/dL | 76.00     |
| T3, ng/dL      | 111.60    |
| T4, ng/dL      | 7.05      |
| IGF-1, ng/mL   | 134.25    |
| Cortisol, μg/dL| 1.92      |

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aAST: aspartate transaminase; ALT: alanine aminotransferase; γ-GTP: γ-glutamyl transpeptidase; ALK: anaplastic lymphoma kinase; T3: triiodothyronine; T4: thyroxine; IGF-1: insulin-like growth factors-1; ACTH: adreno-cortico-tropic-hormoneuria.
Additionally, the anti-inflammatory properties of herbs could reduce the subclinical or clinical infections, and subsequently provide a beneficial effect on the immune system and benefit the health of pigs, which could account for the enhanced growth performance in this study.

**Nutrient digestibility**

In this study, the ATTD of DM, N, and energy were increased in pigs fed HEM diets compared with those fed basal diets. Similar effects of herbs in finishing pigs were reported in previous studies. Wang et al. (2007) demonstrated that dietary supplementation with herbs increased the nutrient digestibility of DM and N. Yan et al. (2011b) suggested that the inclusion of **Houttuynia cordata** and **Taraxacum officinale** led to a higher ATTD of DM and N. It is generally accepted that the phytogenic additives could improve digestive tract function by increasing the activity of digestive enzymes of gastric mucosa and the nutrient utilisation of livestock (Chrubasik et al. 2005; Srinivasan 2005). In addition, herbs could inhibit pathogenic microorganism’s growth and modify intestinal microbiota because of the antibacterial properties, as a result, provide beneficial effects on the gastrointestinal ecosystem. Czech et al. (2009) have confirmed that the beneficial effect of herbs could be attributed to the positive active substances on the digestive processes and nutrient metabolism. Huang et al. (2012) have also supported that medicinal herbs supplementation provided a healthy and functional intestine, which in turn enhanced the nutrient digestibility. Therefore, the increased digestive capacity and the stabilised gut microbial balance may be considered the primary reasons for the improvement of nutrient digestibility.

**Blood profiles**

The only difference in blood profiles observed in this study was a decreased concentration of cortisol when the pigs fed HEM supplementation diet. The concentrations of cortisol in blood, released by the adrenals, are often used as major physiological indicators of stress (Ruis et al. 1997). In modern pig husbandry, animals are exposed to many stress factors that may affect their health and growth performance, these problems arise especially from environmental conditions such as barren house and management factors. Therefore, it can be concluded that the HEM (**S. baicalensis** and **L. japonica**) used in this study may play a key role in reducing stress in pigs. In accordance with the present study, Wang et al. (2007) reported that the inclusion of herbs could linearly decline serum cortisol level in finishing pigs. It has been demonstrated that a large group of plant-derived compounds in herbs, such as alkaloids, flavonoids, phenolics, and essential oils possess antistress, tranquilising and sedative properties (Pei 1991). Additionally, previous literature indicated that the higher level of cortisol had negative effects on reducing immunity (Segerstrom & Miller 2004), the immunomodulatory activity of **S. baicalensis** and **L. japonica** can improve pig’s health in response to stress as well. However, no more comparisons could be made with other studies because investigations on the use of **S. baicalensis** and **L. japonica** extracts in pigs are limited, further studies are still essential to verify the antistress effect of these herbs on pigs.

**Meat quality**

It is well known that the dietary means could easily modify the fatty acid composition of tissues in monogastric animals, thus impacting on meat quality (Wood et al. 2004). Due to the antioxidant properties contained in herbs, the use of herbs and spices as antioxidants is not important only for the health of the animals, but also for the oxidative stability of their products (Frankić et al. 2009). Previous studies have demonstrated that **S. baicalensis** inhibited lipid peroxidation in rat liver homogenate (Kimura et al. 1981). Cai et al. (2004) also confirmed the antioxidant effect of **L. japonica extract in vitro**. Antioxidant effects of **S. baicalensis** and **L. japonica** extracts on TBARS and antioxidant enzymes were confirmed in vitro by Cai et al. (2004). Those results may suggest that herbs could be used as natural antioxidants for meat and could potentially improve meat quality.

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**Table 6. Effects of Scutellaria baicalensis and Lonicera japonica extract mixture supplementation on meat quality in finishing pigs**

| Items | 0 | 0.025 | 0.05 | SEM | Linear | Quadratic |
|-------|---|-------|------|-----|--------|-----------|
| Meat colour | | | | | | |
| Lightness (L*) | 56.16 | 56.26 | 55.97 | 0.51 | 0.808 | 0.764 |
| Redness (a*) | 15.71 | 15.57 | 15.75 | 0.21 | 0.897 | 0.561 |
| Yellowness (b*) | 5.40 | 5.44 | 5.79 | 0.18 | 0.186 | 0.512 |
| Sensory evaluation | | | | | | |
| Colour | 3.35 | 3.05 | 3.40 | 0.27 | 0.899 | 0.359 |
| Firmness | 3.25 | 3.65 | 3.45 | 0.17 | 0.437 | 0.200 |
| Firmness | 3.20 | 3.65 | 3.10 | 0.18 | 0.704 | 0.061 |
| Cooking loss, % | 36.03 | 35.78 | 36.89 | 1.89 | 0.758 | 0.779 |
| Drip loss, % | | | | | | |
| d1 | 3.85 | 3.80 | 3.25 | 0.42 | 0.360 | 0.648 |
| d3 | 7.74 | 6.37 | 6.77 | 0.63 | 0.317 | 0.294 |
| d5 | 12.03 | 10.70 | 11.87 | 0.62 | 0.861 | 0.152 |
| d7 | 14.92 | 13.14 | 14.31 | 0.93 | 0.659 | 0.244 |
| pH | 5.21 | 5.32 | 5.45 | 0.03 | 0.002 | 0.832 |
| LM area, cm² | 48.02 | 50.25 | 49.83 | 1.54 | 0.439 | 0.508 |
| TBARS, mg MDA/kg | 0.027 | 0.023 | 0.022 | 0.001 | 0.015 | 0.183 |

*Level of HEM, %*

The meat samples were taken from **longissimus** muscle at the 10th rib (right side of carcass).

All parameters were measured starting at 24 h after the carcass chilling at 2 °C.
baicalensis have been traced to several of its flavones, which include baicalein, wogonin, and scullcap flavone I and II (Takagi et al. 1980). The anti-oxidative activity of L. japonica could be attributed to polyphenols, which exhibit various antioxidant properties (Choi et al. 2007). Consistent with the antioxidant function, the present study found that the supplementation of S. baicalensis and L. japonica extract mixture decreased the TBARS level of meat. The TBARS is frequently used method for measurement of lipid oxidation, the lower the TBARS value, the less oxidation has taken place (Yang et al. 2006). The reason for the beneficial effect on meat quality is possibly due to the antioxidant properties of HEM. Similarly, previous studies have suggested that the herbs, such as S. chinensis, H. cordata, T. officinale, Melissa officinalis L., Humulus upulus L. and Urtica dioica extracts could exhibit positive effects on meat color, LM area and fatty acid composition in finishing pigs (Szewczyk et al. 2006; Hanczakowska & Świątkiewicz 2006; Ao et al. 2011; Yan et al. 2011b). However, it can be concluded the polyphenols were somewhat transferred to meat, and further studies are needed to evaluate the potential risk of the residuals for consumers. Moreover, the meat pH is an important characteristic of meat quality (Gou et al. 2002). Previous study has suggested that the increased ultimate pH exerted a positive impact on the tenderness of meat (Huff-Lonergan et al. 2000). In this study, dietary herbal extract supplementation improved the meat pH value at 24 h. The higher meat pH that was observed in the present study may be due in part to the alka-loids in herbs. Similar to our study, Zhou et al. (2013) reported that inclusion of Captis chinensis herb extract in finishing pig diets increased longissimus muscle pH at 24 h after slaughter.

Conclusions

In conclusion, incorporation of the HEM (S. baicalensis and L. japonica extract mixture) into the finishing pigs diets could provide a positive effect on growth performance and nutrient digestibility. Additionally, the pH of the meat was increased and the TBARS was decreased with the HEM supplementation. Furthermore, an antistress activity was observed in the herbs used in this study. More researches are needed to determine the antistress effect of S. baicalensis and L. japonica extract in pigs, especially weaning pigs.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

References

Ao X, Yan L, Meng QW, Zhou TX, Wang JP, Kim HJ, Cho JH, Kim IH. 2011. Effects of Saururus chinensis extract supplementation on growth performance, meat quality and slurry noxious gas emission in finishing pigs. Livest Sci. 138:187–192.

AOAC 1995. Official method of analysis, 16th ed. Washington, DC: Association of Office Analytical Chemists.

Ball RO, Ahernie FX. 1987. Influence of dietary nutrient density, level of feed intake and weaning age on young pigs. II. Apparent nutrient digestibility and incidence and severity of diarrhea. Can J Anim Sci. 67:1105–1115.

Cai Y, Luo Q, Sun M, Corke H. 2004. Antioxidant activity and phenolic compounds of 112 traditional Chinese medicinal plants associated with anticiarcin. Life Sci. 74:2157–2184.

Choi C, Jung HA, Kang SS, Choi JS. 2007. Antioxidant constituents and a new triterpenoid glycoside from Flos Lonicerae. Arch Pharm Res. 30:1–7.

Chrubsasik S, Pittler MH, Roufogalis BD. 2005. Zingiberis rhizoma: a comprehensive review on the ginger effect and efficacy profiles. Phytomedicine. 12:684–701.

Costa LB, Berencht ein B, Almeida VV, Tse M, Braz DB, Andrade C, Mourão GB, Miyada VS. 2011. Phytophobic additives and sodium butyrate as growth promoters of weanling pigs. Arch Zootecn. 60:687–698.

Costa LB, Luciano FB, Miyada VS, Gois FD. 2013. Herbal extracts and organic acids as natural feed additives in pig diets. South Afr J Anim Sci. 43:181–193.

Czech A, Kowalczek E, Grela ER. 2009. The effect of a herbal extract used in pig fattening on the animals’ performance and blood components. Ann Univ Mariae Curie-Skłodowska. 27:25–33.

Dorman H, Deans SG. 2000. Antimicrobial agents from plants: antibacterial activity of plant volatile oils. J Appl Microbiol. 88:308–316.

Franki T, Vo ljić M, Salobir J, Rezar V. 2009. Use of herbs and spices and their extracts in animal nutrition. Acta Agr Slov. 94:95–102.

Galina J, Yin G, Ardo L, Jeney Z. 2009. The use of immunostimulating herbs in fish. An overview of research. Fish Physiol Biochem. 35:669–676.

Gou P, Comaposada J, Arnau J. 2002. Meat pH and meat fibre direction effects on moisture diffusivity in salted ham muscles dried at 5 °C. Meat Sci. 61:25–31.

Grela ER. 2000. Influence of herb supplements in pig feeding on carcass traits and some organoleptic and chemical parameters of meat. Roczniki Naukowe Zootech. 6:167–171.

Hanczakowska E, Światkiewicz M. 2006. The effect of lemon balm (Melissa officinalis L.) or hop (Humulus upulus L.) extracts on pig meat quality. Anim Sci. 1:168–169.

Honikel KO. 1998. Reference methods for the assessment of physical characteristics of meat. Meat Sci. 49:447–457.

Huang CW, Lee TT, Shih YC, Yu B. 2012. Effects of dietary supplementation of Chinese medicinal herbs on polymorphonuclear neutrophil immune activity and small intestinal morphology in weanling pigs. J Anim Physiol An N. 96:285–294.

Huff-Lonergan E, Lonergan S, Vaske L. 2000. pH relationships to quality attributes: tenderness. Meat Sci Recip Series. 53:1–4.
Kimura Y, Okuda H, Tani T, Arichi S. 1981. Studies on Scutellariae Radix. IV. Effects on lipid peroxidation in rat liver. Chem Pharm Bull. 29:2610–2617.

Li H, Jiang Y, Chen F. 2004. Separation methods used for Scutellariae baicalensis active components. J Chromatogr B. 812:277–290.

Namkung H, Li J, Gong M, Yu H, Cottrill M, de Lange C. 2004. Impact of feeding blends of organic acids and herbal extracts on growth performance, gut microbiota and digestive function in newly weaned pigs. Can J Anim Sci. 84:697–704.

Nofrarias M, Manzanilla EG, Pujols J, Gibert X, Majo N, Segalés J, Gasa J. 2006. Effects of spray-dried porcine plasma and plant extracts on intestinal morphology and on leukocyte cell subsets of weaned pigs. J Anim Sci. 84:2735–2742.

NPPC. 1991. Procedures to evaluate market hogs. Des Moines (IA, USA): National Pork Production Council Publ.

NRC. 2012. Nutrient requirements of swine, 11th Ed. Washington, DC: National Academy Press.

Oetting LL, Utiyama CE, Giani PA, Ruiz UDS, Miyada VS. 2006. Effects of herbal extracts and antimicrobials on apparent digestibility, performance, organs morphology and intestinal histology of weaning pigs. Rev Bras Zootec. 35:1389–1397.

Park JH, Kang SN, Chu GM, Jin SK. 2014. Growth performance, blood cell profiles, and meat quality properties of broilers fed with Saposhnikovia divaricata, Lonicera japonica, and Chelidonium majus extracts. Livest Sci. 165:87–94.

Paschma J, Wawrzynski M. 2003. Effect of dietary herb supplement for pigs on growth parameters, slaughter traits and dietetic value of pork. Roczniki Naukowe Zootechniki. 30:79–88.

Pei X. 1991. The Chinese approach to medicinal plants. Their utilization and conservation. In: O. Akerele, V. Heywood, H. Syne (ed.) Conservation of medicinal plants. Cambridge, UK: Cambridge University Press. p. 305–313.

Ruis MA, Te Brake JH, Engel B, Ekkel ED, Buist WG, Blokhuis HJ, Koolhaas JM. 1997. The circadian rhythm of salivary cortisol in growing pigs: effects of age, gender, and stress. Physiol Behav. 62:623–630.

Sauvan D, Perez JM, Tran G. 2004. Tables of composition and nutritional value of feed materials: pigs, poultry, cattle, sheep, goats, rabbits, horses and fish. Wageningen, Netherlands: Wageningen Academic Publishers. p. 304.

Segerstrom SC, Miller GE. 2004. Psychological stress and the human immune system: a meta-analytic study of 30 years of inquiry. Psychol Bull. 130:601–630.

Shang X, Pan H, Li M, Miao X, Ding H. 2011. Lonicera japonica Thunb.: ethnopharmacology, phytochemistry and pharmacology of an important traditional Chinese medicine. J Ethnopharmacol. 138:1–21.

Shoba G, Joy D, Joseph T, Majeed M, Rajendran R, Srinivas PS. 1998. Influence of piperine on the pharmacokinetics of curcumin in animals and human volunteers. Planta Med. 64:353–356.

Srinivasan K. 2005. Spices as influencers of body metabolism: an overview of three decades of research. Food Res Int. 38:77–86.

Sullivan ZM, Honeyman MS, Gibson LR, Prusa KJ. 2007. Effects of triticale-based diets on finishing pig performance and pork quality in deep-bedded hoop barns. Meat Sci. 76:428–437.

Szewczyk A, Hanczakowska E, Swiatkiewicz M. 2006. The effect of nettle (Urtica dioica) extract on the fattening performance and fatty acid profile in the meat and serum lipids of pigs. J Anim Feed Sci. 15:81–84.

Takagi S, Yamaki M, Inoue K. 1980. Studies on the water-soluble constituents of the roots of Scutellaria baicalensis Georgi (Wogon). Yakugaku Zasshi. 100:1220–1224.

Utiyama CE, Oetting LL, Giani PA, Ruiz UDS, Miyada VS. 2006. Effects of antimicrobials, prebiotics, probiotics and herbal extracts on intestinal microbiology, diarrhea incidence and performance of weaning pigs. Rev Bras Zootecn. 35:2359–2367.

Wagner H, Ulrich-Merzenich G. 2009. Synergy research: approaching a new generation of phytopharmaceuticals. Phytomedicine. 16:97–110.

Wang Y, Chen YJ, Cho JH, Yoo JS, Wang Q, Huang Y, Kim HJ, Kim IH. 2007. The effects of dietary herbs and coral mineral complex on growth performance, nutrient digestibility, blood characteristics and meat quality in finishing pigs. J Anim Feed Sci. 16:397–407.

Wenk C. 2003. Herbs and botanicals as feed additives in monogastric animals. Asian-Austral J Anim Sci. 16:282–289.

Witte VC, Krause GF, Bailey ME. 1970. A new extraction method for determining 2-thiobarburturic acid values of pork and beef during storage. J Food Sci. 35:582–585.

Wood JD, Richardson RI, Nute GR, Fisher AV, Campo MM, Kasapidou E, Sheard PR, Enser M. 2004. Effects of fatty acids on meat quality: a review. Meat Sci. 66:21–32.

Yan L, Meng QW, Kim IH. 2011a. The effect of an herb extract mixture on growth performance, nutrient digestibility, blood characteristics and fecal noxious gas content in growing pigs. Livest Sci. 141:143–147.

Yan L, Meng QW, Kim IH. 2011b. The effects of dietary Houttuynia cordata and Taraxacum officinale extract powder on growth performance, nutrient digestibility, blood characteristics and meat quality in finishing pigs. Livest Sci. 141:188–193.

Yan L, Meng QW, Kim IH. 2012a. Effect of an herb extract mixture on growth performance, nutrient digestibility, blood characteristics and fecal microbial shedding in weaning pigs. Livest Sci. 145:189–195.

Yan L, Zhang ZF, Park JC, Kim IH. 2012b. Evaluation of Houttuynia cordata and Taraxacum officinale on growth performance, nutrient digestibility, blood characteristics, and fecal microbial shedding in diet for weaning pigs. Asian-Austral J Anim Sci. 25:1439–1444.

Yang YX, Kim YJ, Jin Z, Lohakare JD, Kim CH, Oh SH, Lee SH, Choi JY, Chae BJ. 2006. Effects of dietary supplementation of astaxanthin on production performance, egg quality in layers and meat quality in finishing pigs. Asian-Austral J Anim Sci. 19:1019–1025.

Zhou TX, Zhang ZF, Kim IH. 2013. Effects of dietary Coptis chinensis herb extract on growth performance, nutrient digestibility, blood characteristics and meat quality in growing-finishing pigs. Asian-Austral J Anim Sci. 26:108–115.