INTRODUCTION

For centuries, traditional oriental herbal products have been used in the treatment of diseases. They are consumed as supplements and considered to enhance the immune system (Yuan et al., 2016). One such product is Sipjeondaebo-tang (ST, Shi-Quan-Da-Bu-Tang in Chinese or Juzen-taiho-to in Japanese), which is made of 10 different natural herbs (Jeon et al., 2014). It is frequently prescribed for the treatment of depression, physical weakness, anemia, anorexia, and fatigue (Chino et al., 2005; Liu et al., 2008). In addition, ST has been reported to have beneficial biological activities, including the enhancement of antitumor, anti-inflammatory, and immunomodulatory activities (Chino et al., 2005; Jeon et al., 2014). In South Korea, ST is a by-product obtained from ST extract after repeated steaming, which is discarded as a waste product in soil or fields and not used further. Thus, it would be advantageous to investigate ways to improve the quality of ST so that it could be used as a feed additive to enhance poultry growth (Mateos et al., 2012). In general, poultry feed pellets containing a greater quantity of fine particles improve growth performance (average daily gain and feed-to-gain ratio), which can lead to a reduction in feed wastage (Saldaña et al., 2015). Thus, the inclusion of pelleted ST in the feed may improve the quality of duck meat; moreover, the benefits from pellets would be more pronounced than those from powder because of the greater quantity of...
Bioactive materials and their antioxidant effects. Until now, the antioxidant effect of ST has not been evaluated clearly, and there are no reports whether the use of ST could improve duck meat quality during storage. The objective of this study was to assess the quality and color during the storage of breast and thigh meat from ducks fed a diet supplemented with pelleted ST.

MATERIALS AND METHODS

ANIMALS, DIETS, AND SLAUGHTER PROCEDURE

All experimental procedures complied with the guidelines for animal care of Gilhong Farm, Geochang (South Korea). The ST sample materials obtained from Yusim company (South Korea) were converted into pellets using the methods of Chung et al. (2018). In total, 90 1-d-old Pekin ducks were randomly allocated to one of the two groups: the control group (basal diet) and the T1 group (basal diet + pelleted 1% ST powder). The birds were distributed in six cages with 15 birds per cage, and the experiment was performed in triplicate. A starter diet with 22% crude protein was provided to all ducks for the first 21 days, and a finisher diet with 17% crude protein was provided from Days 22 to 42. Ad libitum access to food and water was provided during the study. At the end of the experimental period, ducks were put on a fast for 12 h and transferred to the slaughterhouse in accordance with conventional Korean procedures. Eighteen ducks, randomly collected from each cage, were electrically stunned. After stunning, the neck blood vessels were cut, and exsanguination occurred. After slaughter, the carcasses were deboned, and the breast and thigh muscles were isolated. All visible skin and excessive connective tissues were removed before the evaluation of the meat quality and color parameters. All samples were packed in sealable plastic bags and stored between 0 and 7 days at 4°C for measurement of pH, thiobarbituric acid reactive substances (TBARS), 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging activity, and meat color. The color values (CIE L*, a*, and b*) were measured at the surface of every meat sample by using a Minolta chromameter (Minolta CR-300, Osaka, Japan), and the results were expressed as L* (lightness), (a*) redness, and b* (yellowness).

STATISTICAL ANALYSIS

Selected ducks from each cage were used for the experimental analysis of meat quality and color. All data were analyzed using SAS statistical software (SAS, 2002). Student’s t-test was performed to check whether the differences between the means were significant at the 5% level.

RESULTS

Table 1 shows the breast and thigh meat quality during refrigerated storage of the duck that had been fed on pelleted ST. In breast meat, there was no significant difference (P>0.05) between the two groups in the pH, TBARS, and DPPH radical-scavenging activity on day 0, in contrast to day 7, after adding pelleted ST to the diet. However, only pH was affected in thigh meat (P<0.05) on day 7, while pH, TBARS, and DPPH radical-scavenging activity were not affected from day 0 to 7 after adding pelleted ST to the diet. The results for meat color are shown in Table 2. Significant differences (P<0.05) were observed in L* and b* values of breast meat from day 0 through 7 between the two groups, but not for a* values. However, for thigh meat, feeding pelleted ST did not show any significant difference (P>0.05) in L*, a*, and b* values from day 0 through 7 between the two groups. In addition, a single observation on day 0 provided significantly different b* values (P<0.05).

DISCUSSION

In the current study, we found that the antioxidant effect of a diet supplemented with ST on breast meat quality differed from days 0–7. This supported a similar study in rats (Jeon et al., 2014). Prior to ethanol administration, pretreatment with Sipjeondaebotang water extract (SDTW) significantly increased glutathione (GSH) content and antioxidant enzyme activity and decreased malondialdehyde (MDA) concentration in the rat tissue in comparison to the tissue of rats administered with ethanol.
alone. In our study, although the thigh meat quality did not change with respect to these particular parameters, tissues from the ducks fed the ST-supplemented diet showed stronger antioxidant activity than the ducks fed the control diet. Both the breast meat and thigh meat had higher DPPH radical-scavenging activity and lower TBARS, which are important indices for determining the antioxidant properties during storage. The antioxidant effects of ST may be attributed to the constituent herbs, which are also known to exhibit various other important biological effects (Lu et al., 2004; Ramesh et al., 2012; Jeon et al., 2014). However, the underlying mechanism of action remains unclear. In general, most research on ST has focused on its pharmacological action. Jeon et al. (2014) proposed that owing to its antioxidant effects, SDTW may also play a role in gastroprotection. In the current study, antioxidant properties of ST may be a major contributor to the observed difference and, therefore, we assessed whether the antioxidant effects of ST affected the breast and thigh meat of ducks during refrigerated storage.

Table 1: Breast and thigh meat quality in duck fed diets with pelleted sipjeondaebo-tang by product during refrigerated storage.

| Item                  | Storage days | Treatment1 SEM | Significance |
|-----------------------|--------------|---------------|--------------|
| Breast pH             | 0            | 6.04          | 6.01         | 0.045 NS     |
|                       | 7            | 6.12          | 6.05         | 0.084 *      |
| TBARS (mgMA/kg)       | 0            | 0.17          | 0.20         | 0.065 NS     |
|                       | 7            | 0.19          | 0.11         | 0.094 *      |
| DPPH radical scavenging (%) | 0       | 82.3          | 83.5         | 2.500 NS     |
|                       | 7            | 83.9          | 85.7         | 0.734 *      |
| Thigh pH              | 0            | 6.81          | 6.93         | 0.253 NS     |
|                       | 7            | 6.89          | 6.79         | 0.069 *      |
| TBARS (mgMA/kg)       | 0            | 0.35          | 0.15         | 0.058 NS     |
|                       | 7            | 0.32          | 0.11         | 0.157 NS     |
| DPPH radical scavenging (%) | 0       | 82.1          | 83.4         | 1.258 NS     |
|                       | 7            | 84.9          | 86.9         | 1.338 NS     |

1Control: basal diet; T1: 1% ST by product with pelleting; 2Results are reported as means ± SE; 3NS: not significant. *p<0.05.

CONCLUSION

The results of the study indicated that dietary supplementation with ST pellets conferred additional antioxidant activity on breast meat. The supplementation with ST pellets increased DPPH radical-scavenging activity and reduced the TBARS values in both the breast and thigh meat of ducks. However, there were no changes in the color of breast and thigh meat of ducks fed the ST supplemented diet, which may be due to a reduction in lipid peroxidation. Overall, the dietary supplementation with ST pellets may improve antioxidant capacity and contribute to better meat quality.

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AUTHORS CONTRIBUTION

Gee-Dong, Lee contributed to this study for analyzing the data and revising the manuscript. In Hag, Choi as corresponding authors supervised the experiment and wrote the manuscript.

CONFLICT OF INTEREST

The authors should state no conflict of interest.

REFERENCES

• AOAC (2000). Official methods of analysis. (17th ed.) Association of Official Analytical Chemists; Gaithersburg, MD.
• Baker R, Günther C (2004). The role of carotenoids in consumer choice and the likely benefits from their inclusion into products for human consumption. Trends Food Sci. Technol. 15: 484–488. https://doi.org/10.1016/j.tifs.2004.04.009
• Blois MS (1958). Antioxidant determination by the use of a stable free radical. Nature. 4617: 1199-2000. https://doi.org/10.1038/1811199a0
• Chino A, Sakurai H, Choo MK, Koizumi K, Shimada Y, Terasawa K, Saiki I (2005). Juzentaihoto, a Kampo medicine, enhances IL-12 production by modulating Toll-like receptor 4 signaling pathways in murine peritoneal exudate macrophages. Int. Immunopharmacol. 5: 871-882. https://doi.org/10.1016/j.intimp.2005.01.004
• Chung TH, Kim CM, Choi IH (2018). A study on growth performance of ducks fed diets with different types of sipjeondaebo-tang byproduct meal and red ginseng marc with fermented red koji and ammonia fluxes in duck litter using alum or aluminum chloride. J. Poult. Sci. 55:112-116. https://doi.org/10.2141/jpsa.0170092
• Fernandez-Lopez J, Zhi N, Àleson-Carbonell L, Perez-Alvarez JA, Kuri V (2005). Antioxidant and antibacterial activities of natural extracts: Appl. Beef meatballs. Meat Sci. 69: 371-380. https://doi.org/10.1016/j.meatsci.2004.08.004
• Jeon WY, Shin IS, Shin HK, Lee MY (2014). Gastroprotective effect of the traditional herbal medicine, Sipjeondaebo-tang water extract, against ethanol-induced gastric mucosal injury. BMC Complem. Altern. M., 14: 373. https://doi.org/10.1186/1472-6882-14-373
• Liu H, Wang J, Sekiyama A, Tabira T (2008). Juzen-taiho-to, an herbal medicine, activates and enhances phagocytosis in microglia/macrophages. Tohoku J. Exp. Med. 215: 43-54. https://doi.org/10.1620/tjem.215.43
• Lü AP, Jia HW, Xiao C, Lu QP (2004). Theory of traditional Chinese medicine and therapeutics method of diseases. World J. Gastroenterol., 10: 1854-1856. https://doi.org/10.3748/wjg.v10.i13.1854
• Mateos GG, Jiménez-Moreno E, Serrano MP, Lázaro R (2012). Poultry response to high levels of dietary fiber sources varying in physical and chemical characteristics. J. Appl. Poult. Res. 21: 156–174. https://doi.org/10.3382/japr.2011-00477
• Ramesh T, Kim SW, Hwang SY, Sohn SH, Yoo SK, Kim SK (2012). Panax ginseng reduces oxidative stress and restores antioxidant capacity in aged rats. Nutr. Res. 32: 718-726. https://doi.org/10.1016/j.nutres.2012.08.005
• Saldaña B, Guzmán P, Safáa HM, Harzalli R, Mateos GG (2015). Influence of the main cereal and feed form of the rearing phase diets on performance and digestive tract and body traits of brown-egg laying pullets from hatch to 17 weeks of age. Poult. Sci. 94: 2650-2661. https://doi.org/10.3382/ps/pev240
• SAS (2002). SAS/STAT software for PC. Release 9.1, SAS Institute Inc., Cary, NC, USA.
• Yuan H, Ma Q, Ye L, Piao G (2016). The traditional medicine and modern medicine from natural products. 21: 559. https://doi.org/10.3390/molecules21050559
• Witte VC, Krause GF, Baile ME (1970). A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. J Food Sci., 35: 352-358. https://doi.org/10.1111/j.1365-2621.1970.tb04815.x