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Effect of fermented water plantain on growth performance, meat composition, oxidative stability, and fatty acid composition of broiler

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ABSTRACT

The study was conducted in order to select proper microbial strains for the development of fermented water plantain (*Alisma canaliculatum* A. Br. et Bouche) (FWP) as well as to examine their effects on the growth performance, meat composition, oxidative stability, and fatty acid composition of meat from broilers. In experiment 1, 16 strains from the Korean Collection for Type Cultures (KCTC), including *Lactobacillus acidophilus*, *Lactobacillus plantarum*, *Enterococcus faecium*, *Bacillus subtilis*, *Bacillus coagulans*, and *Saccharomyces cerevisiae*, were evaluated. The strains were tested for their acid, bile, and heat tolerance levels. Among them, *L. acidophilus* KCTC 3111, *E. faecium* KCTC 2022, *B. subtilis* KCTC 3239, and *S. cerevisiae* KCTC 7928 were selected for production of FWP. In experiment 2, 140 Ross broiler chicks were allocated to four different 5-week-long dietary groups: NC (basal diet), PC (basal diet with 0.005% oxytetracycline), FWP-0.5% (basal diet with 0.5% dried powder of fermented water plantain using whole plant parts), and FWP-1% (basal diet with 1% FWP). Results indicated that FWP-0.5% supplementation increased body weight, body weight gain, and improved FCR ($P<0.05$) compared to the NC and FWP-1% supplementation. FWP-0.5% diet increased crude protein content of both breast and thigh meats compared to PC diet, whereas crude fat content of thigh meat decreased compared to NC diet ($P<0.05$). Absolute and relative breast meat weights increased ($P<0.05$) in the FWP groups compared to the NC group. Further, gizzard relative weights increased while kidney weights decreased in the FWP groups compared to the PC and NC group respectively ($P<0.05$). Proventriculus and ceca weights increased ($P<0.05$) in the FWP-1% and FWP-0.5% groups respectively than the PC group. FWP-0.5% diet decreased stearic acid content but increased eicosapentaenoic acid and docosahexaenoic acid content in both breast and thigh meats whereas, reduction of arachidonic acid content was observed in the supplemented group of breast meat compared to other groups ($P<0.05$). Further, lower ($P<0.05$) thiobarbituric acid reactive substances values of breast and thigh meats were achieved in the FWP groups compared with the PC and NC groups, respectively. Based on these results, it is suggested that 0.5% FWP supplementation would be a functional feed additive for broilers.

1. Introduction

Plant extracts serve as the ingredients of many popular commercial diet preparations currently used in animal production. They provide antioxidant (Cross et al., 2007),

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antimicrobial (Manzanilla et al., 2004), immunity development (Ko et al., 2008), and growth-promoting effects (Lee et al., 2009). Ever since the ban on antibiotic growth promoters in animal feeds by the European Union (regulation: 1831/2003/EC), producers have sought alternative natural feedstuffs to meet industry demands. Water plantain (*Alisma canaliculatum* A. Br. et Bouche; WP) has many uses in traditional Korean medicine (Kim, 2003). Dried tuber is the main medicinal part of the WP plant. However, other parts (i.e. leaves, stems, and seeds) also contain bioactive components. Previous studies have shown that the main components of this plant are protostane- and seco-protostane-type triterpenes (Peng et al., 2002) such as alisols A, B, and C, alisol A 24-acetate, alisol B 23-acetate, guaiane-type sesquiterpenes (Yoshikawa et al., 1994; Peng et al., 2003) such as alismols A, B and C, orientatol A, B, and kaurane diterpenes such as oriediterpenol and oriediterpenoside (Nakajima et al., 1994; Peng et al., 2002). To date, all protostane triterpenes have been shown to occur only in Alisma plants, and they are considered to be chemotaxonomic markers of the genus. Mikryakova (2001) previously found a high concentration of Fe (7557 μg/g) in WP tissues. Functionally, alisma displays, hepatoprotective (Hong et al., 2006), antitumor (Huang et al., 2006), and antibacterial effects (Mikamo et al., 1998). Further, the butanol fraction of *A. canaliculatum* has been shown to reduce blood glucose levels, plasma triglycerides, free fatty acids, and cholesterol in streptozotocin-induced diabetic rats (Kim, 2003). Antioxidant and antidiabetic activities have also been attributed to WP in rats (Choe et al., 2008). In a recent study, WP supplementation had no negative effect on growth performance, fatty acid profile of meat, or serum biochemical parameters of broilers (Hossain et al., 2012b).

Probiotics include various types of micro-organisms that improve gut microflora and influence local and systemic immune systems by secreting beneficial enzymes, organic acids, vitamins, and nontoxic antibacterial substances upon ingestion (Jun et al., 2002). Probiotic strains like *Lactobacillus acidophilus* KCTC 3111, *Enterococcus faecium* KCTC 2022, *Bacillus subtilis* KCTC 3239, and *Saccharomyces cerevisiae* KCTC 7928 have been tested previously for their properties and beneficial effects on animals (Kim et al., 2006; Ko and Yang, 2008; Jung et al., 2009; Sarker et al., 2010b; Wu and Ahn, 2011; Yosef et al., 2012).

Fermentation is widely used to produce healthy foods for people and animals, and interest in its application to animal feed is increasing. Recently, there has been growing interest among researchers and the feed industry to develop a functional feed containing a combination of beneficial bacterial strains and medicinal plants. Kim et al. (2007) suggested that plant extracts and *lactobacillus* could be used as alternatives for antibiotic growth promoters for improving the growth performance of broiler chicks. In an earlier broiler experiment, Hossain et al. (2012a) noted that the fermented *A. canaliculatum* rhizome exhibited high tolerance to acid, bile, and heat, and beneficially affects body weight, meat composition, thiobarbituric acid reactive substances (TBARS), and fatty acid composition. Therefore, the present study aimed to evaluate the effects of fermented whole plant parts of water plantain with probiotic strains (FWP) on growth performance, carcass composition, fatty acid composition, and oxidative stability of broiler meat. We hypothesized that synergism between WP components and probiotics metabolites will improve growth performance, carcass composition, fatty acid composition, and reduce the TBARS values in broiler meat.

2. Materials and methods

2.1. Experiment 1

2.1.1. Selection of bacterial strains and tolerance measurement

A total of 16 strains, including *L. acidophilus*, *L. plantarum*, *E. faecium*, *B. subtilis*, *B. coagulans*, and *S. cerevisiae*, were used as candidate probiotic strains (Table 1). These microbes are a part of the Korean Collection for Type Cultures (KCTC), were isolated from human and animal sources, and were obtained from the Korea Research Institute of Bioscience and Biotechnology in Daejeon, Korea. Culture media for the experimental strains were the de Man, Rogosa, and Sharpe (MRS) medium (Difco, Detroit, MI, USA) for *Lactobacillus* spp., nutrient broth (NB) medium (Difco) for *Bacillus* spp., and yeast and mold (YM) medium (Difco) for yeast (Table 1). To test the acid tolerance levels of the strains, simulated gastric juice was made according to a slightly altered method of Kobayashi et al. (1974). Experimental strains were injected into sterilized broth media (50 ml) and then cultivated at 37 °C for 48 h. Each strain (1 ml) was

Table 1
Media and culture methods used for selection of microbial strains.

Microbial strains[a]	Medium[b]	Culture method	Culture time (h)
Lactobacillus acidophilus KCTC 3111	MRS	Anaerobic	48
L. acidophilus KCTC 3146			
L. acidophilus KCTC 3150			
Lactobacillus plantarum KCTC 3104	MRS	Anaerobic	48
L. plantarum KCTC 3107			
Enterococcus faecium KCTC 2022	MRS	Anaerobic	48
E. faecium KCTC 3078			
E. faecium KCTC 3080			
Bacillus subtilis KCTC 1022	NB	Aerobic	48
B. subtilis KCTC 1103			
B. subtilis KCTC 3239			
Bacillus coagulans KCTC 1014	NB	Aerobic	48
B. coagulans KCTC 1015			
Saccharomyces cerevisiae KCTC 7107	YM	Anaerobic	24
S. cerevisiae KCTC 7915			
S. cerevisiae KCTC 7928			

[a] Korean Collection for Type Cultures (KCTC) strains obtained from the Korea Research Institute of Bioscience and Biotechnology, Daejeon, Korea.
[b] MRS: de Man, Rogosa, and Sharpe; NB: nutrient broth; YM: yeast and mold (Difco, USA).