

Effect of functional feed ingredients on the quantity and quality of chicken meat and egg

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Abbreviated title: Functional feed ingredients for chicken

Summary

Both chicken meat and egg is excellent foodstuff due to their compositions of amino acids, mono- and polyunsaturated fatty acids and vitamins. There is evidence that functional feed ingredients can improve the meat yield and egg quality (Patten and Waldroup, 1988; Izat *et al.*, 1991; Mahfudz *et al.*, 1996). In this study, we examine the effect of feed ingredients such as ethanolic extract of shochu distillery by-product (SDBP), organic acids, potassium salt of formic acid (K-diformate) and coenzyme Q10 (CoQ10) on poultry production. Dietary ethanolic extract of SDBP significantly increased food intake, body weight and breast muscle weight. Addition of mixture of formic and propionic acid to a feed significantly decreased abdominal fat weight. Addition of K-diformate to a feed significantly increased the weights of breast muscle and legs. CoQ10 did not affect egg production rate, the weights of egg and egg yolk, and feed efficiency, but significantly increased CoQ10 content in the egg yolk. These findings suggest that ethanolic extract of SDBP, mixture of formic and propionic acids, K-diformate and CoQ10 can be promising candidates for feed additives to improve chicken meat yield and egg quality.

Keywords: feed, ingredient, by-product, formate, egg, meat

Introduction

In-feed antibiotics have been utilized for chicken meat and egg production. However, the use of in-feed antibiotics in animal production has increased the risk of development of drug resistance in pathogens. Thus, a different feed additive that can be used as an alternative to antibiotics is demanded for poultry production.

There is evidence that food materials can improve meat yield and egg quality. For example, Mahfudz *et al.* (1996) reported that shochu distillery by-product (SDBP), which is a by-product resulting from the fermentation of sweet potato for the production of alcohol, improves the growth performance of broiler chickens. Organic acids, which have a long history as food additives to prevent food deterioration and extend the shelf life of perishable food, increase body weight without affecting abdominal fat content of broiler (Izat *et al.*, 1991; Patten and Waldroup, 1988). Probiotic *Rhodopseudomonas palustris* markedly improves egg yolk color (Salma *et al.*, 2007). Dietary nutrients such as isoflavone, fatty acid and fat-soluble vitamins transfer into the egg yolk (Stadelman and Pratt, 1989; Saitoh *et al.*, 2001).

In this study, we examined the effect of functional feed ingredients such as ethanolic extract of SDBP, organic acids, potassium salt of formic acid (K-difformate) and coenzyme Q10 (CoQ10) on the quantity and quality of chicken meat and egg.

Materials and Methods

Animals

Male broiler and white leghorn chicks were obtained from a commercial hatchery at one day of age. They were housed in electrically heated batteries and provided with water and a commercial starter diet *ad libitum*. On day 7, birds were assigned to the experimental groups.

30-weeks-old laying hens were obtained from a commercial poultry farm. They were housed in individual wire cages and fed on a control laying diet *ad libitum* for the first 2 weeks. Hens were assigned to the experimental groups at 32 weeks of age.

Feed intake was measured everyday throughout the experimental period. At the end of each experimental period, birds were measured their body weight and then anesthetized with an intraperitoneal injection of sodium pentobarbital (5 mg/100 g body) before sacrifice.

All experimental procedures followed the guidelines for the care and use of experimental animals at the Rokkodai Campus of Kobe University in Japan.

Experimental design

Experiment 1. The chicks were randomly assigned into three groups and fed either a control diet or a control diet containing ethanolic extract of SDBP at 0.05 or 1.0% for 21 days. After sacrifice, liver and breast muscle were excised and weighed.

Experiment 2. The chicks were randomly assigned into six groups and fed either a control diet or a control diet containing organic acid mixture (A, formic acid; B, A and propionic acid; C, B and lactic acid; D, C and butyric acid; E, D and phosphoric acid) for 21 days. After sacrifice, abdominal adipose tissues were excised and weighed.

Experiment 3. The chicks were assigned into three groups and fed either a control diet, a control diet containing K-difformate or a control diet containing antibiotics for 21 days. After sacrifice, breast muscle and legs were excised and weighed.

Experiment 4. The hens were assigned into two groups and fed either a control diet or a control diet containing CoQ10 at 0.8%. On day 10, 17, 24 and 28, eggs were collected in the morning and egg yolk was frozen by liquid nitrogen and stored at -80 °C for CoQ10 analysis. On day 28, blood was collected from the carotid arteries after sacrifice. Plasma was separated immediately by centrifugation at $3,000 \times g$ for 10 min at 4 °C, frozen by liquid nitrogen and stored at

-80 °C for plasma CoQ10 analysis. Liver was excised, weighed, frozen immediately by liquid nitrogen and stored at -80 °C for CoQ10 analysis.

Plasma and hepatic lipids analyses.

The total lipid of each liver and plasma was extracted from the frozen liver or plasma with chloroform-methanol (2:1, vol/vol). The total CoQ10 of each egg yolk was extracted from the frozen egg yolk with chloroform-methanol (1:2, vol/vol). Very low density lipoprotein (VLDL) was isolated from the frozen plasma using the method of Cham (1976). The total CoQ10 levels of liver, VLDL and egg yolk were determined by HPLC (Menke *et al.*, 2000).

Statistical methods

All data were analyzed by Student's *t* test using the commercial package StatView version 5 (SAS Institute, Cary, North Carolina, USA, 1998).

Results

Ethanol extract of SDBP significantly ($p < 0.05$) increased feed intake, body weight and breast muscle weight in chicks, whereas the feed efficiency was not affected (Fig. 1). Addition of organic acids mixture B in a control diet significantly ($p < 0.05$) decreased abdominal fat weight (Fig. 2) without affecting the body weight and feed efficiency. Dietary K-difformate significantly ($p < 0.01$) increased body weight and the weights of breast muscle and legs (Fig. 3), whereas feed efficiency was not affected. CoQ10 levels in the egg yolk ($p < 0.05$), liver ($p < 0.01$) and VLDL ($p < 0.01$) significantly increased by CoQ10 supplementation (Figs. 4 and 5). Dietary CoQ10 did not affect egg production rate, egg and egg yolk weights, and feed efficiency of laying hens (data not shown).

Fig. 1. Effects of ethanolic extract of SDBP on body weight, feed intake, feed efficiency and breast muscle weight of broiler chicks. *, Significant with respect to control ($p < 0.05$).

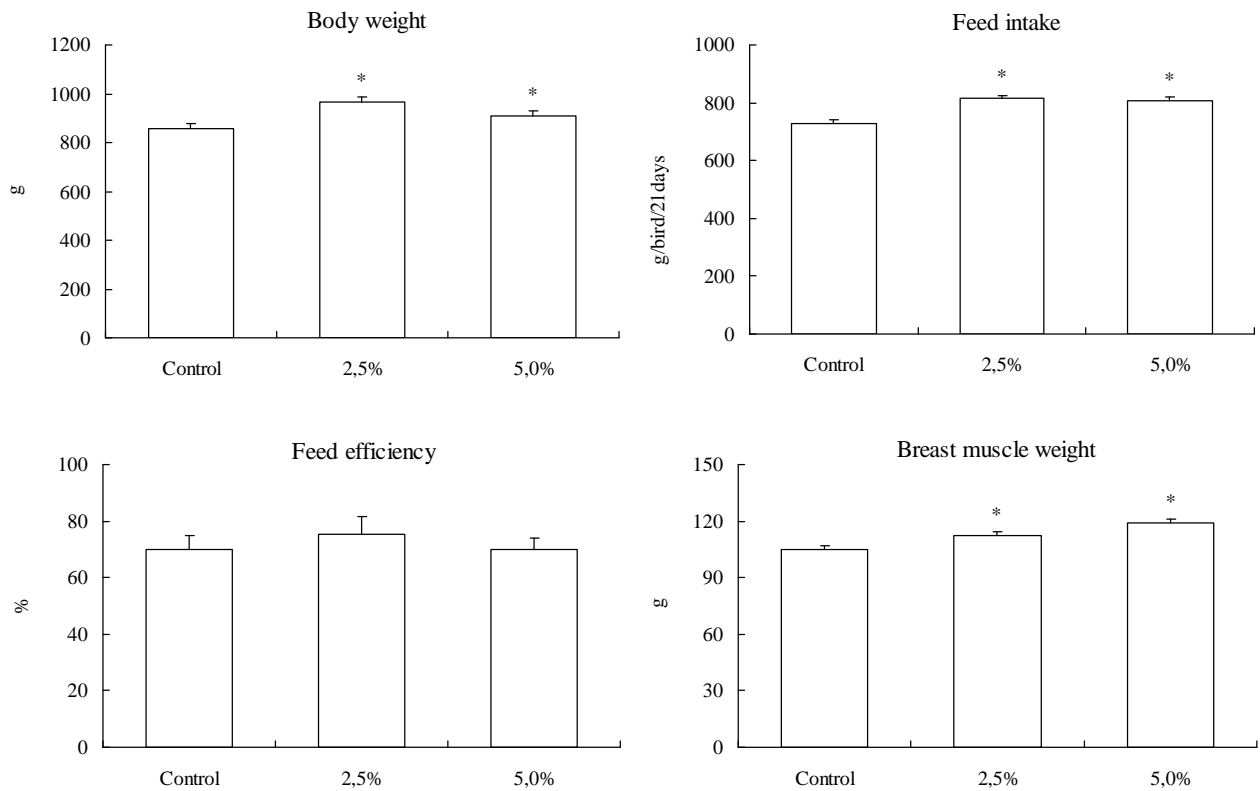


Fig. 2. Effect of dietary organic acid mixture on abdominal fat weight of broiler chicks. A, formic acid; B, A and propionic acid; C, B and lactic acid; D, C and butyric acid; E, D and phosphoric acid. *, Significant with respect to control ($p < 0.05$).

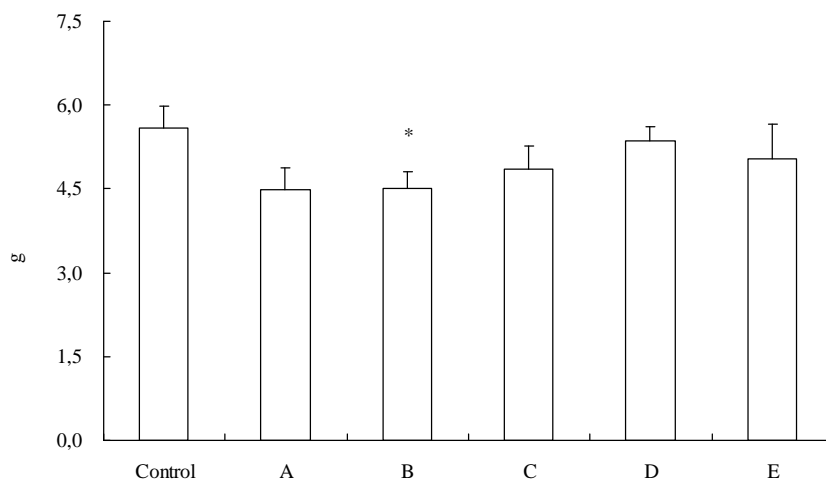


Fig. 3. Effects of dietary K-diformate on the weights of breast muscle and legs in broiler chicks. *, ** Significant with respect to control ($p < 0.05$ and $p < 0.01$).

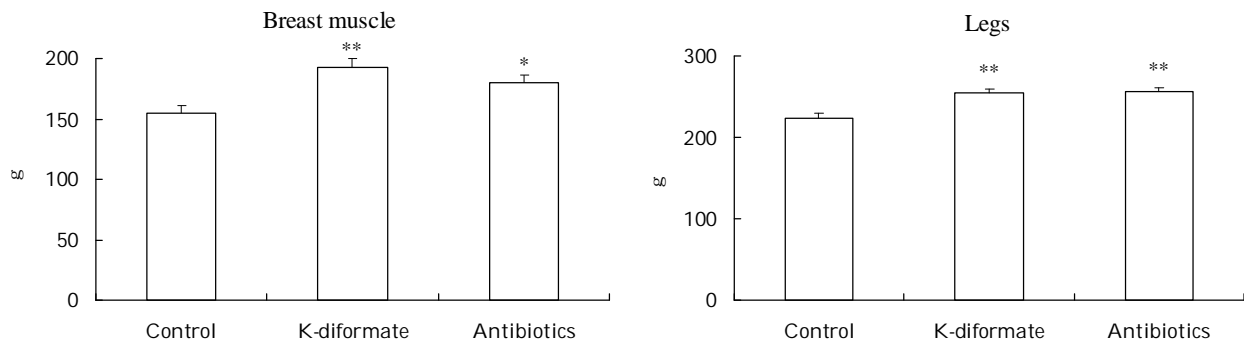


Fig. 4. Effect of dietary CoQ10 on CoQ10 content in the egg yolk of laying hens. *, Significant with respect to day 10 ($p < 0.05$).

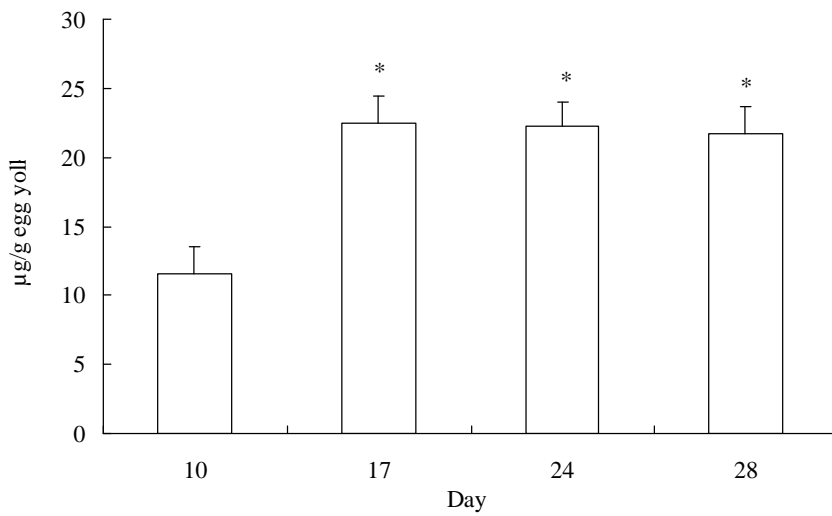
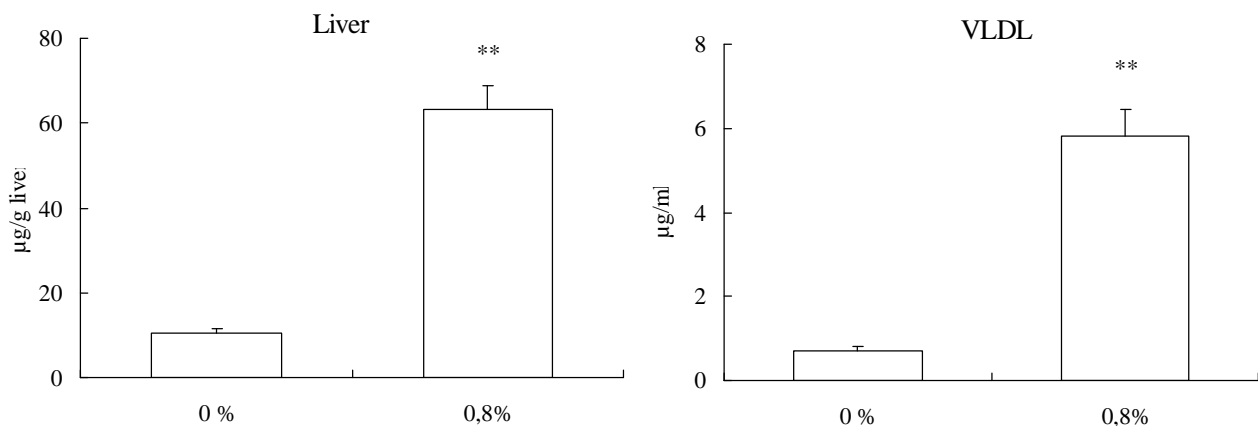


Fig. 5. Effects of dietary CoQ10 on hepatic and VLDL CoQ10 contents in laying hens.
**, Significant with respect to 0% ($p < 0.01$).



Discussion

In this study, we examined the effects of functional feed ingredients on chicken meat and egg production. Mahfudz *et al.* (1996) reported that the SDBP increases body weight gain, feed intake and muscle weight of broiler chicks. In the present study, dietary ethanolic extract of SDBP significantly increased both body weight and breast muscle weight (Fig. 1), suggesting that an unidentified growth factor of SDBP can be extracted by ethanol.

There is evidence that fumaric acid increases body weight in broiler chicks (Izat *et al.*, 1991; Patten and Waldroup, 1988). Furuse and Okumura (1989) reported that dietary acetic acid had a detrimental effect on chicks. In this study, we found that dietary organic acid mixture of formic and propionic acid significantly decreased the weight of abdominal fat without affecting body weight. Thus, the mixture of formic and propionic acid can be used as a functional feed ingredient to reduce an animal by-product.

The use of organic acids has been limited by problems of handling, strong odor, and corrosion during feed processing and its use on the farm. Thus, K-diformate has been developed as an effective growth promoter for both weanling and growing-finishing pigs (Øverland *et al.*, 2000). In the present study, dietary K-diformate significantly improved growth performance and meat yield in chicks as well as in pigs. There is evidence that dietary K-diformate decreases the number of coriform bacteria in the gastrointestinal tract of weanling pig, and this reduction of coriform bacteria

increases the availability of dietary nutrients to the host animal (Canibe *et al.*, 2001). Further study is needed to analyze the microorganisms in gastrointestinal tract and nutrients availability in chicks.

CoQ10, which is a naturally-occurring lipophilic compound and plays a key role in the electron transport system, is widely consumed as a dietary supplement because of its recognition as an important nutrient in supporting human health. Elmberger *et al.* (1989) reported that dietary CoQ10 is repacked into VLDL and released into circulation in rats. In the present study, dietary CoQ10 increased not only egg yolk CoQ10 content but also hepatic and VLDL CoQ10 concentrations. These findings suggest that dietary CoQ10 was transported from liver to egg yolk via blood stream. In conclusion, all our findings suggest that SDBP, organic acids, K-diformate and CoQ10 can be promising candidates for feed additives to improve the chicken meat and egg production.

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