Carcass percentage and digestive organs development of broilers fed diets containing organic selenium and fermented selenium-rich feedstuffs

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Abstract. Fermentation has been practiced to bio convert inorganic substances into more readily available nutrients. Selenium is an important trace mineral functioning to improve growth and health status. A study was carried out to determine the carcass percentage and organ development of broilers fed fermented diets with the addition of selenium. Rice bran from the local market was purchased and finely ground. One kg rice bran added with 1 g sodium selenite as source of selenium (Se) was autoclaved for 20 minutes at 20 psi. The autoclaved rice bran was added with distilled water up to 80% moisture concentration. The autoclaved mixture was incubated with two different fungi (Aspergillus niger and Saccharomyces cerevisiae) for 120 hours to produce fermented rice bran with A. niger (FRBAN) and fermented rice bran with S. cerevisiae (FRBSC). The study used 140 day-old-chicks as experimental animals. The birds were kept in cages for 6 weeks and fed 5 different diets ad-libitum. The treatments were control basal diet (T-1), control + 0.4 ppm Se (sodium selenite; T-2), control basal diet + 0.4 ppm Se from Selplex commercial feed additive rich in Se (T-3), control diet + 0.4 ppm Se derived from FRBSC (T-4) and control basal diet + 0.4 Se derived from FRBAN (T-5). A completely randomized design was adopted in this study with 5 treatments and 4 replications. Results of the study indicate that percentages of liver, gizzard, and carcass were lower in birds fed diets containing sodium selenite. Shorter relative length and diameter of the small intestine were also found in the birds offered the sodium selenite – supplemented diet. The percentages of abdominal fat and breast muscle were not affected by treatment diets. In conclusion, the addition of Se in the form of sodium selenite negatively affected percentages of the liver, gizzard, carcass and digestive tract dimensions. Fermentation of rice bran containing sodium selenite could minimize the detrimental effect of inorganic selenium.

1. Introduction

Agricultural by-products have long been used as animal feeds. The use of rice bran [1], coconut by-products [2], feather meal [3], palm kernel meal [4] and shallot by-products [5] are some examples of the by-products used in broiler diets. Since their qualities are low because of the presence of anti-nutrients, high concentration of indigestible carbohydrates and slow passage rate in the digestive tract [6], their inclusion in the diets is limited. Supplemented of the diets containing agricultural by-products with enzymes [2] and fermentation of agricultural by-products [7] are some efforts to increase their feeding values.
Fermentation has been used by a number of animal nutritionists as one of the alternative solutions to improve the quality of agricultural by-products. A lot of studies have indicated the successful findings of fermented products when they are used as poultry feed ingredients. Rationales behind the fermentation technology in improving feed quality are through the bioconversion of indigestible fraction into more digested substances, from inorganic minerals into more absorbed organic components, enhancing aroma and flavor of the substances and elimination of toxin in the substrates [8]. Fermentation by fungi was mainly applied when solid substrates were used and this technology was called solid-state fermentation (SSF). Compared with submerged liquid fermentation, SSF technology was mainly used in feed technology due to its low production cost and less pollution [9].

Unlike ruminants, poultry could not utilize inorganic minerals and their presence in the poultry diet could be harmful and even toxic. Selenium is an important trace mineral functioning to improve growth and health status due to this mineral is a main component of antioxidant, glutathione peroxidase [10]. This antioxidant is beneficial for poultry to prevent diseases such as myopathies of gizzard, muscular dystrophy and mortality [11,12]. As fungi could bioconvert inorganic selenium into organic minerals, fermentation by fungi could be a way to produce organic selenium that is a pivotal mineral for poultry. A study was conducted to determine the role selenium through fermentation on carcass percentage and digestive organ development of broiler chickens.

2. Materials and methods

2.1. Fermentation protocol
Rice bran was purchased locally and fungi were kindly provided by the Laboratory of Microbiology, Science Faculty, the Tadulako University. Rice bran was finely ground to 1-2 mm size. The fermentation protocol was based on the procedure of Jacob and Prema [13]. The fine substrate of rice bran was autoclaved for 20 minutes at 20 psi. A 0.1% sodium selenite was mixed with the substrate. The mixtures were added with distilled water after being mixed thoroughly. The autoclaved substrate was kept at room temperature. The autoclaved substrates were incubated with either 0.1% A. niger and 0.1% S. cerevisiae. The substrates were placed in plastic bags. After 5 days of incubation, the substrates were oven-dried at 50°C for 48 hours.

2.2. Animals and diets
The study used a total of 140 DOC (day-old broiler chicks). The chicks were placed in 5 pens with a 75-watt bulb in each pen as a brooder. The broiler chicks were transferred after 7 days brooding period into 20 pens and kept the birds for the rest of 5 weeks. All the chicks were vaccinated at day 3 to protect them from New Castle Diseases. From day 1 to 21, the broilers were offered with basal starter and basal grower diets from days 21 to 42. The basal diet can be seen in table 1. The experimental diets were recorded in table 2. Diets and drinking water were provided ad-libitum. Each pen used in this trial was equipped with a drinker and a feeder. The drinker, pens, and surroundings were regularly cleaned throughout the study.
Table 1. Basal diet.

| Feedstuff              | Starter (%) | Grower (%) |
|------------------------|-------------|------------|
| Full fat soybean meal  | 19.5        | 19.3       |
| Corn                   | 61.6        | 65.5       |
| Fish meal              | 3.00        | 3.00       |
| Meat bone meal         | 12.0        | 9.00       |
| Rice bran              | 1.00        | 1.00       |
| Palm oil               | 2.00        | 1.50       |
| Dicalcium phosphate    | 0.10        | 0.10       |
| Salt                   | 0.20        | 0.20       |
| Methionine             | 0.20        | 0.10       |
| Lysine                 | 0.20        | 0.10       |
| Premix                 | 0.20        | 0.20       |

Calculated nutrients

|                |             |
|----------------|-------------|
| Crude protein  | 22.5        |
| Metabolizable energy (Kcal/kg) | 3012        |
| Methionine     | 0.56        |
| Lysine         | 1.29        |
| Selenium       | 0.13        |
| Calcium        | 1.51        |
| Phosphorus     | 0.79        |

Table 2. Experimental diets.

| Treatments                          | Replicates | Birds |
|-------------------------------------|------------|-------|
| T-1: Control                        | 4          | 7     |
| T-2: control + 0.4 ppm Se from sodium selenite | 4          | 7     |
| T-3: control + 0.4 ppm Se from sel-plex | 4          | 7     |
| T-4: control + 0.4 ppm Se from fermented rice bran with S. cerevisiae | 4          | 7     |
| T-5: control + 0.4 ppm Se from fermented rice bran with A. Niger | 4          | 7     |

Sel-plex (commercial feed additive from Alltech)

2.3. Parameters measured

The parameters measured in this study were: percentages of the carcass, breast, abdominal fat, gizzard and liver, relative organ width and length of duodenum, jejunum, and ileum. On the 43, four birds from each pen were randomly taken and killed by cervical dislocation. The killed broilers were dressed and the skin, feathers, neck and shank were removed. Carcass, breast muscle, abdominal fat, gizzard and liver were individually weighed. The width and length of duodenum, jejunum, and ileum were individually measured and expressed in relative length and width.

2.4. Design of experiment and analysis of statistics

A Completely Randomized Design with five different diets and four replicate cages [14]. Analysis of variance was adopted by using a Minitab 16 statistical program. Any differences found in the variance analysis were subject to Tukey test.

3. Results and discussions

3.1. Results
Data on live body weight, percentages of the carcass, breast, abdominal fat, gizzard, and liver were shown in Table 3, while data of relative with and length of duodenum, jejunum, and ileum of broiler chickens were in Table 4.

### Table 3. Live body weight, percentages of carcass, breast, abdominal fat, the gizzard of birds fed the experimental diets.

| Treatments         | Carcass (%) | Breast | Gizzard | Liver | Abdominal fat |
|--------------------|-------------|--------|---------|-------|---------------|
| T-1                | 68.6<sup>a</sup> | 23.7<sup>a</sup> | 1.69<sup>b</sup> | 2.09<sup>a</sup> | 0.82<sup>a</sup> |
| T-2                | 52.7<sup>b</sup> | 20.0<sup>a</sup> | 4.05<sup>a</sup> | 4.92<sup>a</sup> | 0.90<sup>a</sup> |
| T-3                | 69.5<sup>a</sup> | 23.9<sup>a</sup> | 1.20<sup>b</sup> | 1.71<sup>b</sup> | 1.00<sup>a</sup> |
| T-4                | 68.8<sup>a</sup> | 22.0<sup>a</sup> | 1.39<sup>b</sup> | 1.82<sup>b</sup> | 1.03<sup>a</sup> |
| T-5                | 69.1<sup>a</sup> | 21.6<sup>a</sup> | 1.37<sup>b</sup> | 1.87<sup>b</sup> | 1.10<sup>a</sup> |
| P Value            | >0.001      | 0.283  | 0.044   | 0.02  | 0.75          |

T-1: control basal diet; T-2: control basal diet + 0.4 ppm Se from sodium selenite; T-3: control basal diet + 0.4 ppm selenium from Sel-plex; T-4: control basal diet + 0.4 ppm Se from fermented rice bran with *S. cerevisiae*; T-5: 0.4 ppm Se from fermented rice bran with *A. niger*.

| Treatments         | Relative width (cm/kg body weight) | Relative length (cm/kg bodyweight) |
|--------------------|-----------------------------------|-----------------------------------|
| T-1                | 1.09<sup>b</sup> | 0.96<sup>b</sup> | 0.90<sup>a</sup> | 15.4<sup>a</sup> | 88.8<sup>a</sup> | 43.9<sup>b</sup> |
| T-2                | 7.56<sup>a</sup> | 5.65<sup>a</sup> | 4.58<sup>a</sup> | 92.2<sup>a</sup> | 219.9<sup>a</sup> | 213.3<sup>a</sup> |
| T-3                | 1.13<sup>b</sup> | 0.94<sup>b</sup> | 1.00<sup>b</sup> | 16.8<sup>b</sup> | 45.6<sup>b</sup> | 47.3<sup>b</sup> |
| T-4                | 1.37<sup>b</sup> | 1.17<sup>b</sup> | 1.09<sup>b</sup> | 19.9<sup>b</sup> | 48.7<sup>b</sup> | 50.8<sup>b</sup> |
| T-5                | 1.89<sup>b</sup> | 1.26<sup>b</sup> | 1.19<sup>b</sup> | 17.8<sup>b</sup> | 48.1<sup>b</sup> | 50.7<sup>b</sup> |
| P Value            | >0.001       | 0.001   | >0.001   | >0.001 | >0.001 | 0.006 |

T-1: control basal diet; T-2: control basal diet + 0.4 ppm Se from sodium selenite; T-3: control basal diet + 0.4 ppm selenium from Sel-plex; T-4: control basal diet + 0.4 ppm Se from fermented rice bran with *S. cerevisiae*; T-5: 0.4 ppm Se from fermented rice bran with *A. niger*.

### 3.2. Discussions

It has been well believed that inorganic selenium was harmful when present in the diet with high concentration [10,15]. Addition of 0.4 ppm Se in the ration impaired the growth of birds. This finding might indicate the toxic of this inorganic sodium selenite as a source of Se when the diet was added with 0.4 ppm. Interestingly, the same amount of sodium selenite added in the same substrate did not deteriorate the performance of the broiler when fermentation was applied prior to feeding the birds. It can be said that fermentation might eliminate the poisonous effect of inorganic selenium by bioconverting it into the organic selenium [8]. The growth of chickens fed the rice bran added with 0.4 ppm sodium selenite before fermentation was statistically the same as the growth of chickens fed the diet containing Sel-plex. A similar trend was exhibited in the percentage of the carcass in which chickens fed the inorganic selenium diet had a lower percentage of the carcass. The use of two different fungi did not produce a significant difference in the bodyweight of birds.

Although the birds fed the T-2 diet were much lighter, the percentage of liver and gizzard were higher. It is logical that when the birds were bigger, the percentages of organs were smaller compared to the smaller birds. This finding might indicate that the development of the liver and gizzard took place in the starter period and stop growing at the grower period. However, this speculation needs to be verified by further study. Breast muscle and abdominal fat percentages were not affected by the experimental diets.
Developments of each part of the small intestine followed the trend of the development of liver and gizzard. The smaller birds of T-2 had wider and longer duodenum, jejunum, and ileum. Although it is not statistically tested, it seems that duodenum had relatively wider than other parts of the small intestine; jejunum and ileum, while duodenum was relatively shorter than jejunum and ileum of all experimental birds.

4. Conclusions
1. The use of 0.4 ppm Se in the form of sodium selenite in the ration produced a negative effect of broiler performance, carcass percentage, and organ development.
2. An addition of 0.4 ppm Se in the form of sodium selenite could be applied, provided that the feedstuff was fermented.
3. The uses of Fungi Saccharomyces cerevisiae and Aspergillus niger were both beneficial in fermenting feedstuff added with sodium selenite.

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