The use of *Saccharomyces cerevisiae* fermented coconut dregs with the addition of sodium selenite as a source of selenium in broiler diets

U Hatta, A Adjis, S Sarjuni and B Sundu
Animal Husbandry Department, Universitas Tadulako, Palu, 94118, Sulawesi Tengah, Indonesia

E-mail: Ummianihatta71@gmail.com

**Abstract.** Fermentation has been practised in feed technology to bioconvert the inorganic minerals to organic compounds. A study was done to determine the effect of *Saccharomyces cerevisiae* fermented coconut dregs with the addition of selenium on growth performance, feed digestibility and the intestinal response of broiler chickens. The study used 112-day old unsexed broiler chicks for 6 weeks. The broilers were fed with 4 different experimental diets. The diets were basal diet (T1), basal diet plus 0.5% coconut dregs (T2), basal diet plus 0.5% of 5 days fermented coconut dregs (T3) and basal diet plus 0.5% of 7 days fermented coconut dregs (T4). The broilers were fed ad libitum and tap water was offered at all times. The broiler chicks were vaccinated against New Castle Diseases on the fourth day. Feeders and drinkers were placed inside the pen. The feeders, drinkers, pens and surroundings were cleaned whenever necessary. A completely randomized design was used in this study with four different treatment diets, four replicate cages of 7 birds each. The data found in this study was analyzed using an analysis of variance. A Tukey test was applied once a significant effect was detected in the analysis of variance. Results of the study indicate that body weight gain and dry matter digestibility increased when the birds were fed the diets T3 and T4. The relative gizzard weight of birds fed the T3 and T4 was lighter than the birds fed the T1 and T2. Feed intake, feed conversion ratio, carcass percentage and relative intestine weight were not affected by the experimental diets. In conclusion, feeding the birds with diets supplemented with *Saccharomyces cerevisiae*-fermented coconut dregs with additional selenium improved feed quality and broiler performance.

**1. Introduction**
Plants and microorganisms can rely on their nutrients to grow and develop from inorganic compounds and then converted them into organic substances [1]. Yeast is one of the microorganisms used in the fermentation industry to produce more valuable products. Among the yeast, *Saccharomyces cerevisiae* has been used to improve the feeding value of the feedstuffs [1], along with its common use for bakery and alcohol production. The results of using *Saccharomyces cerevisiae* in fermentation technology have been promising to improve the feeding value of several feedstuffs, such as rice bran [2] and coconut dregs [3].

The use of yeast *Saccharomyces cerevisiae* in the feed technology has been done through solid-state fermentation. Since *Saccharomyces cerevisiae* needs a solid substrate as a medium to grow, the application of solid-state fermentation technology is more compatible than submerged liquid fermentation. The use of agricultural by-products to support the growth of yeast [4] is because nearly
all the nutrients needed by yeast could be supplied by the agricultural by-products. Moreover, the capacity of agricultural by-products to bind water produced an ideal environment for the yeast to grow [5].

Mechanisms of *Saccharomyces cerevisiae* in improving the feeding value of feedstuffs are by acting as a probiotic property [6]. More current findings indicated that *Saccharomyces cerevisiae* could bioconvert inorganic nitrogen and sulfur into methionine and cysteine [7] and selenium into selenomethionine [8] during the fermentation process. These findings might be applied to tackle the problems of the availability of limited organic minerals that are beneficial for the production and health status of poultry. One of the minerals present in small amounts in nature is selenium. This trace mineral has been reported to improve immunity [9] growth performance, sperm motility and meat quality [10,11]. Accordingly, a study was conducted to determine the effect of coconut dregs fermented by *Saccharomyces cerevisiae* with the addition of selenium on growth performance, feed digestibility, digestive organ development and carcass traits of broiler chickens.

2. Material and methods

2.1. Fermentation of coconut dregs

Local coconut dregs purchased from the traditional market were oven-dried at 60°C for three consecutive days. The dried coconut dregs were finely ground for the use of fermentation substrate. *Saccharomyces cerevisiae* bought from the local supermarket was used as starter cultures. A method of solid-state fermentation used by Sundu et al (2019) was applied in this study and the fermentation process was carried out in the Laboratory of Animal Nutrition and Feed Technology, Universitas Tadulako [3]. The fine coconut dregs were sterilized using an autoclave for 20 minutes at 20 psi. After cooling at room temperature, the autoclaved coconut dregs were mixed with 0.1% sodium selenite with 98% purity. The substrates were thoroughly mixed with the addition of sterile distilled water to reach 80% moisture. The incubation process was done by adding 0.1% *Saccharomyces cerevisiae* (equivalent to 346 CFU/g) into the coconut dregs. The substrate was then put in transparent plastic bags for either 5 days or 7 days. The plastic bag was perforated to allow aerobic fermentation. The incubated coconut dregs were harvested and oven-dried for 2 days at 50°C. The dried fermented coconut dregs (CFD) were used as a feed additive.

2.2. Experimental birds and diets

The experiment used a total of 112 - day old Cobb chicks. The chicks were placed in 4 electrically heated brooders for 7 days. Protection of New Castle Diseases was done by vaccinating the chicks through ocular installation using Vaksimune® ND B1 on day 3. On day 8, the chicks were then distributed into 16 pens up to days 42. The starter diet was offered when the chicks were in the first three weeks. From days 21 to 42, the broilers were fed with grower diets. The basal diet (table 1) was formulated using the least-cost feed formulation software [12]. The experimental diets were T1 (basal diet), T2 (basal + 0.5% FCD), T3 (basal + 0.5% of 5-days-FCD with the addition of sodium selenite) and T4 (basal + 0.5% of 7-days-FCD with the addition of sodium selenite) and drinking water was provided ad libitum. Each pen was equipped with a 5-litre plastic drinker and a feeder. All the types of equipment used in the cage were cleaned regularly.
Table 1. The basal diet used in this study.

| Ingredients (%)                  | Starter diet | Grower diet |
|----------------------------------|--------------|-------------|
| Maize                            | 50.0         | 50.4        |
| Full fat soybean meal            | 25.0         | 24.5        |
| Rice bran                        | 10.0         | 13.4        |
| Fish meal                        | 13.3         | 11.0        |
| Dicalcium phosphate              | 0.80         | 1.10        |
| Methionine                       | 0.20         | 0.10        |
| Lysine                           | 0.20         | 0.10        |
| Salt                             | 0.20         | 0.20        |
| Mineral and vitamin mix          | 0.30         | 0.20        |

Calculated nutrients

| Metabolizable energy (kcal/kg)   | 3,141        | 3,154       |
| Crude protein (%)               | 23.08        | 21.19       |
| Calcium (%)                     | 1.70         | 0.94        |
| Phosphorus (%)                  | 0.71         | 0.66        |
| Methionine (%)                  | 0.66         | 0.51        |
| Lysine (%)                      | 1.49         | 1.28        |
| Selenium (%)                    | 0.26         | 0.23        |

2.3. Digestibility study

Two birds, randomly taken from each experimental pen, were allocated into the metabolism cage for 7 days (from days 35 to 42). A tray matching the size of the pen was put underneath each metabolic pen. Excreta from each pen were collected daily for 3 consecutive days. The collection of the excreta started at 07.00 am. The total excreta from each pen was weight daily after all the contaminants such as feed particles and feathers were removed. The collected excreta was oven-dried at 50°C for three days. The experimental diets and dried excreta were pooled and stored for the analysis of dry matter and protein content. The digestibilities of dry matter and protein were determined based on the total excreta collection method [13].

2.4. Carcass and digestive organs measurement

At the end of the experiment, all the birds were slaughtered by cervical dislocation. The slaughtered birds were dressed by removing the skin and feathers, neck, shank, digestive tract and organs. Carcass, breast muscle and abdominal fat were individually weighed. Gizzard and intestine were emptied by gentle pressure while the gizzard was cut into two halves and the digest was removed. These emptied gastro-intestinal organs were then individually weighed.

2.5. Experimental design and statistical analysis

A Completely Randomized Design with 4 treatments and 4 replicate cages of 7 birds each [14] were adopted in this study. Data of all parameters found in this study were analysed by using analysis of variance to determine the significant effects of treatments on each parameter. Any differences detected in the analysis of variance were further tested with the least significance difference test (Tukey test) using the statistical software of Minitab [15].
3. Results and discussions

3.1. Results

Data on body weight gain, feed intake, FCR, dry matter and protein digestibility are shown in table 2. The effects of treatment diets on the carcass, gizzard weight, abdominal fat, breast, duodenum, jejunum and ileum weight are presented in table 3. Bodyweight gain, dry matter digestibility and gizzard percentage were significantly (P<0.05) affected by the treatment diets. The birds fed the diets containing FCD dregs with the addition of selenium were heavier and smaller gizzard than the birds fed the diets without selenium addition. Dry matter digestibility of the diets plus fermented coconut dregs with the addition of selenium was higher than the diets without selenium supplementation. Feed intake, FCR, protein digestibility, carcass percentage, abdominal fat, duodenum, jejunum and ileum were not affected (P>0.05) by the treatments.

Table 2. The effect of experimental diets on growth performance and feed digestibility.

| Treatment | BWG (g) | Feed Intake (g) | FCR | DMD (%) | Protein digestibility (%) |
|-----------|---------|-----------------|-----|---------|--------------------------|
| T1        | 1821º   | 3,608           | 1.98| 77.6º   | 77.7º                    |
| T2        | 1822º   | 3,567           | 1.96| 79.7º   | 79.7º                    |
| T3        | 1989º   | 3,716           | 2.02| 84.0º   | 84.0º                    |
| T4        | 2003º   | 3,774           | 1.98| 83.9º   | 83.9º                    |
| SEM       | 25.66   | 86.64           | 0.109| 0.56    | 9.38                     |
| P Value   | >0.001  | 0.345           | 0.978| >0.001  | 0.431                    |

BWG: bodyweight gain; DMD: dry matter digestibility; values with a different superscript within a column are significantly different (P<0.05).

Table 3. Carcass traits and digestive organs dimensions of birds fed the experimental diets.

| Treatment | Carcass (%) | Gizzard (%) | Abdominal Fat (%) | Breast (%) | Duodenum (g/kg BW) | Jejunum (g/kg BW) | Ileum (g/kg BW) |
|-----------|-------------|-------------|-------------------|------------|--------------------|-------------------|----------------|
| T1        | 66.14       | 1.91º       | 1.74              | 22.1       | 9.3                | 35.7              | 34.7           |
| T2        | 69.84       | 1.84º       | 2.15              | 21.6       | 9.6                | 35.9              | 37.6           |
| T3        | 71.04       | 1.64º       | 2.01              | 23.7       | 10.2               | 37.4              | 32.1           |
| T4        | 69.82       | 1.65º       | 2.06              | 21.5       | 10.2               | 35.9              | 32.2           |
| SEM       | 1.69        | 16.6        | 0.01              | 1.41       | 0.83               | 2.54              | 2.82           |
| P Value   | 0.26        | 0.00        | 0.69              | 0.69       | 0.83               | 0.96              | 0.49           |

Values with a different superscript within a column are significantly different (P<0.05); BW: Bodyweight; SEM: Standard error means.

3.2. Discussions

The use of agricultural by-products to replace conventional feedstuffs, in many cases, failed to produce the same results as birds fed the conventional feedstuffs-based diets [16]. Several attempts have been done to improve their feeding values, but the results were still far from the expectation. Instead of using agricultural by-products as feed ingredients, it is better to use them as feed additives provided that specific nutrients or beneficial secondary metabolites in the agricultural by-products can be enriched. Improving the concentration of specific nutrients through fermentation has been successfully proven in several studies the increased concentration of amino acids [7], production of cellulase [17], mannanase [18] and increased selenium concentration [3] are to name some of the benefits of fermentation. These benefits could lead to the improved feeding value of the diets. Accordingly, when the fermented coconut dregs either with or without sodium selenite addition were offered to the broilers, bodyweight gain increased. The increased body weight gain of broilers was nothing to do with feed intake as feed intake was unaffected. Extrapolating from the feed intake and dry matter digestibility, significant improvement of digestible dry matter intake was found and this might be the reason for an improved body weight gain of broilers in this present study. The effect of the treatment on feed conversion ratio was not significant.
Expectedly, feed digestibility of the diet either in the form of dry matter digestibility was affected by the treatments in the present study. The birds fed the fermented coconut dregs produced better dry matter digestibility, this finding is following [3]. It is not hard to elaborate on the increased feed digestibility due to fermentation. The production of cellulase [17] and mannanase [18] in the fermented coconut by-products are the reasons. Among these two enzymes produced, cellulase might play an important role in breakdown the cellulose present in the diets. Once the fibre matrix was open up due to cellulase activity, nutrients trapped in the fibre matrix would be accessible by digestive enzymes produced by digestive organs. Although mannans present in a small amount in the full-fat soybean meal [19], their presence in the diets was reported to be anti-nutrients and thus affect the digestibility of the diet. Mannanase enzyme produced during fermentation as reported might destroy the anti-nutritive property of soybean mannan [18].

To clarify the above speculation of the action of enzyme produced during fermentation, measuring the relative size of the gizzard might be logical [20]. The birds fed the fermented diets (T3 and T4) had lighter gizzard than those of birds fed the unfermented coconut dregs. Since birds grind the feed in the gizzard, the higher work volume of the gizzard due to higher dietary fibre in the diets could lead to a bigger muscular gizzard [20]. The presence of enzymes either mannanase or cellulase that is not produced by the digestive organs of poultry, could facilitate the digestion process of the diets in the gizzard and thus lead to the gizzard lighter. Other digestive organs starting from the duodenum, jejunum and ileum were not affected by the treatment diets. This might indicate that these digestive tracts did not work based on physical activity but through enzymatical action. Accordingly, the size of the duodenum, jejunum and ileum were not affected by the treatment diets.

The effect of fermentation on the carcass traits has been studied by some authors [3,7]. Although body birds fed the fermented coconut dregs were heavier than those birds fed the diets without supplementing with fermented coconut dregs, the carcass percentage was not statistically different. This present study was following the previous study of Heryandi et al (2018) birds that were fed fermented pineapple skin produced the same carcass weight and percentage as birds fed fermented unsupplemented [21]. Abdominal fat and breast weight were also not affected by the treatment.

4. Conclusions
Fermentation of coconut dregs for 5 days either with or without selenium addition could improve the body weight gain of birds, feed digestibility and had lighter gizzard. Feed intake, FCR, protein digestibility, carcass percentage, abdominal fat, breast, duodenum, jejunum and ileum were not affected by the treatment diets.

Acknowledgement
Our sincere thanks go to the Ministry of Research, Technology and Higher Education of the Republic of Indonesia for the research funds enabling us to carry out this research. We also appreciate the dean of the animal husbandry and fishery, the University of Tadulako for providing us with a research facility. We are indebted to the students for their help in doing fermentative work and taking care of the birds.

References
[1] Lyons T P 2002 Navigating From Niche Markets to Mainstream: A Feed Industry Kakumei Proc. Alltech’s 16th Annu. Asia Pacific Lect. Tour (China: Nottingham Nottingham Univ. Press) pp 1–16
[2] Mozin S, Hatta U, Sarjuni S, Gobel M and Sundu B 2019 Growth performance, feed digestibility and meat selenium of broilers fed fungi-fermented rice bran with addition of inorganic selenium Int. J. Poult. Sci. 18 438–44
[3] Sundu B, Hatta U, Mozin S and Adjis A 2019 The effect of fermented coconut dregs with the addition of inorganic selenium on feed digestibility, growth performance and carcass traits of broiler chickens Livest. Res. Rural. Dev. 31
[4] Filler K 2001 Production of enzymes for the feed industry using solid substrate fermentation
[5] Bhargav S, Panda B P, Ali M and Javed S 2008 Solid-state fermentation: an overview Chem. Biochem. Eng. Q. 22 49–70

[6] Onifade A A, Odunsu A A, Babatunde G M, Olored G R and Muma E 1999 Comparison of the supplemental effects of Saccharomyces cerevisiae and antibiotics in low-protein and high-fibre diets fed to broiler chickens Arch. Anim. Nutr. 52 29–39

[7] Hafsa H, Damry H B, Hatta U and Sundu B 2020 Fermented coconut dregs quality and their effects on the performance of broiler chickens Trop. Anim. Sci. J. 43 219–26

[8] Aruna T E, Aworh O C, Raji A O and Olagunju A I 2017 Protein enrichment of yam peels by fermentation with Saccharomyces cerevisiae (BY4743) Ann. Agric. Sci. 62 33–7

[9] Surai P F and Kochish I I 2019 Nutritional modulation of the antioxidant capacities in poultry: The case of selenium Poult. Sci. 98 4231–9

[10] Mozin S, Hatta U, Sarjuni S, Toana N M, Gobel M and Sundu B 2020 Carcass percentage and digestive organs development of broilers fed diets containing organic selenium and fermented selenium-rich feedstuffs IOP Conf. Ser.: Earth Environmen. Sci. 492 12132

[11] Ebeid T A 2009 Organic selenium enhances the antioxidative status and quality of cockerel semen under high ambient temperature Br. Poult. Sci. 50 641–7

[12] Pesti G M, Miller B R and Chambers R 1986 User- Friendly feed Formulation Program (UFFF) version 1.11–256k (Atlanta: The University of Georgia)

[13] Kong C and Adeola O 2014 Evaluation of amino acid and energy utilization in feedstuff for swine and poultry diets Asian-Australasian J. Anim. Sci. 27 917–25

[14] Steel R G D and Torrie J A 1980 Principles and Procedures of Statistics (New York: McGraw Hill)

[15] Minitab I N C 2003 Data analysis and quality tools Release 14 for windows (USA: Minitab Inc)

[16] Sundu B, Kumar A and Dingle J 2006 Response of broiler chicks fed increasing levels of copra meal and enzymes Int. J. Poult. Sci 5 13–8

[17] Hatta U, Sjofjan O, Subagiyo I and Sundu B 2014 Effects of fermentation by Trichoderma viride on the nutritive value of copra meal, cellulase activity and performance of broiler chickens Livest. Res. Rural. Dev. 26

[18] Bahri S, Sundu B and Apiantio M R 2019 Mannanase activity produced through fermentation of coconut flour at various pH by Aspergillus niger J. Physics: Conf. Ser. 1242 12009

[19] Jackson M E, Fodge D W and Hisao H Y 1999 Effects of beta-mannanase in corn-soybean meal diets on laying hen performance Poult. Sci. 78 1737–41

[20] Sundu B 2009 Gastro-intestinal response and passage time of pelleted diets in the digestive tract of broilers Int. J. Poult. Sci. 8 976–9

[21] Heryandi Y, Adrizal N N and Mahata M E 2018 Research article carcass characteristics and organ development of broilers fed fermented pineapple peel [Ananas comosus (L.) Merr] waste using a local microorganism solution derived from bamboo sprouts Int. J. Poult. Sci. 17 229–33