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Carcass quality of broilers fed with banana tuber meal enriched with *Saccharomyces cerevisiae* as a β-glucan fiber

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Abstract: The background of the study is that broilers have high levels of fat and cholesterol in the body, which reduces the quality of the carcass. One way to improve this is by adding feed additive β-glucan. This study aims to evaluate the addition of banana tuber flour containing Saccharomyces cerevisiae as a source of β-glucan fiber in feed on broiler carcass quality. The method used was a completely randomized design consisting of 5 treatments and 4 replications, each treatment unit contained 10 chickens, making a total of 200 chickens raised for 37 days. β-glucan in feed was given at levels of 0, 25, 50, 75, and 100 ppm. Drinking water was given ad libitum, while feed was given using manufactured feed. Treatment was given at the age of 16 to 37 days. Parameters measured included live weight and carcass, and percentage of carcass and ab-dominal fat. Data were analyzed using ANOVA. The results revealed that banana tuber flour enriched with Saccharomyces cerevisiae as β-glucan fiber in feed significantly ($P<0.05$) increased live weight and body weight, but did not have a significant effect ($P>0.05$) on carcass percentage and abdominal fat. In conclusion, banana tuber flour enriched with Saccharomyces cerevisiae as β-glucan fiber in feed can increase live weight and body weight of broilers best at a concentration of 25 ppm.

Keywords: broiler, carcass, β-glucan, *Saccharomyces cerevisiae*

Introduction

Broiler farming is one of the businesses that continues to be developed to meet the animal protein needs of the community. This can be seen in (Ditjennakkeswan, 2023) which states that the broiler population in Indonesia increased from 2.8 billion broilers in 2021 to 3.1 billion broilers in 2022. Broiler meat is a meat that is in great demand by consumers because in addition to being a meat that has high nutrition, broiler meat also has economic value and is easily available. This is reinforced by the increase in broiler meat consumption in Indonesia from 2021 - 2022, which started from 0.126/capita/week to 0,139/capita/week (Ditjennakkeswan, 2023). Broilers have shorter growth than other chickens, because within 5 weeks broilers are able to produce a body weight of 1.75 - 2 kg. The high demand for broiler meat is a potential success for broiler farmers. The success of broiler farming is also influenced by several factors, namely breeds, feed and management. Measures of broiler productivity can be seen from live weight, carcass weight and carcass percentage. However, rapid growth in broilers is accompanied by rapid fat growth as well. Broiler fat reaches 20% and contains 79 mg/100 g body weight of cholesterol. (Atmomarsono, 2004). Excess fat content is a consideration for farmers who are aware of the public's desire for meat that is rich in nutrients and low in fat. One of the factors of broiler growth and fat is from the feed factor. Reducing broiler fat through dietary adjustments is crucial. A significant approach involves incorporating β-glucan fiber into their feed.

β-glucans influence fat metabolism by binding to fatty acids, cholesterol, and bile salts within the gastrointestinal tract. Fatty acids and cholesterol bound to fiber cannot form micelles that are needed for fat absorption to pass through the unstirred water layer into enterocytes. As a result, the fat that binds to the fiber cannot be absorbed and will continue to the large intestine to be excreted through feces. β-glucan in this process can reduce broiler cholesterol and fat levels (Santoso, 2011). *Saccharomyces cerevisiae* serves as a readily accessible source of β-glucan.

Saccharomyces cerevisiae, a type of yeast, produces β-glucan from its cell wall. This cell wall structure includes proteins linked to sugars forming glycoproteins and manoproteins, and contains mannan, chitin, as well as β-1,3-glucan and β-1,6-glucan polysaccharides (Kwiatkowski & Kwiatkowski, 2012). β-glucan contained in *Saccharomyces cerevisiae* is about 55%-65%. For *Saccharomyces cerevisiae* to grow in the media, it requires nutrients such as carbon, nitrogen, oxygen, vitamins, and minerals. Glucose is typically utilized as the carbon source in the media (Yunilawati et al., 2015). One of the easily available sources of glucose for *Saccharomyces cerevisiae* is banana tuber.

Banana tuber contains 17.46% dry matter; 16.00% ash; 0.96% crude protein; 14.50% crude fiber; 0.75% crude fat; 67.79% NFE; and 3202 kcal gross energy (Sutowo et al., 2017). The NFE/starch content in banana tuber makes it suitable as a medium for *Saccharomyces cerevisiae* to synthesize β-glucan. Given the information above, research is needed to evaluate the impact of banana tuber enriched with β-glucan fiber from *Saccharomyces cerevisiae* on carcass quality, including live weight, carcass weight, and abdominal fat.

Methods

Place and Time of Implementation

This research was conducted in the Department of Animal Husbandry, Politeknik Negeri Jember.

Tools and Materials

The tools used in this maintenance are chicken cages, sprayers, pH meters, feed and drinking containers, brooders, thermometers, buckets, shovels, plastic mats, scales, measuring cups, knives, ovens, grinding machines, polypropylene (PP) plastic, barrels, ram screens, sanitation tools, stationery, baskets, scales, cutting knives, pluckers, plastic and stationery.

The materials used in the implementation of this research are as follows: DOC broiler strain Cobb, water, BR1 commercial feed, brown sugar, lime, vitamins, medicine, formalin, husk, detergent, Kepok banana tuber and *Saccoremyces cerviciae* starter.

Research Procedure

The production of banana tuber flour enhanced with β-glucan from *Saccharomyces cerevisiae* involved several steps. First, all necessary tools and materials were prepared. The banana tuber was cut into small, thin slices, sun-dried, and then ground into flour. The flour was mixed with an equal weight of water (50%) and stirred until smooth. This mixture was steamed for 45 minutes, then cooled, and inoculated with 0.5% *Saccharomyces* *cerevisiae* starter based on the weight of the banana tuber flour. The mixture was then sealed in black plastic to ensure an anaerobic environment and fermented for three days. After fermentation, the product was sun-dried. The resulting banana tuber flour, now enriched with β-glucan, was ready for analysis and use.

Application and Treatment

This study employed a completely randomized design (CRD) comprising five treatments, each with four replicates. Each replicate included 10 broilers, resulting in a total of 200 broilers and 20 randomization units. The treatments began when the chickens were 16 days old and continued until they were 37 days old. The feed treatments were as follows: T0 = basal feed, T1 = basal feed + 25 ppm β-glucan, T2 = basal feed + 50 ppm β-glucan, T3 = basal feed + 75 ppm β-glucan, and T4 = basal feed + 100 ppm β-glucan. The dosage of *Saccharomyces cerevisiae* fermented banana tuber flour was determined based on the β-glucan content analyzed in Table 1.

Tabel 1. Analysis test results of β-glucan content from fermented banana tuber flour and *Saccharomyces cerevisiae*

No	Sample Code	Test Parameter	Unit	Result	Test Method
1	Fermentation	β-glucan	%	0,224	In-house method

Sumber : Integrated Laboratory and Technology Innovation Center, University of Lampung

The β-glucan content was found to be 0.224% per 1 kg of fermented banana tuber flour with *Saccharomyces cerevisiae*. Converting 0.224% to ppm or milligrams results in 2,240 mg. The feed mixing dosages with banana tuber flour were as follows: T1 = 2,240 mg ÷ 25 ppm = 89.6 kg feed + 1 kg banana tuber flour, T2 = 2,240 mg ÷ 50 ppm = 44.8 kg feed + 1 kg banana tuber flour, T3 = 2,240 mg ÷ 75 ppm = 29.8 kg feed + 1 kg banana tuber flour, and T4 = 2,240 mg ÷ 100 ppm = 22.4 kg feed + 1 kg banana tuber flour.

Feed Composition

The feed, sourced from PT. Panca Patriot Prima, was administered twice daily: at 7:00 am, providing 40% of the total daily requirement, and at 4:00 pm, providing the remaining 60%. The nutritional composition of this feed is detailed in Table 2.

Table 2. Nutrient content of feed

Nutrient content	Total
Water Content (%)	Maximum 12%
Crude Protein (%)	20 - 22 %
Lysine	Minimum 1,20 %
Methionine	Minimum 0,45 %
Methionine + Cystine	Minimum 0,80 %
Threonine	Minimum 0,75 %
Tryptophan	Minimum 0,19 %
Crude Fat (%)	Maximum 6 %
Crude Fiber (%)	Maximum 5 %
Ash (%)	Maximum 7 %

Nutrient content	Total
Calcium (%)	Minimum 0,9 - 1,1 %
Phosphor (%)	Minimum 0,7 - 0,9 %
Coccidiostat	Robenidin
Alfatoxin	Maximum 40 ppb
Urea content	ND (not detected)

Source from : PT. Panca Patriot Prima

Data Collection

When the chickens reached 37 days old, they were slaughtered by placing them in a hanging device with their heads positioned downward. The jugular vein, carotid artery, trachea, and esophagus were severed at the neck and head junction. The chickens were then left hanging for 1 to 1.5 minutes until the blood ceased dripping. Next, they were immersed in hot water at around 60°C to facilitate feather removal, which was done automatically using a plucking machine. The data collected included live weight, carcass weight, carcass percentage, and abdominal fat.

Research Parameters

1. Live weight: the live weight measured is the weighing at the end of maintenance.
2. Carcass weight: chickens were weighed after slaughter with missing blood, feathers, feet, head, neck, and visceral organs to obtain carcass weight.
3. Carcass percentage: To determine the carcass weight, the chickens were weighed post-slaughter, excluding blood, feathers, feet, head, neck, and visceral organs. The collected data on carcass weight were obtained through weighing. The carcass percentage was calculated using the formula: carcass percentage (%) = carcass weight (g) / live weight (g) x 100%.
4. Percentage of abdominal fat: The weight of abdominal fat in broiler chickens was determined by weighing the fat collected from around the gizzard and the layer attached between the abdominal muscles and intestines (Salam et al., 2017). The percentage of abdominal fat was calculated by dividing the weight of the abdominal fat by the carcass weight (in grams) and multiplying by 100% (Firinicha, 2022).

Data Analysis

The data analysis used in this study is Analysis of Variance (ANOVA) using the f test to determine whether it is different or not. If the results obtained are different, further tests are carried out using the Smallest Real Differences (SRD) to find out how big the difference.

Results and Discussion

The impact of incorporating banana tuber enriched with β-glucan fiber from *Saccharomyces cerevisiae* into the feed on live weight, carcass weight, and carcass percentage is presented in Table 3.

Table 3. Average live weight, carcass weight, carcass percentage, and abdominal fat percentage of broilers feed with banana tuber enriched with β-glucan fiber from *Saccharomyces cerevisiae*.

Parameters	Treatment				
	T0	T1	T2	T3	T4
Live weight (g)	1995.00[a]	2060.00[b]	1990.00[a]	2020.00[a]	2105.00[c]
Carcass weight (g)	1444.75[a]	1509.00[b]	1450.00[a]	1469.00[a]	1511.75[b]
Carcass percentage (%)	72.42	73.24	72.87	72.72	71.82
Abdominal fat percentage (%)	0.98	0.87	1.35	1.70	1.59

Note: [a-c] Different superscripts on the same line indicate significant differences (P<0,05).

Live weight

The results showed the highest average live weight numerically T4 (2,105 g/head) with β-glucan 100 ppm, while the lowest average of all treatments was T2 (1990 g/head) with a dose of 50 ppm. These results indicate that the effect of the addition of β-glucan has a significant effect (P <0.05) on broiler live weight. It is known that the results of the SRD test show that the T0 treatment (control) produces a significantly different live weight (P <0.05) with T4, the addition β-glucan gives better results due to the β-glucan content of *Saccharomyces cerevisiae* has a probiotic function to increase the activity of digestive enzymes so that food that is well absorbed can be utilized by chickens for tissue growth and weight gain (Kumalasari et al., 2020). This is because the β-glucan content of *Saccharomyces cerevisiae* contains *Bacillus* bacteria which can also inhibit the growth of *Escherichia coli, Clostridium spp., Campylocbacter spp.,* and *Streptococcus* (Tang et al., 2011).

In addition, *Bacillus* can also survive in bile salts plus these bacteria can be symbiotic with *Lactobasillus* in the digestive tract of poultry (Zurmiati et al., 2014) and make the digestive tract healthier (Imam et al., 2018; Suryadi et al., 2022b). So that more food nutrients are absorbed in the digestive tract which results in higher small intestine and body weights (Imam et al., 2015, 2018, 2020, 2024; Suryadi et al., 2021, 2022a), maintaining the immune system (Suryadi et al., 2024), physical quality (Imam et al., 2023) and sensory broiler meat (Imam et al., 2022).

Based on the harvest weight in the T4 treatment, the highest average weight is 2.105 g. This is due to the nutritional content of the feed ingredients in the T4 treatment. This is due to the nutritional content of feed ingredients in T4 by giving β-glucan according to the results of a study from (Ahmad, 2005) in his research which states that adding *Saccharomyces cerevisiae* which has probiotic, prebiotic and immunity functions in feed can reduce growth and increase live weight and improve the appearance of broiler chickens. (Zhang et al., 2012) reinforced in their research, stating that broilers fed finisher feed supplemented with β-glucan had a higher live weight than chickens fed control feed.

Carcass Weight

The results showed the highest average carcass weight numerically T4 (1511.75 g/head) with the addition with β-glucan 100 ppm, while the lowest average of all treatments was T0 (1444.75 g/head). These results indicate that the effect of the addition β-glucan has a significant effect ($P<0.05$) on broiler carcass weight. The results of the significant difference test showed that the average carcass weight of the T4 treatment was 1.511 g higher than the other treatments. The effect of carcass weight is caused by live weight which also shows a significant difference (P 0.05). Carcass production is closely related to body weight and carcass size which is quite varied. This difference is caused by body size, the level of fatness and the level of meat attached to the chest. (Puspitasari et al., 2019) state that a large live weight will be directly proportional to the large carcass weight and vice versa if the live weight is small it produces a small carcass weight. (Akhadiarto, 2010) also mentions that the achievement of carcass weight is an important factor in assessing production which is closely related to live weight, where the more live weight increases, the more carcass weight increases. (Purba, 1990) dded that if the live weight is low, it will produce a low carcass weight because the carcass is only the main component is bone and muscle.

Carcass Percentage

The results showed the highest average carcass percentage numerically T4 (73.24%) with the addition β-glucan 25 ppm, while the lowest average of all treatments was T4 (71.28%) with a dose of 100 ppm. The analysis revealed that supplementing feed with banana tuber flour, enriched with β-glucan fiber from *Saccharomyces cerevisiae*, did not significantly influence the percentage of broiler carcasses. The results showed no notable effect ($P>0.05$) on the carcass percentage when this flour was added to the feed. the addition β-glucan was higher in the T1 treatment, which was 73.24%. This is due to more feed nutrients absorbed in the digestive tract resulting in higher live weight and carcass weight even though the carcass percentage is not significantly different. Not significantly different carcass percentage is due to the consumption of feed rations that are relatively almost the same and not much different from each treatment so as to produce carcass weights that are not much different, resulting in a carcass percentage that is not significantly different. It can be seen that the live weight and carcass weight have a positive correlation, the higher the live weight, the higher the carcass weight but produces a different carcass percentage. It is suspected that there are other things that affect the insignificance of the carcass percentage because the addition β-glucan at a dose of 25-100 ppm in the feed produces almost the same cutting weight so that it affects the weight and percentage of carcass produced. (Rihi, 2004) suggested that a relative increase in the percentage of carcasses produced will not significantly impact the proportion of meat and bone in the carcasses. According to (Soeparno, 2015), the percentage of carcass is determined by both the growth rate and the quality of the feed. The growth rate, reflected by the increase in body weight, influences the slaughter weight and, consequently, the proportion of the carcass obtained..

Abdominal Fat Percentage

The results showed the lowest average percentage of abdominal fat numerically T1 (0.87%) with the addition β-glucan 25 ppm, while the highest average of all treatments was T3 (1.70%) with a dose of 75 ppm. The results of the analysis of the addition β-glucan had no significant effect ($P>0.05$) on the percentage of broiler abdominal fat. A lower average percentage of abdominal fat indicates a higher quality carcass. The accumulation of fat in the abdominal cavity contributes to the overall weight of the carcass. The average percentage of abdominal fat obtained in this study is still in the normal range of 0.87% to 1.70%. This is in accordance with the opinion (Salam et al., 2017) which states that the percentage of broiler abdominal fat ranges from 0.73-3.78%. (Puspitasari et al., 2019) stated that the formation of abdominal fat in the chicken body occurs due to the excess energy obtained by the feed it consumes. (Pratikno, 2011) added that the formation of fat tissue is formed quickly at the age of six weeks, while at the age of 15-36 days it is still relatively low, which is around 3% of body weight. At that age, fat is not formed too much because the food substances absorbed by the body are still used for growth. The absence of significant differences in the percentage of abdominal fat is suspected that the addition β-glucan cannot reduce abdominal fat. (Kazempour et al., 2017) in his research which provides 110% β-glucan content in broiler chickens stated that the decline in abdominal fat was due to the β-glucan content in the addition of insufficient feed which would not have an effect on abdominal fat. It is very clear that in this study the β-glucan content was only 0.224% which is very much different.

The highest average percentage of abdominal fat is T3 which is 1.70% higher than the T0 treatment which is not given treatment, this result indicates that the provision of β-glucan does not give maximum results on abdominal fat. In line with research from (Imam & Suryadi, 2021; Tang et al., 2011) which states that the addition of β-glucan fiber to feed does not have a clear statistical effect on the fat component.

Conclusion

Based on the results and discussion, it can be concluded that the effect of adding β-glucan in feed can increase live weight and carcass weight with the best addition level of 25 ppm.

References

Ahmad, R. Z. (2005). Pemanfaatan khamir Saccharomyces cerevisiae untuk ternak. *Wartazoa*, *15*(1), 49–55.

Akhadiarto, S. (2010). Pengaruh pemberian probiotik temban, biovet dan biolacta terhadap persentase karkas, bobot lemak abdomen dan organ dalam ayam broiler. *Jurnal Sains Dan Teknologi Indonesia*, *12*(1).

Atmomarsono, U. (2004). Upaya menghasilkan daging broiler aman dan sehat. In *Pidato pengukuhan guru besar Fakultas Peternkan, Universitas Diponegoro*. Diponegoro University Press.

Ditjennakkeswan. (2023). *Statistik Peternakan dan Kesehatan Hewan*. Direktorat Jenderal Perternakan dan Kesehatan Hewan, Kementerian Pertanian Republik Indonesia.

Firinicha, R. (2022). *Bobot karkas dan lemak abdomen ayam broiler yang diberi ransum berbahan* *lokal berprobiotik sebagai pengganti ransum komersil*. Skripsi. Fakultas Peternakan. Universitas Jambi.

Imam, S., Mahfudz, L. D., & Suthama, N. (2015). Pemanfaatan asam sitrat sebagai acidifier dalam pakan stepdown protein terhadap perkembangan usus halus dan pertumbuhan broiler. *Jurnal Litbang Provinsi Jawa Tengah*, *13*(2), 153–162.

Imam, S., Mahfudz, L. D., & Suthama, N. (2018). Perkembangan mikrobia usus ayam broiler yang diberi pakan stepdown protein dengan penambahan asam sitrat sebagai acidifier. *Jurnal Litbang Provinsi Jawa Tengah*, *16*(2), 191–200.

Imam, S., & Suryadi, U. (2021). Effect of banana weevil enriched with beta-glucan from Saccharomyces cerevisiae on productivity and abdominal fat of broiler chickens. *{IOP} Conference Series: Earth and Environmental Science*, *672*(1), 12039.

Imam, S., Suryadi, U., & Fitriani, R. A. N. (2020). Suplementasi β-glukan dari Saccharomyces cerevisiae dengan Media Bonggol Pisang pada Pakan Terhadap Bobot dan Panjang Relatif Usus Halus Broiler. *Journal of Animal Center (JAC)*, *2*(2), 49–51.

Imam, S., Suryadi, U., & Hanafi, M. I. (2023). Physical Quality of Broiler Chicken Meat Added with Banana Weevil Enriched?-glucan from Saccharomyces cerevisiae in Feed. *Bantara Journal of Animal Science*, *5*(1), 17–27.

Imam, S., Suryadi, U., Hertamawati, R. T., & Haqqi, F. M. (2024). Perkembangan usus halus dan pertumbuhan ayam kampung super yang diberi sinbiotik pada pakan yang diturunkan kandungan proteinnya. *Tropical Animal Science*, *6*(1), 1–12.

Imam, S., Suryadi, U., Shiddiqy, A., Hertamawati, R. T., Prasetyo, A. F., & Rahmasari, R. (2022). Kualitas sensoris daging broiler akibat penambahan β-glukan pada pakan. *Conference of Applied Animal Science Proceeding Series*, *3*, 182–190.

Kazempour, F., Shargh, M. S., Jahanian, R., & Hassani, S. (2017). Effect of dietary β-glucan supplementation on growth performance, carcass characteristics and gut morphology in broiler chicks fed diets containing different theronine levels. *Animal Feed Science and Technology*, *234*, 186–194.

Kumalasari, C., Setiawan, I., & Adriani, L. (2020). Pengaruh pemberian probiotik kering berbasis susu sapi, kacang hijau, dan kedelai terhadap performa ayam broiler. *Jurnal Peternakan Indonesia*, *22*(1), 110–118.

Kwiatkowski, S., & Kwiatkowski, S. E. (2012). Yeast (Saccharomyces cerevisiae) glucan polysaccharides-occurrence, separation and application in food, feed and health industries. *The Complex World of Polysaccharides*, 47–70.

Pratikno, H. (2011). Lemak abdominal ayam broiler (Gallus sp) karena pengaruh ekstrak kunyit (Curcuma domestica Vahl.). *Bioma*, *13*(1), 17–24.

Purba, D. K. (1990). *Perbandingan karkas dan non karkas pada ayam jantan kampung, petelur dan broiler umur enam minggu*. Skrips. Fakultas Peternakan. IPB University.

Puspitasari, D. K., Sjofjan, O., & Widodo, E. (2019). Pengaruh penambahan tepung bonggol pisang pada pakan terhadap berat karkas, persentase karkas, dan lemak abdominal ayam pedaging. *Jurnal Nutrisi Ternak Tropis*, *2*(1), 33–41.

Rihi, J. L. (2004). Produksi karkas dan kualitas fisik daging kelinci lokal yang diberi konsentrat dengan level protein berbeda. *Buletin Peternakan*, *28*(2), 65–71.

Salam, S., Fatahilah, A., Sunarti, D., & Isroli, I. (2017). Berat karkas dan lemak abdominal ayam broiler yang diberi tepung jintan hitam (Nigella sativa) dalam ransum selama musim panas. *Sains Peternakan: Jurnal Penelitian Ilmu Peternakan*, *11*(2), 84–90.

Santoso, A. (2011). Serat pangan (dietary fiber) dan manfaatnya bagi kesehatan. *Magistra*, *23*(75), 35–40.

Soeparno. (2015). *Ilmu dan Teknologi Daging* (6th ed.). Universitas Gadjah Mada Press.

Suryadi, U., Hertamawati, R. T., & Imam, S. (2022a). Fermented meat and digestive tract of snail as amino acid supplements for functional feed of native chickens. *IOP Conference Series: Earth and Environmental Science*, *980*(1), 012020.

Suryadi, U., Hertamawati, R. T., & Imam, S. (2022b). Hydrolyzation of snail (Achatina fulica) meat with rice water as novel probiotic supplements for animal feed. *Veterinary World*, *15*(4), 937–942.

Suryadi, U., Hertamawati, R. T., & Imam, S. (2024). Immunobiotic potential of fermented snail meat hydrolysate in local chicken with low protein content. *Journal of Advanced Veterinary and Animal Research*, *11*(1), 71–77.

Suryadi, U., Imam, S., & Ahmad, A. F. (2021). Protein hidrolisat daging bekicot (Achatina fulica) sebagai pengurang penggunaan tepung ikan terhadap performa ayam kampung super. *Jurnal Ilmu Peternakan Terapan*, *5*(1), 37–42.

Sutowo, I., Adelina, T., & Febrina, D. (2017). Kualitas nutrisi silase limbah pisang (batang dan bonggol) dan level molases yang berbeda sebagai pakan alternatif ternak ruminansia. *Jurnal Peternakan*, *13*(2), 41–47.

Tang, X. Y., Gao, J. S., Yuan, F., Zhang, W. X., Shao, Y. J., Sakurai, F., & Li, Z. D. (2011). Effects of Sophy β-glucan on growth performance, carcass traits, meat composition, and immunological responses of Peking ducks. *Poultry Science*, *90*(4), 737–745.

Yunilawati, R., Rahmi, D., Aviandharie, S. A., & Syamsixman, S. (2015). Pemanfaatan Ampas Inti Sawit (Palm Kernel Mill/PKM) Sebagai Media Fermentasi Saccharomyces Cerevisiae Sebagai Penghasil β-Glukan. *Jurnal Kimia Dan Kemasan*, *37*(1), 1–8.

Zhang, Z. F., Zhou, T. X., Ao, X., & Kim, I. H. (2012). Effects of β-glucan and Bacillus subtilis on growth performance, blood profiles, relative organ weight and meat quality in broilers fed maize–soybean meal based diets. *Livestock Science*, *150*(1–3), 419–424.

Zurmiati, Z., Mahata, M. E., Abbas, M. H., & Wizna, W. (2014). Aplikasi probiotik untuk ternak itik. *Jurnal Peternakan Indonesia*, *16*(2), 134–144.