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The performance of Balinese pigs fed with different protein levels

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***Abstract*---**This study aims to determine the effect of feeding rations with different protein levels. This research was conducted in Nyitdah Village, Kediri District, Tabanan Regency, Bali, which lasted for 12 weeks. The design used was a completely randomized design (CRD) consisting of four treatments and four replicates. Each replicate contained one pig. The treatments were Balinese pigs fed a ration with 14% protein level (P1), Balinese pigs fed a ration with 16% protein level (P2), Balinese pigs fed a ration with 18% protein level (P3), and Balinese pigs fed a ration with 20% protein level (P4). The variables observed were performance, nutrient digestibility, and income over feed cost. The results showed that growing pigs fed different protein levels had no significant effect (P>0,05) on initial and final weights, body weight gain, ration consumption, FCR, and nutrient digestibility. It can be concluded that feeding rations with protein levels of 14% to 20% showed no significant effect on the performance of the pigs and nutrient digestibility, however, rations with 16% protein content produced the highest income over feed cost.
Keywords*---*nutrient digestibility, performance, protein, sus scrofa domesticus.

Introduction

The need for animal protein in the community from year to year is increasing along with the increase in the number of Balinese pigs that are the mainstay livestock for farmers in the countryside which are raised as a form of savings. The guinea pig has excellent adaptability to the environment, especially in hot regions, lack of water, and poor feed. As germplasm that farmers have maintained since ancient times, the Balinese pig can produce many offspring between 8 and 14 heads and can be raised in a very simple way. This simple maintenance includes loose maintenance, tied under a tree, and feeding from kitchen scraps. The maintenance of Balinese pigs is called by the people in Bali as a water tray. This means that the pigs that are raised are just water containers, that is, all the waste produced during the cooking process in the kitchen (Wibawa et al., 2024).

In recent years, the population of Balinese pigs has declined compared to the populations of purebred pigs such as Landrace, Hampshire, and Duroc. According to data obtained from the Bali Provincial Livestock and Animal Health Office (2021), the Balinese pig population decreased from 436,800 heads in 2021 to 371,499 heads in 2023. However, in areas with feed limitations, extreme air temperatures, and conditions that do not allow the maintenance of purebred pigs, the guinea pigs can still survive well. Balinese pork is still very much needed by consumers, especially for religious ceremonies and popular babi guling dishes (Budaarsa, 2014). According to Soewandi (2013), the daily weight gain in Balinese pigs is only around 0.14 ± 0.05 kg, while in imported pigs such as landraces, the body weight gain can reach 0.24 ± 0.09 kg per day. Because of this low productivity, many farmers have switched to choosing to raise imported pigs. The existing condition related to the main problem in the development of Balinese pigs is low productivity. One of the factors causing this is the maintenance system that is still traditional, the amount

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of feed provided is not enough and the feeding has not referred to the principles of nutrition science (Gunawan, 2002; Zakaria, 2004), especially feeding that has not taken into account the needs of food substances for various levels of production. This situation is caused by insufficient information about the nutritional needs of Balinese pigs. Population increases, production, and efficiency of Balinese pig businesses need to be improved from traditional to agribusiness.

Research on the nutritional needs of Balinese pigs has never been conducted, so farmers still rely on estimates in providing feed. In traditional Balinese pig farms, feeding has not accurately considered nutritional needs. This could mean providing feed as is or using commercial feed that is designed for purebred pigs (such as the type for fattening). Differences in protein levels in feed not only affect growth but also livestock health and reproduction, ultimately affecting overall productivity (Jones et al., 2019). According to research conducted by Sumadi et al. (2016), Balinese pigs that were given rations with a ME/CP balance of 2800 kcal/16 % used the most efficient feed, providing the highest weight gain at the ME/CP balance of 2950 kcal/18 %. This shows the importance of further research to determine the right protein levels to improve the production performance of Balinese pigs.

Materials and Methods

Livestock, rations, and research drafts

This research was carried out in Nyitdah Village, Kediri District, Tabanan Regency, Bali, which lasted for 12 weeks. This study used 16 pigs from the weaning phase of the starter. The pigs used were 16 pigs which were then randomized based on their weight. The rations given in this study were rations with different protein levels. The provision of rations is carried out twice a day, namely, morning and evening. The drinking water provided comes from the well and is given ad *libitum*. The design used was a complete randomized design (RAL) consisting of four treatments and four replicates. Each test contains one pig. The treatment given was a Balinese pig given a ration with a protein level of 14% (P1), a Balinese pig given a ration with a protein level of 16% (P2), a Balinese pig given a ration with a protein level of 18% (P3), and a Balinese pig given a ration with a protein level of 20% (P4).

Table 1
Composition and nutrient content in the experimental feed

Ingredients and Nutrition	Treatment			
	P0	P1	P2	P3
Yellow Corn (%)	50	45	40	34,5
Polard (%)	20	19,8	14	12
Rice Bran (%)	16,5	13,7	16,5	15,5
CP Concentrate 152 (%)	13	21	29	37
Shellfish Flour (%)	0,5	0,5	0,5	0,5
Sum	100	100	100	100
ME (kcal/kg)	2893	2898,3	2899,5	2898
PK (%)	14,01	16,05	17,66	19,60
SK (%)	6,77	6,81	7,00	7,20
Fish (%)	0,51	0,79	1,06	1,34

Information:
P1 Pigs fed rations with a protein level of 14 %
P2 Pigs fed rations with a protein level of 16 %
P3 Pigs fed with a protein level of 18%
P4 Balinese pigs given rations with a protein level of 20%

Results and Discussion

Performance, nutrient digestibility, and income over feed cost

The final weight of rationed Balinese pigs with different protein levels ranged from 41.47 kg to 46.44 kg per head. The P2 treatment showed the highest final weight of 46.44 kg, 11.98% higher than P1. Meanwhile, P3 and P4 were 5.88% and 2.51% higher respectively compared to P1 (Table 5.1). The increase in final weight at P2 showed that a

protein level of 16% was able to support optimal growth in Balinese pigs. Statistically, this final weight difference had no real effect (P>0.05).

The results showed that the initial weight of Balinese pigs fed with different protein levels (14%, 16%, 18%, and 20%) did not experience a statistically significant difference (P>0.05). This uniformity confirms that the randomization process has been carried out precisely, thus ensuring that the results of the study are more accurate in assessing the effect of protein levels in feed on the growth performance of Balinese pigs. The homogeneity of the initial weight in this study proved that before the treatment was given, the variation of protein content in the feed had no effect on the initial weight of the livestock, and the growth during the study period was completely influenced by the nutritional content of the feed, not by individual factors such as the difference in initial weight between individuals. These findings are consistent with the results of previous research conducted by Antara et al. (2014) and Pinem et al. (2015), which confirms that initial weight homogeneity is an essential factor in livestock nutrition studies. With a uniform initial weight, this study was able to identify that the difference in growth yield was purely due to feed treatment, not by uncontrolled external factors.

The results showed that feeding with protein levels of 14%, 16%, 18%, and 20% resulted in an increase in final weight in Balinese pigs, but statistically, there was no significant difference (P>0.05). This can be caused by an imbalance between energy and protein in feed, where excess protein that is not balanced with enough energy will be used as an energy source rather than for growth, thus causing inefficiency in nutrient utilization (Utami, 2011). The results of this study are in line with the findings of Sumadi et al. (2016), which stated that Balinese pigs fed with a balance of metabolic energy and crude protein (ME/CP) of 2950 kcal/kg and 18% protein experienced a significant increase in body weight. However, at a protein level of 20%, no real difference was found compared to a protein level of 16–18%, indicating that this protein level range was the best level for the growth of Balinese pigs. In addition, Wang et al. (2019), assert that excess protein that cannot be utilized efficiently will be excreted through urine, which not only increases the metabolic load of the kidneys but also causes inefficiencies in feed utilization.

Ration consumption in Balinese pigs ranges from 127.44 kg to 139.87 kg per head. The highest consumption occurred in P2 at 139.87 kg, which is 7.74% higher compared to P1. P3 also showed an increase of 1.8% compared to P1, while P4 experienced a decrease in consumption of 1.83% from P1 (Table 5.1). These results show that a protein level of 16% at P2 improves the palatability and efficiency of ration consumption. However, statistically, the difference in ration consumption between treatments was not significantly different (P>0.05). Based on the results of the study, ration consumption in feeding with protein levels of 14%, 16%, 18%, and 20% increased, but statistically there was no significant difference (P>0.05). These results suggest that an increase in protein levels in rations is not always directly proportional to an increase in feed consumption. Balinese pigs consume more feed at 16% protein levels (P2), but experience decreased consumption at protein levels of 18% (P3) and 20% (P4). This is related to feed palatability, energy-protein balance, and metabolic effects due to excess protein. The best feed consumption occurs at the protein level of 16% because, at this point, the balance of nutrients in the feed is following the physiological needs of the Balinese pig. As protein levels in the ration increase, the palatability of the feed decreases, causing pigs to reduce consumption. According to NRC (2012), feed consumption in pigs increases to the best point along with the increase in protein levels. However, after crossing the maximum threshold, consumption decreases because the body can no longer efficiently utilize excess protein. Furthermore, research by Sumadi et al. (2016), showed that Balinese pigs that were given rations with protein levels of around 16–18% had a better consumption rate compared to higher protein levels. This confirms that there is the best limit in protein delivery, and excess protein does not increase feed consumption or livestock growth.

Body weight gain in Balinese pigs ranges from 30.42 kg to 35.17 kg per head. The P2 treatment resulted in the highest body weight gain of 35.17 kg, an increase of 15.61% compared to P1. Meanwhile, P3 and P4 also increased by 8.32% and 3.55% respectively from P1 (Table 5.1). This shows that protein at the level of 16% can increase the body's protein synthesis optimally. However, there was no statistically significant difference (P>0.05). Based on the results of this study, the provision of rations with protein levels of 14%, 16%, 18%, and 20% in the body weight gain of Balinese pigs increased, but the increase was not statistically significant (P>0.05). This indicates that increased protein levels in the ration do not necessarily provide a real benefit to the growth of the Balinese pig. Other factors, such as digestive efficiency, energy balance, and environmental conditions, also influence these results. This opinion is in line with the research of Widyastuti et al. (2015), which shows that the best limit of protein in the ratio of farm animals depends on the body's ability to utilize nutrients. Monogastric animals such as pigs have a certain threshold in protein use, according to the NRC (2012), the crude protein content required by pigs with a body weight of 50-135 kg ranges from 13.4% to 17.1%. Excess protein does not always result in higher growth but rather can increase nitrogen excretion excessively and lead to feed waste. In addition, Sutrisno (2018), research revealed that the efficiency of protein utilization is greatly influenced by the balance of metabolic energy in the ratio.

The FCR of the Balinese pig ranges from 4.01 to 4.34. P3 had the lowest FCR of 4.01, which indicates an increase in feed efficiency of 7.6% compared to P1. The FCR in P2 and P4 was also lower by 7.37% and 6.45% respectively than in P1 (Table 5.1). The lower FCR indicates that the Balinese pig is more efficient at converting rations into body weight. However, the statistical results showed no significant difference between the treatments (P>0.05). The *Feed Conversion Ratio* (FCR) values of Balinese pigs given protein levels of 14%, 16%, 18%, and 20% in the ratio showed no significant difference in results (P>0.05) however, had an FCR value lower than the treatment of 14%. This variation suggests that the increase in protein content in the feed is not necessarily directly proportional to the improvement in FCR efficiency, as other factors such as energy-protein balance and nutrient digestibility also play an important role in the utilization of feed for growth. According to NRC (2012), the efficiency of FCR is influenced by various factors, such as the energy-protein balance in the ration, nutrient digestibility, and the metabolic efficiency of the livestock body. The study conducted by Nyachoti et al. (2004), found that although an increase in protein in feed can increase livestock growth, this is not always followed by an improvement in FCR due to limitations in excess protein utilization. This is in line with the research of Suryani et al. (2021), which showed that pigs fed rations with the right balance of energy and protein, such as ME/CP ratio of 2805 kcal/kg and 16.08% crude protein, showed better feed use efficiency compared to other balances in addition, this study indicated that an increase in protein levels above the optimum requirement did not necessarily improve feed efficiency.

Table 3
The performance of Balinese pigs given rations with protein levels of 14%, 16%, 18%, and 20%

Variable	Treatment1)				SEM2)
	P1	P2	P3	P4	
Starting Weight (kg/head)	11,06 [a3)]	11.27 [a]	10.96 [a]	11.01[a]	0,88
Final Weight (kg/head)	41.47 [a]	46.44 [a]	43.91[a]	42.51[a]	2,85
Ration Consumption (kg/head)	129.82 [a]	139.87 [a]	132,16 [a]	127.44[a]	5,45
Body Weight Gain (kg/head)	30.42 [a]	35.17 [a]	32.95 [a]	31.50[a]	2,17
Feed Conversion Ratio	4.34 [a]	4.02 [a]	4.01 [a]	4.06[a]	0,18

Information:
1) P1 Balinese Pigs fed rations with a protein level of 14 %
   P2 Balinese Pigs fed rations with a protein level of 16 %
   P3 Balinese Pigs fed rations with a protein level of 18%
   P4 Balinese pigs fed rations with a protein level of 20%
2) *Standard Error of the Treatment Means*
3) Values with different letters on the same line show a real difference (P<0.05)

Table 4
Nutrient digestibility of Balinese pigs given rations with protein levels of 14%, 16%, 18%, and 20%

Variable	Treatment1)				SEM2)
	P1	P2	P3	P4	
Metabolic Energy (K.cal/day)	2630,39[a3)]	3367,61[a]	3215,00[a]	3220,36[a]	139,62
Dry Material Digestibility (%)	77.43[a]	77.54[a]	76.21[a]	79,11[a]	3,18
Crude Protein Digestibility (%)	82.40[a]	84.94 [a]	81.32 [a]	85.90 [a]	2,26
Crude Fiber Digestibility (%)	46.94[a]	47.56 [a]	50.15 [a]	47.48 [a]	6,82

Information:
1) P1 Balinese Pigs fed rations with a protein level of 14 %
   P2 Balinese Pigs fed rations with a protein level of 16 %
   P3 Balinese Pigs fed rations with a protein level of 18%
   P4 Balinese pigs fed rations with a protein level of 20%
2) *Standard Error of the Treatment Means*
3) Values with different letters on the same line show a real difference (P<0.05)

The metabolic energy in Balinese pigs fed rations with different protein levels ranged from 2630.39 Kcal/day to 3367.61 Kcal/day. The P2 treatment showed the highest value of 3367.61 Kcal/day, followed by P4 at 3220.36 Kcal/day, P3 at 3215.00 Kcal/day (Table 4), and P1 at the lowest rate of 2630.39 Kcal/day. Compared to P1, the metabolic energy in P2 increased by 28.06%, while P3 and P4 also increased by 22.23% and 22.41%, respectively. Although there was an increase in all treatments compared to P1, there was no statistically significant difference (P>0.05).

Metabolic energy (ET) is part of metabolic energy (EM) that can be utilized by the body after deducting energy lost in the form of heat due to feed metabolism (*heat increment*). Based on the results of the metabolic energy study of Balinese pigs with protein levels of 14%, 16%, 18%, and 20% in the ration, it showed an increase, but there was no significant difference (P>0.05). This is due to the metabolic mechanism of Balinese pigs that is more flexible in utilizing energy sources so that the variation of protein in the ration does not directly affect its energy metabolism, in line with research conducted by Sumadi et al. (2015), showing that although there is a variation in the balance of energy and protein, there is no significant difference in ration consumption, weight gain, and feed efficiency among treatments indicating that Balinese pigs have a flexible metabolic mechanism in utilizing energy sources so that protein variations in the ration do not directly affect their energy metabolism. This flexibility allows Balinese pigs to maintain energy metabolism efficiency despite variations in protein levels in the ration. According to research by Shi & Noblet et al. (1993), feed with higher protein levels tends to increase metabolic heat production (heat increment), thereby reducing the proportion of energy that can be utilized by the body in the form of metabolic energy (ET).

The digestibility of dried ingredients of Balinese pigs is in the range of 76.21% to 79.11%. The highest score was obtained in P4 with 79.11%, followed by P2 at 77.54%, P1 at 77.43%, and P3 at 76.21%. When compared to P1, P2 showed an increase of 0.14%, while P3 decreased by 1.58%, and P4 increased by 2.17%. Although there was a percentage variation between treatments, the results of statistical analysis showed no significant difference (P>0.05).

Dry matter digestibility is an important parameter in assessing the efficiency of feed utilization by livestock, including Balinese pigs. Based on the results of this study, the digestibility of dried ingredients of Balinese pigs with protein content of 14%, 16%, 18%, and 20% in the ration showed a statistically insignificant difference (P>0.05). This difference suggests that variations in protein levels in the ration do not cause a consistent change in the digestibility of dry ingredients, which indicates that other factors such as feed quality and nutritional balance play a greater role in determining digestive efficiency in Balinese pigs because the digestibility level of dry ingredients is more influenced by the crude fiber content in the ration compared to the protein level. According to NRC (2012), an increase in protein content in feed is not always directly related to an increase in the digestibility of dry ingredients, especially if the ration has a relatively high crude fiber composition. The results of this study are also in line with the findings of Zeng et al. (2017), which stated that the digestibility of dry matter in pigs was more influenced by the composition of feed ingredients, the availability of metabolic energy, and the balance of amino acids compared to the total protein content in the ration.

The digestibility of crude protein ranged from 81.32% to 85.90%. P4 showed the highest score of 85.90%, followed by P2 at 84.94%, P1 at 82.40%, and P3 at the lowest at 81.32%. When compared to P1, P2 increased by 3.08%, while P3 decreased by 1.31%, and P4 increased by 4.25%. Although there was an increase and decrease in values between treatments, there was no statistically significant difference (P>0.05).

The results showed that the digestibility of crude protein of Balinese pigs with protein levels of 14%, 16%, 18%, and 20% in different rations was not statistically real (P>0.05). This suggests that the pig digestive system has certain mechanisms for regulating protein digestion and absorption, so differences in protein levels in feed do not necessarily result in noticeable changes in digestibility. Physiologically, protein digestibility is affected by several factors, including the type and quality of protein, the level of crude fiber in the feed, as well as the efficiency of proteolytic enzymes in the animal's digestive system (McDonald et al., 2011). According to NRC (2012), the digestibility of crude protein in pigs is influenced by the content of essential amino acids and the composition of proteins in the feed. Feeds with higher protein content do not necessarily improve digestibility due to the possibility of increased undigested protein fractions due to the limitations of digestive enzymes in over-hydrolyzing proteins (Stein et al., 2007). Furthermore, research by Oresanya et al. (2008), affirms that the efficiency of protein utilization depends on the balance between protein and energy in the feed. If protein levels are high but not balanced with enough energy, then protein will be used as a source of energy, not for tissue growth or repair.

The digestibility of crude fiber in Balinese pigs ranged from 46.94% to 50.15%. The P3 treatment had the highest crude fiber digestibility of 50.15%, followed by P2 at 47.56%, P4 at 47.48%, and P1 at the lowest at 46.94%. Compared to P1, P2 increased by 1.32%, P3 increased by 6.82%, and P4 increased by 1.15%. However, the addition of protein levels did not show a statistically significant effect on the digestibility of crude fiber (P>0.05).

The results showed that there was no statistically significant difference (P>0.05) in crude fiber digestibility, from feeding with protein levels of 14%, 16%, 18%, and 20% in Balinese pigs. It is influenced by microbes in the

digestive tract, especially in the large intestine which has an important role in the fermentation process of crude fiber. Research by Santoso et al. (2020), shows that the activity of intestinal microbes is more influenced by the availability of substrates in the form of fiber and energy than by the protein content in the feed. Montagne et al. (2003), emphasized that the composition of fiber in feed has an important role in determining the degree of degradation and fermentation by intestinal microbes. Physiologically, increased protein levels in feed can affect microbial activity in the digestive tract, particularly in the cecum and colon, which play a role in the fermentation of crude fiber (McDonald et al., 2011). Proteins serve as a source of nitrogen for microbes, so they can increase microbial populations and activity in degrading coarse fibers. This is in line with the findings of Knudsen (2001), who stated that the availability of nitrogen in the post-gastric digestive system can increase the fermentation of crude fiber and the production of volatile fatty acids (VFA), which ultimately contributes to the efficiency of fiber digestion. This increase is related to increased synthesis of digestive enzymes as well as fermentative activity in the cecum and colon. In addition, the increase in crude fiber digestibility in P4 treatment can be attributed to the synergistic interaction between protein and fiber content in the feed. According to Le Goff et al. (2002), the ratio of protein to fiber in the ration plays an important role in determining the efficiency of nutrient utilization in the digestive tract.

Table 5
IOFC calculation of Balinese pigs given rations with different protein levels

Variable	Treatment1)			
	P1	P2	P3	P4
Feed Price (Rp/kg)	6.200	6.700	7.200	7.700
Ration Consumption (kg/head)	129,82	139,87	132,16	127,44
Feed Cost (Rp/head)	804.869	937.146	951.516	981.307
Weight (kg/head)	41,47	46,44	43,91	42,51
Pork Price (Rp/kg)	56.000	56.000	56.000	56.000
Sales Results (Rp/head)	2.322.460	2.600.500	2.458.820	2.380.560
IOFC (*Income Over Feed Cost*)	1.517.592	1.663.354	1.507.304	1.399.253

Information:
1) P1 Balinese Pigs fed rations with a protein level of 14 %
P2 Balinese Pigs fed rations with a protein level of 16 %
P3 Balinese Pigs fed rations with a protein level of 18%
P4 Balinese pigs fed rations with a protein level of 20%

IOFC (Income Over Feed Cost) in Balinese pigs given rations with different protein levels ranges from Rp 1,399,253 to Rp 1,663,354. The highest IOFC value was found in the P2 treatment of IDR 1,663,354, followed by P1 of IDR 1,517,592, P3 of IDR 1,507,304, and P4 of the lowest of IDR 1,399,253. Compared to P1, IOFC in P2 increased by 9.62%, while in P3 it decreased slightly by 0.68%, and in P4 it decreased further by 7.79%. The results showed that the value of *Income Over Feed Cost* (IOFC) in P2 was 9.60% higher than that of P1, P3, and P4. These results show that increasing protein levels in rations by up to 20% does not provide greater economic benefits than lower protein levels. Treatment with a protein content of 16% (P2) resulted in the highest IOFC, which indicates the best balance between feed costs and income from livestock sales. In contrast, an increase in protein levels above 16% was not followed by an increase in body weight or comparable feed efficiency, so IOFC values tended to be lower. This finding is in line with the results of the research of Deor et al. (2024), which states that increasing protein levels in feed needs to be accompanied by ration conversion efficiency so that the additional costs incurred do not exceed the profits obtained. In the context of economic efficiency, IOFC is an important parameter in assessing the profitability of livestock businesses. Although variations in protein levels in rations do not show a significant difference to IOFCs, farmers need to consider other aspects such as the availability and price of feed ingredients as well as the specific nutritional needs of livestock to maximize profits.

Conclusion

Feeding with a protein level of 14% to 20% did not show a significant effect on the performance of Balinese pigs. The results showed that there was no real difference in the digestibility of the rationed Balinese pigs with a protein level of 14% to 20%. However, rations with a protein content of 16% produce the highest *Income Over Feed Cost* (IOFC).

Suggestion

Based on this conclusion, it is recommended that the use of rations with a protein level of 16% be considered in the cultivation of Balinese pigs because it provides *the highest Income Over Feed Cost* (IOFC). It can also be suggested to students as a reference in writing the final project.

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