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Inclusion of dietary multi-mineral-vitamin ("Pignox") on growth performance in weaned piglet

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Abstract
"Pignox" is a mixture of several kinds of vitamins and minerals, as a supplement in feed to stimulate the growth of piglets. This study evaluated the effects of multi vitamin-mineral-mix supplementation on the growth performance of weaned piglet. A total of 96 weaned piglets were randomly allocated to four treatments in a 60-day experiment with four levels of vitamin-mineral-mix (0%; 0.10%; 0.20%; and 0.30%, repspectively) supplementation in rice bran based diets. The results showed that "Pignox" supplementation increased significantly different ($p<.05$) in the average daily gain and feed digestibility. Piglets fed with the diets containing 0.1%-0.30% of Pignox showed lower feed conversion ratio than the unsupplemented group ($p<.05$). In addition, multi vitamin-mineral-mix supplementation increased feed consumption compared to the unsupplemented group ($p<.05$). In conclusion, the administration of multi vitamin-mineral-mix was effective in improving growth performance of weaned piglets.

Keywords: Mineral, vitamin, digestibility, piglet

Introduction
Pig is one of the commodities that has an important role in meeting the needs of the community's meat as a source of animal protein, because it has beneficial properties such as prolific, efficient in converting feed ingredients into meat, age reaches short cutting weight and high carcass percentage. Especially in Bali, pigs are superior cattle to meet the needs of the community's meat, this is because the majority of Balinese people embrace Hinduism and the many regional traditions that use pig livestock as traditional ceremonies (Bidura and Gomes, 2019) [5].

The success of pig farming is determined by several factors, one of which is the ration. Rations containing balanced food substances and in accordance with the needs of livestock are expected to improve the quality and productivity of livestock. The pattern of animal husbandry in Indonesia, including Bali, is a traditional farm on a small scale. One way that can be done to make the most of the ration is supplementation of complex vitamins and minerals. Mineral-vitamin complex is useful for increasing the digestibility of the ration given. Complex mineral-vitamins contain various trace minerals and vitamins, such as Zn which functions as an activator of enzymes in metabolic processes and carboxy peptidase enzymes that play a role in protein metabolism (El-Husseiny *et al*., 2018) [11].

The most basic agricultural agro-industrial waste product used in the preparation of pig rations is rice bran. Rice bran contains enormous potential, both as an energy source, a source of crude fiber, or other macronutrient sources. The limiting factor of its use in pig rations is the high content of phytic acid, tannins, and crude fiber, so that pigs are very difficult to digest these compounds, especially in weaning piglets (Bidura *et al.,* 2008) [6].

According to Kahlique *et al.* (2003) [16], rice bran is a by-product of the rice milling industry, which is abundantly available (around 10% by weight of rice) during the harvest season. Unfortunately this by-product contains phytic acid as a high phytate that can bind minerals, making it difficult to digest by monogastric animals. These anti-nutritional factors cause a reduction in feed intake and suppress the performance of monogastric animals. The potential of rice bran as an energy source for pigs depends on the cell wall content, the degree of microbial fermentation in the poultry large intestine, the absorption and production of volatile fatty acids (Wang *et al.,* 2003) [30]. Therefore, feed that uses high rice bran, needs to be supplemented with minerals and vitamins. Feeding diet containing 12500 vitamin A IU kg^{-1}, 264 Zn mg kg^{-1} and 15.7 Cu mg kg^{-1} were produced best productive and reproductive performances of broiler breeders (El-Husseiny *et al*., 2018) [11].

Vitamin A has essential role in vision, bone and muscle growth, reproduction and maintenance of healthy epithelial tissue (Fouad *et al*., 2018) [12].

In weaning, young piglets experience changes in nutritional requirements that can result in impaired growth and functional morphological damage in the intestine, such as villous shorting, crypt elongation, and reduced digestive enzyme activity and nutrient transport (Bidura and Gomez, 2019; Hu *et al*., 2013) [5, 15]. However, the use of ZnO was prohibited and restricted in the European Union because zinc remains a heavy metal which tends to accumulate in the soil and is therefore toxic to animals (Mavromichalis, 2011) [19], so ZnO intake is limited (3000 ppm) in the short time after weaning must be applied.

Trace element requirements have given many considerations, because any advantages or disadvantages in one element can interfere with the use of other minerals (Geraseev *et al*., 2000) [13], disrupt the health, productivity, and even survival of livestock. Zn excess is known to cause Cu deficiency, and Cu is very important for a number of enzymes involved in Fe transport and metabolism (Mateos *et al*., 2004) [18]. In addition, most trace elements digested by pigs are excreted in feces and urine. Feeding high Zn and Cu in the feed can increase the excretion of these elements and pose a potential environmental threat. Therefore, an accurate prediction of the need for trace elements can minimize the excretion of trace elements and environmental pollution (Chizzotti *et al*., 2009) [9]. Copper is an important trace element that plays an important role in the body's biochemical reactions; However, the requirements and their interactions with other minerals are not clearly understood (Solaiman *et al*., 2006) [29]. Antagonists, such as Mo, S, and Fe, at high concentrations in feed can increase Cu mineral requirements (McDowell, 2003) [20].

This study evaluated the effects of multi vitamin-mineral-mix supplementation on the growth performance and feed digestibility in weaned piglet.

Animals and experimental design

A total of 96 crossbred piglets (Duroc_Landrace_Sadleback) with an average weight of 8.17±0.24 kg, weaned at 30±3 d age and randomly allotted to four treatments in a completely randomised design. Pigs were allotted to four treatments, in a 60-day experiment with four levels of vitamin-mineral-mix (0%; 0.10%; 0.20%; dand 0.30%, repspectively) supplementation in rice bran based diets. All diets were isonitrogenous (CP: 18%) and isoenergetic (ME:3160 kcal/kg). The diets were formulated to meet the nutrient requirements for poultry (NRC.,1979) [21] for 8 weeks of experiment. The ingredients and chemical compositions of the feed are shown in Table 1.

The basal diet was formulated and manufactured before starting the trial, without the inclusion of any antibiotic growth promoters or antibiotic growth promoter alternatives. Pigs had free access to experimental diets and drinking water. A combination of daylight and artificial light was used, with a 12-h light/dark cycle. The weight and feed consumption were measured on day 0 and 30 postweaning for the calculation of average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FCR). Pen feed intake and individual body weight were recorded weekly. The average daily gain and feed conversion ratio (FCR) were calculated.

Retention and excretion of nutrients

To determine nutrient digestibility values (dry matter and organic matter digestibility): The amount of feed used is 400 g, this amount is based on a preliminary test with the consumption of pig feed rations. All piglets are not fed for 24 hours to ensure that their digestive tract is empty of leftover feed. After 12 hours of fasting, the piglets are given 400 grams of feed until they run out and drinking water is still given ad libitum. Stool collection is performed on the following day or after 12 hours of previous feeding. Water was available *ad libitum* during the trial period. The excreta samples were frozen, allowed to reach equilibrium with atmospheric humidity, weighed, and pounded through a 1 mm filter. Excreta samples were dried at 70 ^{0}C for 72 h, ground and passed through 1 mm screen along with feed samples to pass through a 1 mm screen before being analysed to determine dry matter (DM) and organic matter (OM), respectively. Dry matter (DM) and organic matter (OM), and ash determination were carried out in accordance with the Official Analytical Chemistry Association (2005)[4]. All tests are carried out in triplicate.

Table 1: Ingredients and calculated composition of the basal diet (percentage as-fed basis).

	Basal diets	**Compositions**
Ingredients (%)*:*		
Yellow corn		53.50
Rice bran		20.00
Soybean		13.00
Fish meal		10.50
Coconut oil		3.00
Total		100
Chemical composition ***)*:		
Metabolizable energy (ME)	(kcal/kg)	3159
Crude protein (CP)	(%)	18.03
Crude Fiber (CF)	(%)	4.23
Ether Extract (EE)	(%)	10.97
Calsium (Ca)	(%)	0.88
Phosphor (P-av)	(%)	0.45
Argynine	(%)	1.33
Lysine	(%)	1.26
Metionin+sistein	(%)	0.76
Tryptophan	(%)	0.69

*) The composition "Pignox" in every gram contains: 40 mg Olaquindox; 5000 IU of vitamin A; 800 IU Vitamn D3; 2 mg of vitamin E; 0.8 mg of vitamin K3; 0.4 mg of vitamin B1; 0.8 mg of vitamin B2; 0.4 mg of vitamin B6; 8 ug of vitamin B12; 8 mg of nicotinic acid; 6 mg Ca-D-pantothenate; 200 mg of cholin chloride; 40 mg of methionin; 8 mg Mn; 0.4 mg I; 16 mg Fe; 0.2 mg Co; 20 mg Cu; and 20 mg Zn (Medion, Bandung-Indonesia; Kementan RI No.D 06121109FTS.2)

**) Based on calculation according to Scott *et al*. (l982)

Statistical analysis. All data were analyzed by one-way ANOVA to determine the difference between treatments. If differences were found (P<0.05), further analysis is carried out with Duncan's multiple range test.

Results

In the current studied, pigs fed supplemented with 0.2-0.3% multi-mineral-vitamin (“Pignox”) diet had increased (p<.05) final BW and ADG compared than other dietary treatments at the end of observed (Table 2). Overall, multi-mineral-vitamin supplementation had significantly increased (p<.05) feed consumption and feed efficiencies during the entire

experiment.

Supplementation of multi-mineral-vitamin in basal diets were significant differences (P<0.05) in the dry matter digestibility and organic matter digestibilty were observed among the dietary groups (Table 2).

Table 2: Inclusion of dietary multi-mineral-vitamin ("Pignox") on growth performance in weaned piglet

Variables	Groups[1]				SEM[2]
	A	B	C	D	
Initial body weught (kg)	8.16a	8.21a	8.08a	8.18a	0.213
Final body weight (kg)	20.31b[3]	20.75b	22.26a	22.84a	0.507
Average daily gains (g/d)	202.50b	209.00b	236.33a	244.33a	8.597
Feed consumption (g/d)	467,83b	471.67b	494.00a	522.83a	6.792
Feed conversion ratio (feed consumption:ADG)	2.31a	2.26a	2.09b	2.14b	0.029
Dry matter digestibility (%)	69.73b	69.95b	72.92a	72.78a	0.816
Organic matter digestibility (%)	71.69b	71.82b	75.03a	74.97a	0.908

Note

1. The basal diet supplemented with vitamin-mineral-mix: 0% as control (A); 0.1% (B); 0.2% (C); and 0.3% (D), respectively.
2. SEM: standard error of treatment means
3. Means with different superscripts within raw values are significantly different (P<0.05)

Discussion

Increased final body weught dand body weight gain caused by the content of mineral-vitamin complex in the basal diets. Mineral is one of the substances that has a major role in the growth and reproduction of livestock, such as energy metabolism, protein metabolism, and biosynthesis of essential substances (Combs, 2008) [10]. Mineral needs for livestock can be grouped into two types, namely macro minerals and micro minerals. Macro minerals consist of calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg), sodium (Na), chlorine (Cl), and sulfur (S). Trace minerals consist of iron (Fe), copper (Cu), zinc (Zn), molibd (Mo), manganese (Mn), cobalt (Co), chromium (Cr), nickel (Ni), and iodine (I). As normal levels in the feed can stimulate protein synthesis. Mineral Cu and Co together improve the digestibility of crude fiber. While Zn is one of the few micro minerals that have a role as an enzyme activator (Bidura and Gomes, 2019) [5].

Minerals are inorganic elements that are very essential and are often found in the bodies of living things, but the amount or concentration is relatively small. The function of minerals is mostly in highly metabolic processes and if the concentration in the body decreases it can cause reversible abnormalities. Metabolism of calcium minerals is a process that is sufficient to maintain calcium by carrying out several chemical reactions in the body (El-Husseiny *et al*., 2018) [11]. Calcium is a mineral that is very important for bone health. Minerals are not digested, but they are absorbed directly by the body and they cannot be stored in the body, but are secreted or thrown out of the body (Abdulla *et al*., 2016) [1]. Phosphorus mineral is the second most mineral in the body, about 1% of body weight. Phosphorus minerals are the main food ingredients used by all organisms for growth and energy sources. Phosphorus is present in bones and teeth, and in cells, namely muscles and extracellular fluid (Peters and Mahan, 2008) [22].

Studies have shown that mineral complex (Rusmawan *et al*., 2018), and mineral Zn (Hill *et al.*, 2001) [14] were beneficial to growth performance and health status of weaning piglet. Different results are reported by Schell and Kornegay (1996) [26] that the growth performance of weaned piglet was not improved with ZnO supplementation. Abdulla *et al.* (2016) [1] reported that increasing the level of Ca to 1.25% can improve broiler performance and apparent nutrient digestibility. Calcium has important biological functions and must be provided in adequate amounts. Inadequate Ca intake may affect bone mineral content, muscle function and other body mineral functions (Peters and Mahan, 2008) [22].

Iron mineral (Fe), before being absorbed, in the stomach the iron is released from organic bonds, such as protein. Absorption mainly occurs in the upper part of the small intestine with the help of special protein transports. There are two types of protein transport within the intestinal mucosal cells that help iron absorption, namely transferrin and ferritin. Iron in the feed is in the form of iron-hem as in hemoglobin and myoglobin in animal feed, and non-hem iron in plant foods. Of all the mineral elements, the biggest Ca and P elements, with a ratio of Ca:P is 2:1. Usually foods that contain lots of protein also contain lots of phosphorus. According Bidura and Gomes (2019) [5], copper is closely related to iron in the formation of blood. In pigs, these elements are also important for food growth and conversion. Lack of this element will cause pigs to easily scours (diarrhea). Mg minerals are needed for bone formation and normal reproduction. This lack of stretches causes pigs to become paralyzed. Rice bran contains many Mg elements, because in general pigs in Indonesia get a lot of food from rice bran, so that Mg deficiency does not occur.

Vitamins also have an important role for livestock. Vitamin A is involved in the vision system and the management of epithelial tissue on the entire surface of the body outside and inside, as well as various endocrine/gonadal glands (Combs, 2008) [10]. Vitamin A deficiency can cause loss of appetite (anorexia), severe diarrhea, there is no coordination in moving, and lose weight and the skin becomes rough. Vitamin D is needed for general growth of an animal compared to bone growth alone. Vitamin D deficiency can affect the repetition system of young animals. Vitamin E functions in the normal metabolism of nerves, contraction of tendons, circulation, respiration, digestion, excretion, growth, feed conversion and reproduction. Animals that lack vitamin E will interfere with reproduction. B-complex vitamins are used by animals to meet their biological needs (Bidura and Gomes, 2019) [5].

Vitamin B, is a combination or a complex of many vitamins (Vitamins B_1, B_2, B_6, and B_{12}). Pigs that have Vitamin B_2 deficiency can cause decreased appetite, indigestion, coarse fur, and cause sudden death. Vitamin B_2 (Riboflavine) is important for growth and weight gain. Vitamin B_6 (Pyridoxine) functions to process amino acids. Deficiency of this vitamin in pigs can result in decreased appetite, decreased

growth and weight, tendons become stiff and lack of blood.

Castilha *et al.* (2018) [8] reported that vitamin B_6 supplementation enhanced the pork quality and the increasing levels of standardized ileal digestible tryptophan enhanced the lean meat yield of 70-100 kg gilts. Vitamin B_6 is very important in the maintenance of energy metabolism, in the form of pyridoxal phosphate coenzymes, especially in situations of low glycemia (eg fasting), because it is an enzymatic cofactor of glycogen phosphorylase, responsible for the division of glycogen to release glucose (glycogenolysis), producing glucose-1-phosphate, which will be available to maintain glycemia. The role of vitamin B_6 in animal organisms contributes to the use of more than half of the total available concentration, due to the abundance of the enzyme glycogen phosphorylase in muscles (Combs, 2008) [10].

Supplementation of vitamin E in the diet compensates for the negative effects of heat stress in poultry and significantly improves the blood biochemical profile in broilers (Shah *et al*., 2016) [25]. Vitamins are absorbed from the intestinal lumen, as are minerals. Absorption is influenced by many factors including types of vitamins and their solubility. Vitamin absorption occurs in the ileum section. In ilium there is also an absorption of water and minerals.

Feed Conversion Ratio (FCR) is a comparison between the amount of feed consumption and weight gain in a certain time unit. Based on statistical analysis the most efficient FCR value is 2,09 in the treatment of crossbred pigs fed rations with Pignox supplementation of 0.20% (C), whereas according to Roni *et al.* (2017) [23], FCR of crossbred pigs given traditional ration with 0.25% supplementation and 0.50% "Pignox" was 5.63. Feed conversion is strongly influenced by the quality of the ration, strains, disease and cage management. In line with the opinion of Campbell and Lasley (1985) [7], that the efficient use of feed depends on the ability of animals to digest feed and the amount of feed lost in the metabolic process. Bidura and Gomes (2019) [5] states that several factors affect feed conversion, such as age of cattle, nationality, nutrient content of rations, temperature and conditions of livestock, management and good use of seedlings.

Li *et al*. (2001) [17] reported that mineral Zn administration increased the villus width and the villus height-to-crypt depth ratio. Administration of high concentration of dietary Zn moderately increased the villus height and tended to decrease the crypt depth in the lower small intestine in piglets. Bidura *et al*. (2008) [6] reported that one aspect that determines the high and low quality of feed is the content of protein, energy, vitamins, minerals, and other ingredients that support growth and biological digestion processes. The increasing amount of feed consumption in each treatment is caused by different mineral-vitamin content, because supplementation of complex mineral-vitamins can increase metabolism in the livestock body. According to Bidura and Gomes (2019) [5] that the amount of feed consumption is strongly influenced by the level of energy and protein ration. In addition to ration consumption is influenced by nutrients contained in the feed, it is also influenced by palatability and method of feeding. Palatability will be affected by physical parameters, such as hardness of feed ingredients, color, shape, cutting or chopping, texture and chemical parameters such as water content, protein and substances in feed (Soeharsono, 2010) [29]. Dietary supplements with Vitamin E, Vitamin D and Ca antagonized increased weight gain and weight loss of the uterus caused by ovariectomy. Three dietary supplements also significantly increase serum Ca, phosphorus, bone-specific alkaline phosphatase and osteocalcin but reduce levels of interleukin-1β, interleukin-6 and high serum pyridinoline in osteoporosis in ovariectomized rats (Alfky *et al*., 2016) [2]. Vitamin E plays a major role in bone health with its antioxidant and anti-inflammatory activity, suppresses osteoclastogenesis and stimulates bone formation and increases uterine weight.

Conclusion

We conclude that supplementation in basal diets of 0.1-0.3% multi-mineral-vitamin were increased feed digestibility and growth performance of weaned piglets.

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