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The combination effect of superovulation induction and dietary protein level in sow towards birth weight, mortality, and litter size of weaning piglets

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Abstract This study was aimed to evaluate the birth weight, mortality, and litter size of weaning piglets in sow given superovulation hormones and level of protein diet before mate. Eighteen gilts, weighing 100–107 kg were used in this research. Both PMSG and hCG hormones were used as the superovulation agent and prostaglandin PGF2α as estrous synchronization. The statistical design used in this experiment was completely randomized with a 2×3 factorial pattern, where the combination of each factor was repeated three times. The superovulation hormone as the first factor, consisted of two levels of treatment, i.e., without hormone injection (NSO) and with hormone injection (SO), and dietary protein as the second factor, consisting of three levels of treatment, i.e., 14%, 16%, and 18%. The variables measured include: birth weight, mortality, and weaned litter size of piglets. The results showed that the administration of superovulation induction combined with dietary protein level affected significantly on birth weight, mortality, and litter size of weaning piglets better than non-superovulation induction treatments. The research concluded that the administration of both superovulation induction and dietary protein level in sows before their mating were able to increase birth weight, suppress mortality, and increase of weaning litter size of the piglets.

1. Introduction

The reproductive ability of pigs is mainly determined by the success of the sows to produce large, healthy, and strong piglets so that their survival is high. The body weight of piglets at birth is strongly influenced by the accumulated growth during pregnancy, starting from the development of the zygote to the embryo, then to the fetus, until the time of birth In the development of livestock reproduction science, superovulation hormones, such as Pregnant mare's serum gonadotropin (PMSG) and Human Chorionic Gonadotrophin (hCG), have the advantage of stimulating an increase in the secretion of pregnancy hormones, which in turn improves the reproductive system of livestock, and also expected to increase livestock production through improved growth in the prenatal phase during pregnancy, and milk production during lactation.

Good reproductive performance if not coupled with the need for quality feed from sows during lactation will have a negative impact on milk production, the survival of piglets, increased mortality and will have an impact on the litter size of weaning. Pig as a prolific animal, along with the increase in the number of litter size, the potential for piglet born below normal birth weight is also higher. Application of superovulation agent in gilts before mate, gives an effect of improvement on the performance of birth weight in piglets, even though the number of children is large, as well as an enhancement in the phenotype of the piglets [1]. Superovulation application accompanied by an increase in feed quality will

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increase milk production during lactation [2–4]. Superovulation, regardless of feed quality, affects the mortality rate of born piglets [5]. Endocrinological factors, biochemical factors, and psychological and nutritional factors also affect milk production, for example, stress conditions when the sow is nursing and the nutritional requirement during lactation [6].

This study aimed to produce a breakthrough in the field of pig reproduction, by producing piglets born with a high number of births, with the same average birth weight, and reducing mortality and high weaning litter size.

2. Materials and methods

2.1. Materials

The experimental pigs used in this study were 18 gilts, with body weights between 100–107 kg. Meanwhile, the hormones used as superovulation agents were PMSG (Folligon, Intervet, North-Holland) and hCG (Chorulon, Intervet, North-Holland), as well as prostaglandins PGF2α (Prosolvin, Intervet, North-Holland) as estrous synchronization. The experimental diet used in this study consisted of three treatments with different protein levels, 14%, 16%, and 18%, respectively. The dietary treatments were formulated using feed ingredients: corn, rice bran, coconut meal, fish meal, and concentrate. The nutrient composition of the dietary treatments is presented in table 1.

Table 1. Nutrient composition of dietary treatments

Feed nutrition	P1	P2	P3
Crude protein (%)	14.3427	16.3922	18.4417
Crude fiber (%)	8.3215	8.2355	8.1495
Metabolic energy (kcal/kg)	3291.3050	3323.6088	3355.9128

2.2. Methods

The statistical design used in this experiment was completely randomized with a 2×3 factorial pattern, where the combination of each factor was repeated three times. The superovulation hormone as the first factor consisted of two levels of treatment: without hormone injection (Non-Superovulation=NSO) and with hormone injection (with Superovulation=SO), and dietary protein as the second factor, consisting of three levels of treatment, 14%, 16%, and 18%. The analysis of variance was used in this study to analyze the effect of each treatment and the interaction of treatment factors on the measured variable by linear model procedure. Furthermore, determining the comparison between the results of each treatment and each treatment interaction was carried out by statistical tests.

2.3. Procedure of the study

Eighteen experimental gilts were grouped into two groups, each with 9 gilts, where the first group was called superovulation (SO) and the other group was called non-superovulation (NSO). The superovulation group was injected with both PMSG and hCG at a single dose of 400/200 (600 superovulation) IU per head. Besides the superovulation treatment, the SO group was also fed dietary treatments with three protein levels. The NSO group was given an injection of physiological NaCl per head and dietary treatments with three protein levels. Synchronization of estrus was carried out by injecting 1 ml of PGF2α for each gilt, administered at an interval of 14 days. On the second injection of PGF2α, which was three days before estrus, the superovulation agent injection was administered intramuscularly.

Pregnant gilts from each experimental group were reared together using postal cages. At 14 days before the piglets were born, the animals were placed individually in 8.75 m^2 (2.5m×3.5m) pens and kept for up to 49 days postpartum.

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3. Results and discussion

The reproductive performance of sows observed in the study was presented in table 2.

Table 2. The effect of treatment on Piglets Birth Weight (BW), Mortality Rate (MR), Weaned Litter Size (WLS).

Parameter	Treatment	P1	P2	P3	Average
		14%	16%	18%	
BW (kg)	SO	1.36^{b}	1.61^{a}	1.56^{a}	1.51
	NSO	1.21^{c}	1.30^{b}	1.31^{b}	1.27
	Average	1.29	1.46	1.44	1.39
MR (%)	SO	20.85^{a}	16.72^{a}	17.31^{a}	18.29
	NSO	38.39^{b}	33.31^{b}	23.13^{a}	31.61
	Average	29.62	25.02	20.22	24.95
WLS	SO	8.33	11.14	9.56	9.68
	NSO	6.39	6.47	7.78	6.88
	Average	7.36	8.81	8.67	8.28

^{abc}different superscripts in the same row and column showed significant differences.

3.1. Piglets birth weight

Observation results (table 2) showed that the mean birth weight of superovulation piglets was 1.51 kg higher (P<0.01) than the mean non-superovulation birth weight (1.27 kg). Meanwhile, the piglet's birth weight fed with a protein level of 16% and 18% was higher (P<0.05) than the protein level of 14%, 1.44 kg, 1.46 kg, and 1.29 kg, respectively. The results of the treatment interactions showed that the interaction between superovulation and feed protein at the level of 16 and 18% resulted in birth weight of 1.61 kg and 1.56 kg, higher (P<0.005) than the interaction between superovulation and protein levels 14%, and also higher than all non-superovulation interaction treatments with all feed protein levels.

Superovulation in sows produces higher birth weight per litter than without superovulation because superovulation increases the activity of pregnancy hormones progesterone and estradiol and growth factors [7–11]. Pregnant Mare's Serum Gonadotropins and Human Chorionic Gonadotrophin play a role in increasing uterine capacity and secretion, as well as intrauterine growth and development [12]. After placentation is strongly influenced by the capacity of the placenta which facilitates the circulation of the substrate from the mother for fetal maintenance [13,14] which in turn affects the flow of nutrients to the developing embryo and fetus [15,16] and genetic expression in embryos and fetuses [10,11,15,17] which in turn will affect birth weight and growth to weaning.

Progesterone and estradiol concentrations during pregnancy have a positive correlation with increased uterine weight, fetal weight in the womb, and birth weight of piglets [1,18]. Furthermore, superovulation can increase early muscle growth characterized by an increase in muscle fiber size (hypertrophy), muscle growth then comes from an increase in the number of muscle fibers (hyperplasia) [14]. As a result of growth and development, which mostly occurs during the gestation period, the weight of the piglets born to superovulated sows was higher. Birth weight is also influenced by the contribution of protein, where the protein requirements for pregnant cattle are usually higher. The protein needs are for the fetus, membrane tissue, basic life, and increase in mammary gland tissue. Campos et al (2011) reported that the detrimental effect of protein restriction on fetal growth during early pregnancy may be due to changes in angiogenesis and growth of the placenta and endometrium, leading to decreased placental-fetal blood flow, maternal to the fetal supply of nutrients, and ultimately to fetal growth retardation [19].

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3.2. Mortality

The mean results of the observations on mortality during the study were presented in table 2. The results showed that the 14% protein level gave a mortality yield of 29.62 and was higher than the mortality that occurred in the 16% and 18% protein levels. Likewise, non-superovulation has a higher mortality rate than superovulation. On the effect of the interaction that gave the highest mortality effect on the interaction of 14% protein level with non-superovulation (38.39%) and the lowest mortality occurred at the interaction of 16% protein level with superovulation.

The results of this analysis also prove that there was a very significant effect on the interaction of protein levels with superovulation and non-superovulation. The results of the statistics test showed that the interaction of 16%, 18%, 14% protein levels with superovulation and 18% protein levels with non-superovulation had the same effect on mortality rates and very significantly lower than interactions treatments between non-superovulation and feed protein of level 14% and 16%. This means that the interaction between superovulation and feed protein levels can reduce the mortality of piglets

3.3. Weaned litter size

The average results of the observations of the effect of treatment on WLS are presented in table 2. The results of the experiment showed that superovulation treatment gave a higher number of WLS than in non-superovulation. Meanwhile, the effect of feed protein levels on WLS showed that 14% protein levels gave lower yields than those of 16% and 18% protein levels. The interaction between superovulation treatment, non-superovulation, and feed protein levels, showed that the superovulation interaction with the feed protein level of 16% gave the highest result, while the interaction between non-superovulation and protein level of 14% gave the lowest result.

The results of statistical tests showed that the combination of superovulation with all levels of feed protein gave higher results ($P<0.05$) than the combination treatment between non-superovulation and all levels of feed protein. The highest WLS results in this experiment were achieved in the interaction of the superovulation treatment with a feed protein level of 16%.

4. Conclusion

The administration of both superovulation induction and dietary protein level in sows before their mating were able to increase birth weight, suppress mortality, and increase weaning litter size, of the piglets.

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