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Effects of early weaning of piglets at 10 days of age on productive performance

Efeitos do desmame precoce de leitões aos 10 dias de idade no desempenho produtivo

Efectos del destete temprano de lechones a los 10 días de edad sobre el desempeño productivo

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Stenia Severo Rabelo
ORCID: https://orcid.org/0000-0002-0000-0284
Universidade Federal de Uberlândia, Brazil
E-mail: steniasevero@hotmail.com
Antônio Liomar Eugênio
ORCID: https://orcid.org/0009-0002-3607-9286
Centro Universitário do Cerrado, Brazil
E-mail: antonioleomar5e@gmail.com
Jordana Lemos Andrade de Andrade
ORCID: https://orcid.org/0000-0003-4102-9443
Universidade Federal de Uberlândia, Brazil
E-mail: jordanaandrade.vet@usp.br
Jéssica Luana Guimarães de Oliveira
ORCID: https://orcid.org/0000-0002-7788-3580
Universidade Federal de Uberlândia, Brazil
E-mail: luanaguimaraescvo@hotmail.com
Jéssica Borges da Silva
ORCID: https://orcid.org/0009-0009-9982-0837
Centro Universitário de Patos de Minas, Brazil
E-mail: jessicabs.vet@hotmail.com
Ednaldo Carvalho Guimarães
ORCID: https://orcid.org/0000-0001-8328-9687
Universidade Federal de Uberlândia, Brazil
E-mail: ecg@ufu.br
Robson Carlos Antunes
ORCID: https://orcid.org/0000-0002-6399-5186
Universidade Federal de Uberlândia, Brazil
E-mail: robson.antunes@ufu.br

Abstract
This study aimed to evaluate weaning at 10 days of age and use of milk replacer, considering that the control group was conventional weaning at 21 days. Two hundred eighty-eight animals were used, and birth weights at 10, 21, 66, and 163 days of age were evaluated. At the slaughterhouse, measurements were taken of hot carcass weight, backfat and muscle thickness, and percentage of lean meat. There was no statistical difference in weight at birth and at 10 days. From 21 days of age onwards, there was a difference in all measures of animal weight and weight gain, with the averages for control animals being higher when compared with the treatment. Regarding measurements at the slaughterhouse, there was a statistical difference in relation to muscle depth and carcass weight, and animals in the control group showed better results when compared with treatment. We concluded that piglets weaned at 21 days of age have greater growth potential, as maximizing weaning weight is a key point in pig production.
Keywords: Animal production; Hyperprolificity; Pig farming.

Resumo
Este estudo teve como objetivo avaliar o desmame aos 10 dias de idade e o uso de substituto lácteo, considerando que o grupo controle foi o desmame convencional aos 21 dias. Foram utilizados 288 animais e avaliados os pesos ao nascer aos 10, 21, 66 e 163 dias de idade. No frigorífico foram realizadas medidas de peso de carcaça quente, espessura de toucinho e músculo e percentual de carne magra. Não houve diferença estatística no peso ao nascer e aos 10 dias. A partir dos 21 dias de idade houve diferença em todas as medidas de peso e ganho de peso dos animais, sendo as médias dos animais controle maiores quando comparadas com o tratamento. Em relação às medidas no abatedouro, houve diferença estatística em relação à deposição muscular e peso da carcaça, sendo que os animais do grupo controle apresentaram melhores resultados quando comparados ao tratamento. Concluímos que os leitões desmamados aos 21 dias de idade apresentam maior potencial de crescimento, pois a maximização do peso ao desmame é um ponto chave na produção suína.
Palavras-chave: Hiperprolificidade; Produção animal; Suinocultura.

Resumen
Este estudio tuvo como objetivo evaluar el destete a los 10 días de edad y el uso de sustituto lácteo, considerando que el grupo control fue destete convencional a los 21 días. Se utilizaron 288 animales y se evaluaron los pesos al nacer a los 10, 21, 66 y 163 días de edad. En el matadero se midieron el peso de la canal caliente, el grosor de la grasa dorsal y del músculo y el porcentaje de carne magra. No hubo diferencia estadística en el peso al nacer y a los 10 días. A partir de los 21 días de edad hubo diferencia en todas las medidas de peso de los animales y ganancia de peso, siendo los promedios de los animales control mayores en comparación con los del tratamiento. En cuanto a las mediciones en matadero, hubo diferencia estadística en relación a la profundidad del músculo y el peso de la canal, y los animales del grupo control mostraron mejores resultados en comparación con el tratamiento. Concluimos que los lechones destetados a los 21 días de edad tienen mayor potencial de crecimiento, ya que maximizar el peso al destete es un punto clave en la producción porcina.
Palabras clave: Cría de cerdos; Hiperprolificidad; Producción animal.

1. Introduction

The development of pig farming worldwide in recent years is characterized by the intensification of production processes, by increasing the scale of production and the use of technologies related to genetics, nutrition, reproduction, and health. The advancement of genetic improvement provided a significant increase in the number of weaned/sow per year. Due to this increase, some challenges have arisen, especially in the lactation phase, in which the sow's requirement is greater than its physiological capacity. However, the amount of milk ingested per piglet is inadequate, the growth rate of piglets is limited by the milk supply, and consequently there is an increase in neonatal mortality (Bruns et al., 2018). In addition, the lack of teats due to a large litter size may lead to an increase in low-birth-weight piglets.

The number of piglets born increased from 13.3 in 2006 to 15.8 pigs in 2016 (Kemp et al., 2018). To meet the nutritional requirements of the piglet, it is necessary for the sow to have a high milk production, which causes loss in body reserves of adipose tissue, resulting in a greater energy expenditure. This negative energy balance in the lactation phase increases the wean-to-estrus interval (WEI), in addition to decreasing the total number of piglets born in the subsequent farrowing (Strathe et al., 2017).

In Brazil, the practice of weaning is usually carried out from 21 to 28 days. Early weaning is an alternative that aims to solve the increase in catabolism caused by the hyperprolificity of the sow. However, animals weaned early tend to present difficulties in the ingestion of solid foods. As a result, high technology and maximum digestibility milk substitutes have been developed, which aim to meet the nutritional needs of the piglet. Thus, this study aimed to evaluate the performance of piglets weaned at 10 days of age, transferred to the nursery, using commercial milk substitute.

2. Methodology

Research on animals was conducted according to the institutional committee on animal use (072/19).

2.1 Animals and management

The experiment was carried out in a commercial finishing pig farm, with a herd of approximately 500 sows, located in the municipality of Patrocínio, Minas Gerais, Brazil (18°46’23”S 46°56’11”W, altitude of 965 m). Piglets from 24 hybrid sows (Large White X Landrace, DB-25 line) were used, from the 2nd to the 6th farrowing order. Sows were inseminated with semen from an AGPIC-337 TG ELITE boar. At parturition, males and females were randomly separated to be used in the experiment.

During the gestation period, the sows were housed in individual cages and fed a gestation diet of 3,150 Kcal of metabolizable energy, once a day. At the farrowing house, the sows were accommodated in pens, each housing eight individuals, and during the suckling phase, the sows were fed a lactation ration with 3,450 Kcal of metabolizable energy, five times a day, with *ad libitum* access to water through fixed pacifier drinkers. Sows selected to participate in the experiment were not subjected to synchronization of farrowing with oxytocin.

At the nursery, the studied animals were housed in collective pens with a suspended plastic floor, with a space of 0.4 m² per animal. Two pens containing 12 animals were used in the experiment. Heating was provided by infrared lamps, controlled by a thermostat, which automatically shut down when the temperature reached 34 °C and restarted when it reached 30 °C.

The animals weaned early were fed with levels of elements per kg of the substitutes A and B (Tables 1 and 2).

Table 1 - Composition of substitute A.

Element	**Substitute A**
Crude Protein	Min. 18 %; Max. 22 %
Raw fat	Min. 9.35 %; Max. 12.65 %
Lysine	Min. 15.03 g; Max. 18.4 g
Methionine	Min. 5.4 g; Max. 6.7 g
Ethereal Extract	Min. 100 g
Gross Fiber	Max. 25 g
Mineral Matter	Max. 100 g
Moisture	Max. 75 g
Calcium	Min. 4.6 g; Max. 8.6 g
Phosphor	Min. 3.2 g; Max. 7.2 g
Sodium	Min. 1.2 g; Max. 5.2 g
Iron	Min. 140 mg; Max. 160 mg
Copper	Min. 150 mg; Max. 170 mg
Zinc	Min. 80 mg; Max. 120 mg
Manganese	Min. 35 mg; Max. 55 mg
Iodine	Min. 1 mg; Max. 1.4 mg
Selenium	Min. 0.2 mg; Max. 0.4 mg
Vitamin A	Min. 14400 UI; Max. 17600 UI
Vitamin D3	Min. 1800 UI; Max. 2200 UI
Vitamin E	Min. 140 UI; 210 UI
Citric acid	Min. 300 mg. Max. 900 mg
Fumaric acid	Min. 4000 mg; Max. 6000 mg
Stare	Min. 400 FTU; Max. 600 FTU

Min.: minimum; Max.: maximum. Source: Commercial substitute.

Table 2 - Composition of substitute B.

Element	**Substitute B**
Crude Protein	Min. 18 %; Max. 24 %
Raw fat	Min. 12 %; Max. 18 %
Lysine	Min. 10 g; Max. 25 g
Methionine	Min. 2 g; Max. 9 g
Ethereal Extract	Min. 131 g

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Gross Fiber	Max. 19.6 g
Mineral Matter	Max. 70 g
Moisture	Max. 40 g
Calcium	Min. 3 g; Max. 10 g
Phosphor	Min. 2 g; Max. 9 g
Sodium	Min. 2 g; Max. 8 g
Iron	Min. 90 mg; Max. 110 mg
Copper	Min. 150 mg; Max. 170 mg
Zinc	Min. 80 mg; Max. 120 mg
Manganese	Min. 40 mg; Max. 60 mg
Iodine	Min. 0.3 mg; Max. 1 mg
Selenium	Min. 0.2 mg; Max. 0.4 mg
Vitamin A	Min. 20000 UI; Max. 30000 UI
Vitamin D3	Min. 3000 UI; Max. 5000 UI
Vitamin E	Min. 100 UI; Max. 200 UI
Citric acid	Min. 18000 mg; Max. 22000 mg
Fumaric acid	-
Stare	-

Min.: minimum; Max.: maximum. Source: Commercial substitute.

From 10 to 13 days, the piglets were fed with substitutes A and B, diluted in water in the proportion of 2.5 liters of water to 1 kg of substitute, being 900g of formulation A and 100g of B, supplied *ad libitum* in polyvinyl chloride troughs, with mouths for 10 animals. From the 14th to the 17th day, a mixture of 900g of formulation A and 100g of the pre-turbo feed used on the farm was supplied, diluted in water in the proportion of 2.2 liters of water to 1 kg of mixture. From 18 to 21 days, only the pre-turbo feed was supplied in dry form in funnel-type troughs with feed moistening valves. Water was freely available from pacifier drinkers and auxiliary drinkers. In the subsequent phases of rearing, the animals were fed diets formulated to meet the nutritional requirements as recommended by Rosgtano et.al (2011), in accordance with the farm standard.

2.2 Experimental design

A randomized block design (RBD) was used with two treatments and six blocks; within each block, 48 animals were used, i.e., within each block 24 repetitions (animals) of each treatment were evaluated. The treatments tested were control (weaning at 21 days) and treated (weaning at 10 days). Therefore, in six blocks, 288 animals were used in total.

At ten days old, half of each sow's litter, corresponding to six animals, was sent to the nursery, and the remaining ones stayed with their mother. In the nursery, two pens were used to hold 12 piglets each, totaling 24 animals. Six piglets from other sows were placed in a farrowing cage. Thus, the two treatments maintained the same number of animals for up to 21 days, both in the nursery and in the maternity ward. The animals in the different experimental groups were kept under similar conditions from 21 days of age until the end of the finishing phase to reduce experimental error (Pereira et al., 2018).

2.3 Variables analyzed/Data collected

At birth, all piglets were weighed individually on a B-MAX® digital scale and received a tattoo on the ear with their respective number within the experiment. Piglets weighing between 1.0 kg and 1.8 kg, approximately half of them being female and half being male, were selected. At 10 days of age, individual piglets were weighed again using the same scale.

At 21 days of age, the weight of the animals that were destined for the nursery was measured. At that moment, earrings were fastened according to their tattoo number for better identification of the animals. Upon leaving the nursery, at 66 days of age, all animals were weighed individually. At the end of the finishing phase, at 163 days of age, the animals were weighed again. At all rearing stages, the weight gain of all animals was measured.

Carcass yield analyses were carried out in one slaughterhouse located in the municipality of Patos de Minas-MG. Hot carcass weight, backfat thickness, muscle thickness, and percentage of lean meat were measured. Measurements were performed with a Hennessey® gun and, subsequently, the carcasses were stored in a cold room.

To apply the parametric test (ANOVA), the basic assumptions of normality of the mathematical model's residuals and homoscedasticity of treatment variances were verified through the Shapiro-Wilks and Levene tests, respectively, using a reference significance of 5%. These tests indicated residuals with normal distribution and homoscedasticity of variance for the analyzed variables (p-value>0.05). Thus, the general mathematical model used was (Equation 1): $Y_{ij} = \mu + t_i + b_j + e_{ij}$
where: Yij is the value observed in the experimental plot that received treatment i in block j; m is the overall mean of the variable; ti is the effect of treatment i, bj is the effect of block j; and eij is the experimental error of the plot that received treatment i in block j.

For the variables that presented a p-value <0.05 within the treatment factor of the ANOVA, significant differences among the treatments were observed. Conversely, for variables with a p-value >0.05, there is insufficient evidence to assert the presence of significant differences among the treatments. Analyses were made using the statistical program Action version 2.8.

3. Results

We observed no difference in weight at birth and at 10 days (Table 3). From 21 days of age onwards, however, there was a statistical difference, with the average weight of animals weaned at 21 days of age being heavier when compared with those weaned at 10 days of age.

Table 3 - Average weights of animals.

Variable	Control	Treatment	p value
Birth weight (kg)	1.42[a]	1.43[a]	0.537
Weight at 10 days (kg)	3.52[a]	3.51[a]	0.791
Weight at 21 days (kg)	6.42[a]	4.72[b]	0.000
Weight at 66 days (kg)	25.88[a]	23.13[b]	0.000
Weight at 163 days (kg)	125.53[a]	119.43[b]	0.000

The means followed by the same letter do not differ from each other by the Scott-Knott test, with a 5% probability. Source: Authors.

According to Table 3, there was no difference in weight at birth and at 10 days. From 21 days of age, there was a statistical difference in the average weight of the animals, with the average weight of animals weaned at 21 days being higher compared to the average weight of animals weaned at 10 days.

When the environmental conditions were different between the two groups evaluated (treatment and control), the control group, which had the piglets in contact with their mother for longer, began to show better weight gain results at 10 days of life (Table 4).

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Table 4 - Mean weight gain of animals.

Variable	Control	Treatment	p value
Birth to 10 days (kg)	2.10[a]	2.07[a]	0.580
From 10 days to 21 days (kg)	2.89[a]	1.21[b]	0.000
From 21 days to 66 days (kg)	19.45[a]	18.40[b]	0.002
From 66 days to 163 days (kg)	99.65[a]	96.29[b]	0.005

The means followed by the same letter do not differ from each other by the Scott-Knott test, with a 5% probability. Source: Authors.

Table 4 shows weight gains at different ages and production stages, with greater weight gains from 10 days of age onwards for animals weaned at 21 days of age.

The animals in the control group obtained better results in muscle depth and carcass weight when compared with the animals in the treatment (Table 5).

Table 5 - Means of slaughterhouse data.

Variable	Control	Treatment	p value
Muscle depth (mm)	69.37[a]	67.49[b]	0.005
Backfat thickness (mm)	11.32[a]	11.06[a]	0.387
Lean meat percentage (%)	60.54[a]	60.43[a]	0.623
Carcass weight (kg)	92.17[a]	87.91[b]	0.000

The means followed by the same letter do not differ from each other by the Scott-Knott test, with a 5% probability. Source: Authors.

In Table 5, we show that there was a difference in muscle depth and carcass weight, with the control group animals achieving better results compared to the treatment group animals.

4. Discussion

Early weaning is an alternative that seeks to solve problems resulting from the birth of many piglets, incompatible with the number of teats and with the sow's milk production. Additionally, the practice of weaning is a moment that has a great impact on the piglets, leading to physiological, structural, and functional changes all over the body. Although there is no consensus on which model best represents the age-related weight gain behavior in pigs, it is known that the growth rate is higher in the first days of the animal's life (Schinkel et al., 2004). Thus, incorrect handling in the first days of life may impair the performance of the animal.

Stressors occur during weaning, such as separation from the mother, change of environment, difficulty adapting to feeders and drinkers, social change, and diet change, which lead to decreased immunity, intestinal changes, and reduced food consumption, consequently affecting the growth rate and animal performance (Xu et al., 2015).

In an intensive pig production system, piglets can be weaned at one or two weeks of age and, consequently, there is an amplification of the physiological and behavioral effects of weaning (McLamb et al., 2013; Li et al., 2017). Social stresses are generated by separation from the mother and mixing animals from other litters, whereas environmental stresses are generated by handling and transporting animals in different physical environments (Campbell et al., 2013; Sutherland et al., 2014). All these stressors may increase cortisol concentration.

Weary et al. (1999), evaluating weaning at 14 and 28 days of age, reported that piglets weaned at 14 days had more stereotyped behaviors, resulting from stress, when compared with those weaned at 28 days of age. Therefore, the authors concluded that the later the weaning, the less stress for the piglets.

Increased cortisol induces an increase in the production of free radicals, resulting in oxidative damage to proteins, as well as lipid peroxidation, which may lead to cytotoxicity and cellular damage (Szabó, 2003). Therefore, piglets separated early from their mother go through stressful situations in an advanced and amplified way, inducing greater cell toxicity, directly affecting nutrient absorption and body growth.

In the first 24 hours after weaning, functional and structural changes occur in the small intestine, which include a decrease in villus height and a reduction in the specific activity of digestive and absorptive enzymes in piglets (Hall and Byrne, 1989). In addition, among the physiological and gastrointestinal factors impacted by the weaning transition, disruption of the microbiota is likely to occur, being recognized as one of the keys that lead to post-weaning diarrhea (Isaacson and Kim, 2012). As a result, the animal reduces productive performance and weight gain.

As aforementioned, weaning is associated with physiological and functional stress on the gut, and this stress may also reduce food intake. The feed intake of weaned piglets is associated with several factors, such as the number of animals, different types of feeders (Laskoski et al., 2019), and the complexity of the diet (Wolter et al., 2003). Reducing feed intake at weaning inhibits the growth rate of the piglet at all subsequent stages of rearing (McCracken et al., 1995). Thus, right after weaning, the piglets have to adapt quickly to the new diet, so that the animal has a satisfactory performance.

All the aforementioned metabolic and behavioral alterations corroborate our results presented in this study, as early weaned piglets showed greater challenges in terms of survival and weight gain at the beginning of life, affecting body growth and compromising productive performance throughout the entire life cycle.

Another important aspect is that weaning weight has a direct influence on weight at daycare and termination. Higher weaning weight generates a positive and lasting effect on subsequent phases, showing a positive correlation with final finishing weight (Faccin et al., 2020). In the present study, weaning at 10 days impaired piglet performance in the nursery and finishing stages. Piglets weaned at 21 days have greater growth potential, so maximizing weaning weight is a key point in pig production.

Ko et al. (2015) concluded that age and weaning weight also influence carcass traits, and we found similar results. In this study, Hennessey® equipment was used to measure the depth of the muscle and the thickness of the backfat; with the values found, the percentage of lean meat was calculated using prediction equations programmed into the system itself. The percentage of lean meat was directly influenced by muscle depth, backfat thickness, and hot carcass weight.

The low weight of piglets weaned at 10 days of age was negatively correlated with hot carcass weight and muscle depth but did not affect carcass lipid deposition or percentage of lean meat. According to Fávero and Guidoni (2001), backfat thickness contributes with 80% for predicting the percentage of meat in the carcass. This was corroborated by our results, which showed that there was no difference between the groups in terms of backfat thickness and, consequently, there was no difference in the percentage of lean meat.

An important factor in relation to pig production is that, although genetic selection has led to the development of hyperprolific sows, the ability to suckle is limited (Silalahi et al., 2017). In addition, the lack of teats due to a large litter size may lead to an increase in low-birth-weight piglets. An alternative to increase milk production would be to stimulate the development of the mammary gland and milk production through the application of exogenous hormones.

It is known that artificial lactation can be induced by using exogenous hormones in non-pregnant cows (Lakhani et al., 2017), ewes (Kann, 1997), and mares (Korosue et al., 2012). A recent study revealed that it is possible to induce lactation by exogenous hormone treatment in non-pregnant sows, and that high levels of porcine immunoglobulins are contained in milk collected from pseudopregnant sows (Noguchi et al., 2020).

5. Conclusion

We conclude that piglets weaned early show changes resulting from stress, a traumatic event for which the animal is not physiologically prepared. Changing the environment, regrouping the animals, separating the mother, and changing the diet represent major challenges for the piglet, impairing the animal's performance in the subsequent rearing stages, as well as the carcass yield. Early weaning is still used in many Brazilian farms, despite going against the world trend with regard to animal welfare. Therefore, alternatives are needed for sows that produce piglets in excess, such as genetic improvement aiming to increase the amount of milk and the number of sow teats, in addition to breastfeeding techniques, such as induction of milk production and letdown.

Although this study shows that early weaning impairs animal performance, more immediate action is needed regarding surplus piglets, as this higher number of births is currently a reality in pig farming operations. An alternative to this increase in piglet production is temporary confinement and collective lactation, which, from the perspective of animal welfare, are practices that are of interest.

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