

Pelleting of diet for weaning pigs of different initial weights

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ABSTRACT: *Physical form effect of the pre-starter diet supplied during the post-weaning period from 21 to 41 days of age on diet digestibility and animal performance in terms of zootechnical performances of light-weight (5.82kg) and heavy-weight weaning piglets (6.32kg) was evaluated, as well as the residual effects of the treatments until slaughter. Forty-eight female pigs at 21 days of age were evaluated. The experimental design was completely randomized in a 2x2 factorial scheme (meal/pelleted diet vs. light-weight/heavy-weight piglets), with six replicates for the nursery phase and 12 replicates for the growing-finishing phases. Animals received the experimental diet from 21 to 41 days of age. Data were analyzed with ANOVA, setting the significance in 5%. Feeding with the pelleted diet resulted in a 39% greater daily weight gain and a 28% greater feed conversion rate for piglets from weaning to 40 days of age. Pelleting also resulted in a decrease in feed wastage during the first week after weaning (9.15% for meal diet vs. 1.68% for pelleted diet) and; consequently, the results showed an increase in feed consumption. Digestible energy of the pelleted diet (3,626kcal kg⁻¹) was greater than that of the meal diet (3,424kcal kg⁻¹). The physical form improved the performance of weaning pigs and the digestibility of the pre-starter diet, but there wasn't residual effect of the physical form and the weight of a piglet at weaning on live weight at slaughter. **Key words:** feeding, pellet, swine, thermal processing.*

Peletização da dieta para leitões recém-desmamados com diferentes pesos iniciais

RESUMO: *Avaliou-se o impacto da forma física da dieta pré-inicial em leitões leves (5,82kg) e pesados (6,32kg) no período pós-desmame sobre o desempenho zootécnico e digestibilidade da dieta, bem como o efeito residual dos tratamentos até o abate. Foram utilizados 48 leitões fêmeas com 21 dias de idade, distribuídos em delineamento inteiramente ao acaso, em esquema fatorial 2x2 (farelada/peletizada vs. leitões leves/pesados), com seis repetições na fase de creche e 12 repetições na fase de crescimento e terminação. Os leitões receberam as dietas experimentais dos 21 aos 40 dias de idade. Os dados foram submetidos à análise de variância ao nível de 5% de probabilidade. Observou-se que a peletização melhorou em 39% o ganho de peso diário e 28% a conversão alimentar do desmame aos 40 dias de idade. Ao considerar a redução de desperdício da ração peletizada (9,15 vs. 1,68%) na primeira semana pós-desmame, a peletização da dieta proporcionou aumento do consumo de ração. Ao avaliar a digestibilidade da dieta, observou-se que a energia digestível aumentou de 3.424kcal kg⁻¹ na forma farelada para 3.626kcal kg⁻¹ na forma peletizada. A forma física da dieta proporcionou efeitos positivos sobre o peso vivo dos leitões desmamados e energia digestível da dieta. Porém, não foi observado efeito residual da forma física ou peso ao desmame sobre o peso vivo ao abate. **Palavras-chave:** alimentação, pelete, suínos, processamento térmico.*

INTRODUCTION

The process of weaning and allocation to nursery facilities exposes piglets to changes in their physical and social environment. Moreover, the exposed piglets experience nutritional changes, such as the change from a milk-based diet to a solid-feed diet. This transition can be divided into two phases: the acute phase (first five to seven days after weaning, during which time the weaned pigs learn how to eat and resume a level of dry matter intake comparable to the pre-weaning phase) and the subsequent adaptive phase (BURRIN & STOLL, 2003).

Several nutritional and non-nutritional factors influence and determine the zootechnical

performance of animals after weaning, which is generally characterized by a decrease in growth rate. Nutritionally, in addition to the rate of feed consumption, the digestibility of the diet is one of the most important factors affecting zootechnical performance (MAHAN & LEPINE, 1991). The heat processing of diets, such as pelleting, expansion, and extrusion procedures, can increase digestibility (LUNDBLAD et al., 2011).

A supply of pelleted diets to nursery piglets is generally acknowledged to reduce feed wastage and to improve zootechnical performance (HANCOCK & BEHNKE, 2001). Testing and optimization of the feed method processing is fundamentally important because it affects the viability of adopting a pelleted diet. The piglet characteristics at weaning are also

important determinants of zootechnical performance, and piglet weaning weight is positively correlated with the subsequent growth rate (WOLTER et al., 2002). Compared to smaller piglets, heavy-weight piglets are characterized by a higher feed intake and weight gain during the period immediately following weaning (MAHAN et al., 1998).

The objective of the present study was to evaluate the effect of the physical form of the pre-starter diet on the diet digestibility and the zootechnical performance of light-weight and heavy-weight piglets following weaning and their residual effects until slaughter.

MATERIALS AND METHODS

The study was conducted at the Laboratory of Pigs of the Universidade Federal do Paraná (UFPR). Forty-eight female piglets (commercial breed) that were weaned at three weeks of age were used. The piglets were transported for six hours from the pig production unit to an acclimatized nursery, where their initial weight was measured.

Each experimental unit at the nursery phase consisted of two ear-tagged piglets, 0.85m² pen with a plastic slatted floor and access to a nipple drinker and trough feeder (0.45cm animal⁻¹); animals remained in the nursery from weaning until 56 days of age. During the growing-finishing phase, the animals were relocated and grouped, maintaining the treatment scheme of the previous phase, with three animals per pen (3m²). Weights were monitored until 130 days of age. During this period, each animal was considered an experimental unit.

Animals received diets of one of two physical forms from the time of weaning until 40 days of age. The following treatments were tested: 1 - heavy-weight piglets (6.33kg) fed with a pelleted pre-starter diet; 2 - light-weight piglets (5.83kg) fed with a pelleted pre-starter diet; 3 - heavy-weight piglets (6.32kg) fed with a meal pre-starter diet; and 4 - light-weight piglets (5.81kg) fed with a meal pre-starter diet. Piglets did not have access to a selective feeder at the farrowing pen.

Diets were formulated according to ROSTAGNO et al. (2005) to meet or exceed nutritional demands, with both meal and pelleted pre-starter diets designed to be isonutritive and isoenergetic (Table 1). The corn used to formulate the diets was ground using a hammer mill with a 2mm sieve (corn geometric mean diameter [GMD] of 650µm). The meal diet and the pelleted diet had the same composition, with a GMD of 410µm.

The pelleting (micropelleting) of the pre-starter diets was performed by conditioning at a mean temperature of 55°C, low temperature because of the pre-started diet complexity, and a vapor pressure of 1.5kg cm⁻³ for 30 seconds, using a CPM® pellet mill, with a die measuring 50mm in height and a 2-mm hole diameter.

During the final nursery phase (41 to 56 days of age), all of the animals received the same pelleted starter diet (3,350kcal metabolizable energy (ME), 21% crude protein (CP), and 1.3% digestible lysine). During the growing-finishing phase, all of the animals received the same pelleted growing diet from 57 to 100 days of age (3,230kcal ME, 19.25% CP, 1.05% digestible lysine) and the same finishing diet from 101 to 130 days of age (3,230kcal ME, 17.75% CP, 0.85% digestible lysine). The pelleting of the starter, growing, and finishing diets was performed using a Van Arsen® pellet mill, with a die with a 55mm height and a 4mm hole diameter, with conditioning for 40 seconds at a pressure of 2.0kg cm⁻³ and 80°C. Diets were supplied *ad libitum* to all phases.

Animal performance was evaluated for the periods 21-28 days, 29-40 days, and 21-40 days of age. The following variables were analyzed: live weight (LW); mean daily feed intake (considering the offered, consumed, and wasted feed, minus the leftovers) (DFI); mean daily weight gain (DWG); and feed conversion (FC). Feed wastage (FW) relative to the total feed consumed (%) and to the feed consumption corrected for feed wastage (DFI-FW) were calculated for the first seven days after weaning. A partial collection of feces was performed between 37 and 40 days of age in the morning and in the afternoon, and the collected samples were frozen. The acid-insoluble ash (AIA) content was determined according to VAN KEULEN & YOUNG (1977) and considered as a natural internal indigestibility marker for the calculation of digestible energy (MOUGHAN et al., 1991; KAVANAGH et al., 2001).

Feces samples were thawed, homogenized, and dried in a forced-air oven at 55°C to a constant weight. After drying, the feces and feed samples were ground to 1mm and the AIA, dry matter (DM), and gross energy (GE) contents were determined. The DM was determined at 105°C, and the GE was measured using a bomb calorimeter. The AIA and GE were 0.29% and 4,610 kcal kg⁻¹ for the pelleted diet, respectively, and 0.32% and 4,625kcal kg⁻¹ for the meal diet, expressed on a dry matter basis.

Animals were monitored during the subsequent phases to evaluate the residual effects

Table 1 - Percentage composition and calculated nutritional values of the pre-starter diet (on natural matter basis).

Ingredient			%
Corn			44.69
Whey powder			16.22
Soybean meal, 46%			15.00
Micronized soybean			7.60
Mix plus extrusion-cooked ¹			7.50
Spray dried plasma			4.00
Cake residue			2.00
Dicalcium phosphate			0.60
L-lysine HCl			0.43
DL-methionine			0.24
L-threonine			0.22
Premix Vit/Min ²			1.50
Calculated composition			
Metabolizable energy	Unit	Value	
	kcal kg ⁻¹	3.401	
Crude protein	%	21.65	
Lactose	%	12.00	
Milk protein	%	0.72	
Calcium	%	0.69	
Available phosphorus	%	0.54	
Lysine dig.	%	1.44	

¹37% CP, composed of poultry offal meal, corn, soybean protein isolate, antioxidant, and acidifier. ² Vitamin and Mineral Mixture, content per kg diet: Vit. A, 8000UI.; Vit. D3, 1500UI.; Vit. E, 9.8UI.; Vit. K3, 1mg.; Vit. B2, 3.5mg.; Vit. B12, 15mg.; Pantothenic acid, 15mg.; Nicotinic acid, 20mg.; Se, 0.160mg.; Mg, 45mg.; Cu, 52mg.; Fe, 100mg.; Zn, 1100mg.; I, 1.50mg.

of the treatments applied immediately following weaning. The LW, DFI, DWG, and FC were determined for the period from 41 to 56 days of age (the end of the nursery phase), and the LW was also determined at 100 and 130 days of age.

The experimental design was completely randomized in a 2x2 factorial scheme consisting of two physical form of pre-starter diets (meal/pelleted) and two piglet weaning weight (light/heavy), with six replicates per treatment for the nursery phase, including digestibility, and 12 replicates for the growing-finishing phase. Homogeneity of variance of data was tested using the Bartlett test, and ANOVA was performed to compare treatments. Significant interaction were identified according to the factors involved, means of the interaction were compared by Tukey's tests, at 5% probability.

RESULTS AND DISCUSSION

Pelleting the pre-starter diet resulted in an improved DWG and FC and a decreased FW during the first week following weaning ($P < 0.05$, Table 2). There was no significant effect of pelleting on DFI ($P = 0.107$). However, this lack of effect may have

been attributed to the higher observed FW when the animals received a meal diet (9.15 vs. 1.68%) during the first week following weaning ($P = 0.001$) because the DFI-FW was greater for the pelleted diet than for the meal feed ($P = 0.019$). Increase in DFI-FW might have been attributed to the processing because the meal feed had a GMD of 410 μ m and pelleting caused the pelleted feed to be relatively less powdery. MOREIRA et al. (2001) studied the replacement of corn with pre-gelatinized corn and suggested that the fine particle size of the raw material negatively affected feed intake.

Similar performances have been reported by OHH et al. (2002), who tested a corn, soybean meal and dairy product-based diet conditioned at 35°C and pelleted using a die with a 2.8mm diameter hole and observed improvements in the DWG and FC accompanied by an increased DFI during the two weeks following weaning. XING et al. (2004) pelleted a corn, soybean meal and dairy product-based diet conditioned at 60°C and observed an increase in DWG during the first two weeks following weaning, a decreased DFI from 15 to 35 days following weaning, and improvements in FC during all periods compared to the corresponding meal diet.

Table 2 - Effect of the physical form of the pre-starter diet on zootechnical performance during the period immediately following piglets weaning, by weaning weight.

-----21 to 28 days of age-----								
Piglet weaning weight	Physical form	LW ¹ 21 days (kg)	DFI ² (g)	DWG ³ (g)	FC ⁴ (g g ⁻¹)	FW ⁵ (%)	DFI ² - FW ⁵ (g)	LW ² 28 days (kg)
Heavy	Pellet	6.34	242	248	0.99	2.05	237	8.07
Heavy	Meal	6.32	215	160	1.42	9.52	195	7.44
Light	Pellet	5.83	223	244	0.92	1.32	220	7.54
Light	Meal	5.82	186	127	1.50	8.78	170	6.71
-----Main factor-----								
Light-weight piglet at weaning		5.82	205	185	1.21	5.05	195	7.12
Heavy-weight piglet at weaning		6.32	228	203	1.20	5.78	216	7.75
Meal		6.07	200	143	1.46	9.15	182	7.07
Pellet		6.08	232	246	0.95	1.68	228	7.80
-----Probability-----								
Weaning weight		0.001	0.230	0.412	0.991	0.081	0.269	0.001
Physical form		0.697	0.107	0.001	0.001	0.001	0.019	0.001
Interaction		0.958	0.791	0.509	0.275	0.994	0.823	0.563
CV ⁵		1,77	22,72	28,43	15,21	19,13	23,11	5,88

LW¹ - live weight at a given age; DFI² - mean daily feed intake; DWG³ - mean daily weight gain; FC⁴ - feed conversion; FW⁵ - feed waste during the period; CV⁵ - coefficient of variation.

In contrast, the use of a pelleted diet during the nursery phase has been reported by two authors to improve the FC with no effect on DWG and DFI. LUNDBLAD et al. (2011) tested various heat processing treatments (pelleting at 47°C, pelleting at 90°C, expansion at 105°C, and extrusion at 120°C, 4.0mm pellet size) for a wheat meal, soybean meal, and fish flour-based diet for weaning pigs and observed a better FC, with no effect on DFI or DWG compared to the corresponding meal diet. The authors attributed this improvement to a decreased FW. MEDEL et al. (2004) observed a 20% improvement in FC with the use of a pelleted diet (2.5mm) conditioned at 70-75°C. However, this improvement was accompanied by a 15.5% decrease in DFI, with no difference in DWG. The authors attributed the improvement in FC partially to the 3.6% higher digestibility coefficient of gross energy of the pelleted diet and to the decrease in FW (measured in a subsequent experiment conducted under the same conditions to be 8.9% for the meal diet and 2.3% for the pelleted diet).

STEIDINGER et al. (2000) observed that the pelleting of corn, soybean meal, dairy products, and plasma-based diets at temperatures greater than 77°C had negative effects on DWG and DFI from 0 to 7 days following weaning. However, there were no significant differences between piglets fed pelleted (3.9mm) and meal diets from 0 to 28 days following weaning.

A 28% improvement in FC during the first week and a 22% improvement for the weaning period

until 40 days of age were observed ($P < 0.05$, Table 3), which can be attributed to the decrease in FW and the increase in digestible energy of the pelleted diet. An evaluation of the digestibility of the diet for piglets from 37 to 40 days of age revealed a higher digestible energy for the pelleted diet (3,626kcal kg⁻¹) than for the meal diet (3,424kcal kg⁻¹) ($P 0.023$). Pelleting consisted of the application of hot vapor and mechanical pressure to form pellets, and these processes can improve the diet digestibility (MEDEL et al., 2004).

Diet digestibility can also partially determine the DFI of young piglets because digestibility is positively related to feed intake (DONG & PLUSKE, 2007). Therefore, the increase in diet digestibility resulting from processing may have had a positive effect on DFI during the period immediately following weaning. Avoiding decreases in feed intake is desirable by piglets during post-weaning because the intake level is more strongly related than the diet composition to the preservation of the integrity of intestinal villi (BEERS-SCHREURS et al., 1998).

A significant interaction between piglet weight and the physical form of the diet was observed for the DWG from 29 to 40 days of age ($P 0.042$). Heavy-weight piglets receiving a pelleted diet had a greater DWG than light-weight piglets. In contrast, for the meal diet, there was no significant difference in DWG between piglets with different initial weaning weights.

This interaction indicated a favorable effect of the pelleted diet on the DWG of the heavy-

Table 3 - Effect of the physical form of the pre-starter diet on the zootechnical performance and the energy digestibility of piglets, by weaning weights.

Weaning weight	Physical form	-----29 to 40 days of age-----			-----21 to 40 days of age-----			LW ⁴ 40 days (kg)	DE ⁵ of diet (kcal kg ⁻¹)
		DFI ¹ (g)	DWG ² (g)	FC ³ (g g ⁻¹)	DFI ¹ (g)	DWG ² (g)	FC ³ (g g ⁻¹)		
Heavy	Pellet	611	515 ^a	1.19	475	417	1.14	14.26	3.636
Heavy	Meal	550	363 ^{bc}	1.52	426	289	1.49	11.80	3.456
Light	Pellet	502	406 ^b	1.24	399	346	1.15	12.41	3.617
Light	Meal	488	337 ^c	1.45	377	260	1.45	10.76	3.393
-----Main factor-----									
Light-weight piglet at weaning		495	371	1.34	388	303	1.30	11.58	3.505
Heavy-weight piglet at weaning		580	439	1.35	450	352	1.31	13.03	3.546
Meal		519	350	1.48	401	274	1.47	11.28	3.424
Pellet		556	460	1.21	437	381	1.14	13.33	3.626
-----Probability-----									
Weaning weight		0.001	0.002	0.641	0.002	0.004	0.657	0.001	0.664
Physical form		0.096	0.001	0.001	0.064	0.001	0.001	0.001	0.023
Interaction		0.286	0.042	0.054	0.482	0.191	0.383	0.212	0.817
CV ⁵		10,22	12,46	5,50	11,27	12,34	5,31	6,61	5,13

Means followed by the same lower case letter within the same row differ according to the Tukey test ($P < 0.05$); DFI¹ - mean daily feed intake; DWG² - mean daily weight gain; FC³ - feed conversion; LW⁴ - live weight at a given age; DE⁵ - digestible energy (37 to 40 days of age); CV⁵ - coefficient of variation.

weight animals. The DWG is determined by the genetic potential of an animal and its ability to ingest the amount of required nutrients.

No differences in performance were observed between light-weight and heavy-weight piglets during the first week following weaning ($P > 0.05$). Effect of the weight difference on performance during this first week may have been attenuated by weaning stress. However, the initial weight of a piglet at weaning affected performance at 40 days of age, with higher final DFI, DWG and LW values for heavy-weight piglets, but no significant differences in FC ($P < 0.05$). WOLTER et al. (2002) evaluated the effect of weight at birth and liquid supplementation at the farrowing pen. The authors compared heavy-weight (6.6kg) and light-weight (5.7kg) piglets at weaning and observed higher DWG and DFI values and improvement in FC at weaning for heavy-weight piglets from weaning up to 14kg.

The difference in DFI between light-weight and heavy-weight piglets may be related to the capacity of the gastrointestinal tract (GIT) because bigger piglets were observed to have larger GITs (PLUSKE et al., 2003). Interestingly, the relative weight (%LW) of the GIT was previously observed to be higher in lighter piglets weaned at 14 days, and this difference decreased as the post-weaning time passed (PLUSKE et al., 2003). This pattern may explain why no differences in DFI

were observed between light-weight and heavy-weight piglets during the first post-weaning week.

Regarding the residual effects of the evaluated diets determined when all of the animals received a pelleted diet (Table 4), a greater FC was observed for animals that had previously received meal than for animals that had previously received a pelleted diet and for the light-weight animals relative to the heavy-weight animals at weaning ($P < 0.05$). A possible explanation for this could be the decrease in maintenance energy associated with the lower LW of these groups. MAHAN et al. (1998) observed a worse FC during the nursery phase for heavier piglets and attributed this observation to the lower demand for maintenance energy of light-weight piglets.

A significant effect of the initial weaning weight on the LW in the subsequent periods was only observed until 56 days of age ($P 0.01$), and a 0.5kg difference at weaning represented a 1.6kg difference at 56 days of age. No effect was observed after 56 days of age (at 100 and 130 days of age) (Table 2, 3 and 4). At 40 days of age, animals that had received a pelleted diet were 2.05kg heavier than those that received a meal diet ($P 0.001$). The additional weight difference resulting from the use of a pre-starter diet remained significant between 40 and 100 days of age ($P 0.046$), representing a 0.40kg increase relative to the weight difference observed at 40 days of age.

Table 4 - Residual effect of the physical form of the pre-starter diet and weaning weight on the zootechnical performances and live weights of piglets at subsequent growth phases.

-----41 to 56 days of age-----					LW ⁴ 56 days	LW ⁴ 100 days	LW ⁴ 130
Weaning weight	Physical form	DFI ¹ (g)	DWG ² (g)	FC ³ (g g ⁻¹)	(kg)	(kg)	days (kg)
Heavy	Pellet	951	579	1.65	23.53	62.34	89.11
Heavy	Meal	876	574	1.53	20.99	60.12	87.42
Light	Pellet	903	574	1.58	21.60	60.31	86.62
Light	Meal	821	556	1.47	19.67	57.63	84.10
-----Main factor-----							
Light-weight piglet at weaning		862	565	1.52	20.63	58.97	85.36
Heavy-weight piglet at weaning		913	576	1.58	22.26	61.22	88.26
Meal		848	565	1.50	20.33	58.87	85.76
Pellet		927	576	1.61	22.56	61.32	87.86
-----Probability-----							
Weaning weight		0.202	0.703	0.043	0.010	0.066	0.146
Physical form		0.056	0.699	0.001	0.001	0.046	0.290
Interaction		0.922	0.826	0.725	0.605	0.851	0.832
CV ⁵		11,34	12,84	4,98	6,97	7,04	7,97

DFI¹ - mean daily feed intake; DWG² - mean daily weight gain; FC³ - feed conversion; LW⁴ - live weight at a given age; CV⁵ - coefficient of variation.

WOLTER et al. (2002) observed a 0.9kg weight difference at weaning in piglets with different weights at birth (1.3 vs. 1.8kg) and between piglets that did or did not receive supplementation at the farrowing pen. However, the weight at birth had a stronger effect on the subsequent performance and the time required to reach slaughter weight than supplementation at the farrowing pen.

CONCLUSION

Pelleting improved the performance of weaning pigs and the digestibility of the pre-starter diet. However, there wasn't residual effect of the physical form on weight at slaughter. Piglet weight at weaning should be considered an important factor because had impact on weight gain at the initial nursery phase, but without expressive effect on other phases.

BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

Protocol n. 059/2011.

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