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Modeling performance and nutritional requirements of pigs lots during growth and finishing

Modelagem do desempenho e das exigências nutricionais de lotes suínos em crescimento e terminação

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ABSTRACT

Determination of animal profile from production scenarios by modeling is essential to improve production. The objective of this study was to model and evaluate the performance, the supply and nutrients requirements for pigs, during the growing and finishing phases, in real production scenarios. Six scenarios with 2,200 animals, which consumed six ad libitum diets, were selected. The collected data from the production scenarios were modeled based on the average animal. Animals were housed at 65±7 days old and weighing 22.11±1.41kg and were slaughtered at 159±10 days old and weighing 121.18±7kg. Average of the scenarios was greater than 0.27kg for consumption and 0.12kg for weight gain; feed conversion was equivalent to the standard animal profile (SAP). Scenarios were 1.60g higher for the requirement and 2.67g higher for daily digestible lysine per animal when compared to the SAP. Production scenarios showed differences between performance, supply and nutrient requirements for pigs during the growing and finishing phases. Modeling is a tool that can be used to describe and compare the characteristics of each production scenario.

Key words: *animal production, animal profile, InraPorc®, lysine.*

RESUMO

A determinação do perfil animal de cenários de produção, por modelagem, é imprescindível para melhorar a produção. O objetivo deste estudo foi modelar e avaliar o desempenho zootécnico, o fornecimento e as exigências de nutrientes para suínos nas fases de crescimento e terminação em cenários de produção reais. Foram selecionados seis cenários com total de 2.200 animais que consumiram seis dietas ad libitum. Os dados coletados nos cenários de produção foram modelados com base na média animal. Os animais foram alojados com 65±7 dias de idade e 22,11±1,41kg de peso e foram abatidos com 159±10 dias e 121,18±7kg. A média dos cenários foi superior a 0,27kg em consumo e 0,12kg em ganho de peso, a conversão alimentar foi equivalente ao perfil animal padrão (PAP). Os cenários foram superiores em 1,60g para exigência e 2,67g para fornecimento de lisina digestível diária por animal em relação ao PAP. Os cenários de produção apresentam diferenças para desempenho zootécnico, fornecimento e exigências de nutrientes para suínos nas fases de crescimento e terminação. A modelagem é uma ferramenta que pode ser utilizada para descrever e comparar as especificidades em cada cenário de produção.

Palavras-chave: *produção animal, perfil animal, InraPorc®, lisina.*

INTRODUCTION

Industrial pig production is stimulated by the demand for quality animal protein conditioned to maximum animal performance based on diets with high nutrition concentrations and high costs. Food represents about two thirds of swine production costs, therefore reduce the value derived from this fraction is interesting from the economic point of view.

The methods used to estimate nutritional requirements are based on the response of the population (empirical) or individual (factorial) (HAUSCHILD et al., 2010). Results compilation provides tables with static data about nutritional recommendations for general animal profile, such as those published by ARC (1981), NRC (1998) and ROSTAGNO et al. (2011). These tables are conventionally used in industrial production systems to develop empirical diets and food programs.

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Although functional, this procedure applies generalizations to specific scenarios and results in inaccuracies. These inaccuracies can have effects on performance, digestive and metabolic processes regarding protein and lipid deposition (FABIAN et al., 2003), and/or production costs.

Growth phenomena should be evaluated dynamically, depending on the response of the animal to ingested nutrients (SAUVANT et al., 1995), which requires the development of new concepts. The InraPorc® model uses the principles of swine nutrition, such as digestible amino acids, net energy (NOBLET et al., 2001) and the ideal protein, using a dynamic methodology that is both mechanistic and deterministic to represent the phenomena related to nutrition, feed, and genetics (VAN MILGEN et al., 2008). Determination of nutritional requirements is elementary in terms of production efficiency (POMAR et al., 2009), due to diets with higher nutritional precision according to animal profile.

Determining the animal profile of each production scenario (a result of interactions between food consumption, dynamics growth, nutrients use, and the influence of environment) is essential to improve feed efficiency and reduce diets cost and excretion of polluting elements. Studies to identify the specific nutritional requirements of animal profiles in a mechanical and dynamic way are important for balancing diets. In this context, the aim of this study was to model and evaluate the growth performance, supply, and nutrient demands of pigs during the growing and finishing phases in production scenarios.

MATERIALS AND METHODS

Data collection was carried out in an industrial pig production system in the northwest of Rio Grande do Sul, between August and November 2012. The criterion for sampling was an interval of three days, to delimit the number of farms and minimize climatic effects. Data were collected from six farms or production scenarios (PS), i.e. 1PS, 2PS, 3PS, 4PS, 5PS and 6PS, with equivalent management protocols. The scenarios presented variations in terms of facilities, equipment, location and orientation, capacity, and total number of animals. These factors (environment) were implicit in the performance of the PS, as other studies have reported in the literature (DE LANGE et al., 2001; VAN MILGEN et al., 2008).

The scenarios showed an average of 367±186 animals, with a minimum population of 200 (5PS) and maximum of 724 animals (6PS). In total, 2,200 animals were used in six mixed batches (females and castrated males). Recommendations for housing the animals were 64 days old and 22.00kg. The diet program followed a pre-established period, sequence and quantities of each diet for animals in each stage. Ingredients composition were analyzed (AOAC, 1995) and the diets (Table 1) were formulated based on nutritional requirements established through the historic growth performance of farms or the standard animal profile (SAP). Food program was *ad libitum* for all phases and PS. The diet and food programs of the SAP were used in the PS.

Data collection in the scenarios was conducted in randomly selected bays throughout the experimental period, representing at least 20% of the animals housed, with a maximum limit of four bays. This procedure was performed based on the literature (DE LANGE et al., 2001). In each scenario, data on animal performance were collected (age, weight and accumulated consumption of diets) of all pigs in the sample bays for each phase, according to the diet program.

The diet composition data, feed intake and animal performance, from each PS and SAP, were entered into InraPorc® software (INRAPORC®, 2010) to parameterize the model. Parameterization allows characterizing the animal profile of the respective production scenario (VAN MILGEN et al., 2008). The data for each scenario were modeled based on the average animal for all the parameters and 2% diet loss was estimated (BROSSARD et al., 2009). The animal performance curves were calibrated and the nutritional requirements were modeled (ROSSI et al., 2013) to the standard animal profile and the six animal profiles evaluated. The data were submitted to descriptive statistical analysis and compared using absolute relation to the standard deviation.

RESULTS AND DISCUSSION

The performance data of the PS are shown in table 2. The characteristics of the animals in each PS were an average age of 65±7 days old and weight of 22.11±1.41kg. These values are similar to the SAP, although the minimum age was 55 days (6PS) and the maximum was 72 days (1PS), which generated a variation of nine days in the scenarios for the SAP. Likewise, the minimum weight was 19.64kg

Table 1 - Nutritional composition and proximate diets of pigs in the growing and finishing phases.

Ingredients		In	GI	GII	GIII	TI	TII
Corn	%	58.82	61.12	60.71	60.47	45.03	46.27
Soybean meal	%	25.00	24.50	25.10	25.50	21.80	20.50
Sorghum	%	-	-	-	-	20.00	20.00
Whole rice meal	%	5.00	5.00	5.00	5.00	5.00	5.00
Animal fat	%	4.20	3.50	3.65	3.80	3.50	3.15
Meat meal	%	3.50	3.00	2.80	2.70	1.70	2.00
Premix mineral-vitaminic[1]	%	1.50	1.00	1.00	1.00	1.25	1.50
Sodium chloride	%	0.50	0.45	0.45	0.45	0.45	0.45
Limestone	%	0.30	0.50	0.50	0.45	0.65	0.55
Adsorbent	%	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine 78%	%	0.45	0.34	0.27	0.19	0.19	0.18
DL-Methionine 84%	%	0.27	0.19	0.15	0.11	0.10	0.09
L-Threonine 98.5%	%	0.20	0.14	0.11	0.07	0.07	0.05
Phytase	‰	0.01	0.01	0.01	0.01	0.01	0.01
Nutritional composition[2]		In	GI	GII	GIII	TI	TII
Energy net	Kcal	2563	2549	2553	2560	2563	2546
Crude protein	%	19.25	18.79	18.84	18.85	17.41	17.04
Minerals	%	5.31	4.96	4.95	4.90	4.92	5.03
Ether extract	%	8.25	7.57	7.70	7.84	7.37	7.09
Gross fiber	%	1.99	2.00	2.01	2.02	1.92	1.90
Calcium	%	0.71	0.73	0.76	0.73	0.70	0.73
Phosphorus total	%	0.74	0.72	0.71	0.75	0.68	0.72
Lysine digestive	%	1.16	1.05	1.01	0.96	0.86	0.83
Methionine digestive	%	0.46	0.40	0.37	0.34	0.32	0.30
Cysteine digestive	%	0.47	0.41	0.38	0.35	0.32	0.30
Tryptophan digestive	%	0.19	0.18	0.19	0.19	0.17	0.17
Threonine digestive	%	0.78	0.71	0.68	0.65	0.60	0.57
Phenylalanine digestive	%	0.80	0.79	0.80	0.81	0.75	0.73
Tyrosine digestive	%	0.59	0.59	0.60	0.60	0.56	0.55
Leucine digestive	%	1.20	1.20	1.21	1.21	1.20	1.19
Isoleucine digestive	%	0.66	0.65	0.66	0.66	0.62	0.60
Valine digestive	%	0.76	0.75	0.75	0.76	0.71	0.69
Histidine digestive	%	0.45	0.44	0.45	0.45	0.41	0.40
Arginine digestive	%	1.12	1.10	1.11	1.13	1.00	0.97

In - Initial Diet; GI, GII and GIII - Growth Diets; TI and TII - Finishing Diets; [1]Mineral and vitamin supplement per kilogram of product– In Vitamin (Vit.) A 666,667.00IU; Vit. D3 133,350.00IU; Vit. E 3,335.00IU; Vit. K3 200.00mg; Vit. B1 200.00mg; Vit. B2 400.00mg; Vit. B6 265.00mg; Vit. B12 2,000μg; Folacin 70mg; Pantothenic acid 1,335.00mg; Biotin 10.00mg; Choline 100,000mg; Niacin 2,350.00mg; Ca 7.425%; P available (Pavail.) 4.25%; Cu 8,000mg; Fe 5,000mg; Zn 4,000mg; Mn 2,500mg; I 50mg; Se 15mg; Cl 4%; S 0.414%. GI Vit. A 700,000IU; Vit. D3 150,000IU; Vit. E 2,000IU; Vit. K3 200mg; Vit. B1 100mg; Vit. B2 400mg; Vit. B6 200mg; Vit. B12 1,000μg; Folacin 60mg; Pantothenic acid 1,500mg; Biotin 10mg; Choline 140,000mg; Niacin 2,000mg; Ca 9.533%; Pavail. 8%; Cu 10,666mg; Fe 6,666mg; Zn 5,333mg; Mn 3,333mg; I 66.7mg; Se 20mg; Cl 5.9%; S 0.55%. GII Vit. A 700,000IU; Vit. D3 150,000IU; Vit. E 2,000IU; Vit. K3 200mg; Vit. B1 100mg; Vit. B2 400mg; Vit. B6 200mg; Vit. B12 1,000μg; Folacin 60mg; Pantothenic acid 1,500mg; Biotin 10mg; Choline 140,000mg; Niacin 2,000mg; Ca 13.6%; Pavail. 8.2%; Cu 10,666mg; Fe 6,666mg; Zn 5,333mg; Mn 3,333mg; I 66.7mg; Se 20mg; Cl 4.1%; S 0.75%. GIII Vit. A 700,000IU; Vit. D3 150,000IU; Vit. E 2,000IU; Vit. K3 200mg; Vit. B1 100mg; Vit. B2 400mg; Vit. B6 200mg; Vit. B12 1,000μg; Folacin 60mg; Pantothenic acid 1,500mg; Biotin 10mg; Choline 140,000mg; Niacin 2,000mg; Ca 13.84%; Pavail. 11.65%; Cu 12,800mg; Fe 10,000mg; Zn 8,000mg; Mn 5,000mg; I 100mg; Se 30mg; Cl 4%; S 0.66%. TI Vit. A 336,000IU; Vit. D3 72,000IU; Vit. E 960IU; Vit. K3 80mg; Vit. B1 48mg; Vit. B2 192mg; Vit. B6 96mg; Vit. B12 720μg; Folacin 29mg; Pantothenic acid 720mg; Biotin 5mg; Choline 96,000mg; Niacin 960mg; Ca 8.8%; Pavail. 7.92%; Cu 12,800mg; Fe 8,000mg; Zn 6,400mg; Mn 4,000mg; I 80mg; Se 24mg; Cl 2.6%; S 0.66%. TII Vit. A 280,000IU; Vit. D3 60,000IU; Vit. E 800IU; Vit. K3 65mg; Vit. B1 40mg; Vit. B2 160mg; Vit. B6 80mg; Vit. B12 600μg; Folacin 25mg; Pantothenic acid 600mg; Biotin 4mg; Choline 80,000mg; Niacin 800mg; Ca 10.5%; Pavail. 8.30%; Cu 10,666mg; Fe 6,666mg; Zn 5,333mg; Mn 3,333mg; I 66.7mg; Se 20mg; Cl 5.9%; S 0.55%; [2]Calculated based on fresh matter by InraPorc®.

Table 2 - Variables collected and animal performance modeled for production scenarios.

Phase	Farm	------------------------ Collected Data ------------------------			-------------------------- Modeled data --------------------------		
		Age, days	Total Consumption, kg	Weight, kg	Average consumption, kg·dia^{-1}	Gain Medium, kg·dia^{-1}	Feed Conversion[1]
Initial	SAP	64	18.00	22.00	1.36	0.70	1.97
	PS1	72	20.10	23.74	1.38	0.83	1.68
	PS2	64	20.76	21.64	1.37	0.76	1.83
	PS3	58	20.90	19.64	1.21	0.66	1.86
	PS4	70	19.14	22.06	1.49	0.80	1.90
	PS5	71	20.30	23.05	1.66	0.87	1.95
	PS6	55	21.70	22.51	1.59	0.90	1.80
Growth I	SAP	77	40.00	32.00	1.64	0.84	1.98
	PS1	87	40.08	36.25	1.76	1.02	1.76
	PS2	80	41.89	32.89	1.84	0.97	1.93
	PS3	74	42.03	31.17	1.65	0.87	1.94
	PS4	84	40.20	32.42	1.88	0.97	1.98
	PS5	84	40.20	34.17	1.99	1.01	2.01
	PS6	68	38.62	35.41	1.95	1.08	1.84
Growth II	SAP	101	30.00	52.00	1.90	0.96	2.02
	PS1	110	29.13	59.36	2.09	1.13	1.88
	PS2	102	21.02	54.39	2.22	1.11	2.03
	PS3	100	28.03	53.67	2.07	1.03	2.04
	PS4	105	27.18	52.68	2.20	1.07	2.09
	PS5	104	30.15	54.47	2.27	1.09	2.13
	PS6	88	32.98	56.91	2.26	1.19	1.94
Growth III	SAP	117	20.00	67.00	2.06	1.01	2.08
	PS1	123	25.08	73.92	2.28	1.17	2.00
	PS2	111	28.07	64.48	2.46	1.19	2.12
	PS3	113	21.17	66.76	2.31	1.11	2.12
	PS4	116	20.24	64.75	2.37	1.11	2.18
	PS5	117	20.10	67.90	2.42	1.11	2.23
	PS6	102	19.32	73.06	2.45	1.22	2.04
Termination I	SAP	126	40.00	76.00	2.21	1.04	2.17
	PS1	133	40.03	85.62	2.49	1.18	2.16
	PS2	122	42.14	77.62	2.77	1.26	2.25
	PS3	122	42.33	76.51	2.58	1.18	2.22
	PS4	124	40.47	73.41	2.57	1.13	2.33
	PS5	124	40.35	76.32	2.56	1.10	2.37
	PS6	110	36.06	82.60	2.61	1.23	2.17
Termination II	SAP	143	60.00	94.00	2.45	1.04	2.40
	PS1	148	48.44	103.65	2.75	1.15	2.44
	PS2	136	60.88	95.29	3.19	1.31	2.49
	PS3	138	57.39	95.22	2.98	1.26	2.42
	PS4	139	64.16	91.13	2.90	1.11	2.66
	PS5	138	83.60	91.77	2.85	1.03	2.83
	PS6	123	51.06	98.41	2.85	1.19	2.44
Total/Average	SAP	168	208.00	120.00	1.97	0.94	2.13
	PS1	166	202.84	125.44	2.11	1.07	1.99
	PS2	156	214.76	121.42	2.31	1.09	2.12
	PS3	157	211.84	119.74	2.11	1.01	2.10
	PS4	162	211.38	116.13	2.28	1.03	2.23
	PS5	169	234.71	123.71	2.37	1.03	2.35
	PS6	141	199.75	120.63	2.29	1.13	2.05

SAP–Standard Profile Animal; PS - Production Scenario; [1]included 2% loss of diets.

(3PS) and the maximum was 23.74kg (1PS), with a variation of 2.05kg. Variations in age and weight at the beginning of the growing and finishing phases are determined by several factors such as weaning weight and nutrition program (MAHAN & LEPINE, 1991). These factors are difficult to control (TOKACH et al., 2007) and are accepted as a natural component of the process or disregarded due to their complexity.

At the end of the period of 94±7 days, the animals were slaughtered with an average weight of 121.18±7kg and age of 159±10 days old. Average slaughter weight of the scenarios was higher by only 1.18kg and age was lower by 9 days compared to the SAP. The small variation in age and uniformity in weight is explained by the need for homogeneous carcasses. The variations between the scenarios were caused by intrinsic factors of production and/or goals and deadlines set by the industry.

The average performance of the scenarios for daily consumption was higher by 0.27±0.13kg vs. the SAP; the minimum consumption was 2.11kg (1PS) and the maximum was 2.37kg (5PS). The scenarios presented a daily weight gain of 1.06±0.05kg or 0.12kg greater than the SAP. The lowest weight housing in PS resulted in the minimum daily gain of 1.01kg (3PS), while 6PS generated 0.19kg as the maximum gain, exceeding the standard. Feed conversion was irregular between scenarios and throughout the stages, but the final average of 2.14±0.13 was equivalent to the standard.

The data collected in different scenarios show the growth behavior of the animals. This is a complex biological process, which involves an increase in the shape and composition of body mass over time. Mathematical modeling allows for the simulation of real systems to predict animal performance behavior and their nutritional requirements in different production scenarios (LOVATTO & SAUVANT, 2001). Therefore, data from the diets and food programs and the animal profile were used as a basis for modeling simulations (VAN MILGEN et al., 2008).

Overall, the diet program and feeding program developed for the SAP supplied the lysine requirements in all phases. The requirement of daily digestible lysine estimated by InraPorc® for the SAP was of 15.95±2.69g and the amount provided was 18.61±1.70g (Figure 1). In this way, throughout the total period, an excess of 278.85g per animal was expected, understood as a safety margin to adjust for the diversity of scenarios. This procedure is a common practice in conventional nutritional programs, according to the ARC (1981), NRC (1998) and ROSTAGNO et al. (2011), and is justified only by the impossibility of determining the requirements of the scenarios.

In general, there was excess lysine in all scenarios, and the animals got on average 17.6% more lysine than required. When comparing the average daily requirements for lysine, it was found that the scenarios had requirements1.60g higher than that of the SAP, but ingested 2.67g more than expected. The InraPorc® software modeled the requirements and the supply of lysine of each scenario; therefore, it was possible to identify excesses in the phases and in the total period. With nutritional specificities, it is possible to suit the nutritional levels and set diet programs to reduce costs and nutrient excretion without affecting the maximum performance.

The inflection point was 18.51g and occurred at 152 days or 103.32kg of weight. The average of the scenarios resulted in demand for 20.40g lysine at 138 days or 97.65kg of weight. The inflection point indicates the age of the maximum lysine requirement for protein deposition (VAN MILGEN, 2008). The average of the scenarios shows that the animals had an early inflection point at 14±16 days and at a 5.67kg lower weight, but the maximum lysine requirement was superior to the standard by 1.89g. Among the scenarios, the greate stage difference for the inflection point was 42 days between 3PS (157 days) and 6PS (115 days). The biggest difference in weight for the maximum requirement of lysine was 42.7kg, found between 2PS and 5PS. These scenarios also showed the greatest difference between the maximum lysine required, with a difference of 3.6g.

Animals nutritional requirements are influenced by factors intrinsic to the animal, food, environment, and their interactions (NOBLET & QUINIOU, 1999), so the requirements should not be taken as fixed values (FULLER, 2004). Based on the data collected in each PS, associated with pig nutrition concepts used by InraPorc®, it was possible to study the heterogeneity between animal performance and specific nutritional requirements. Differences in nutritional requirements are verifiable, but the adjustment of diet programs and food programs to various production scenarios requires further investigation.

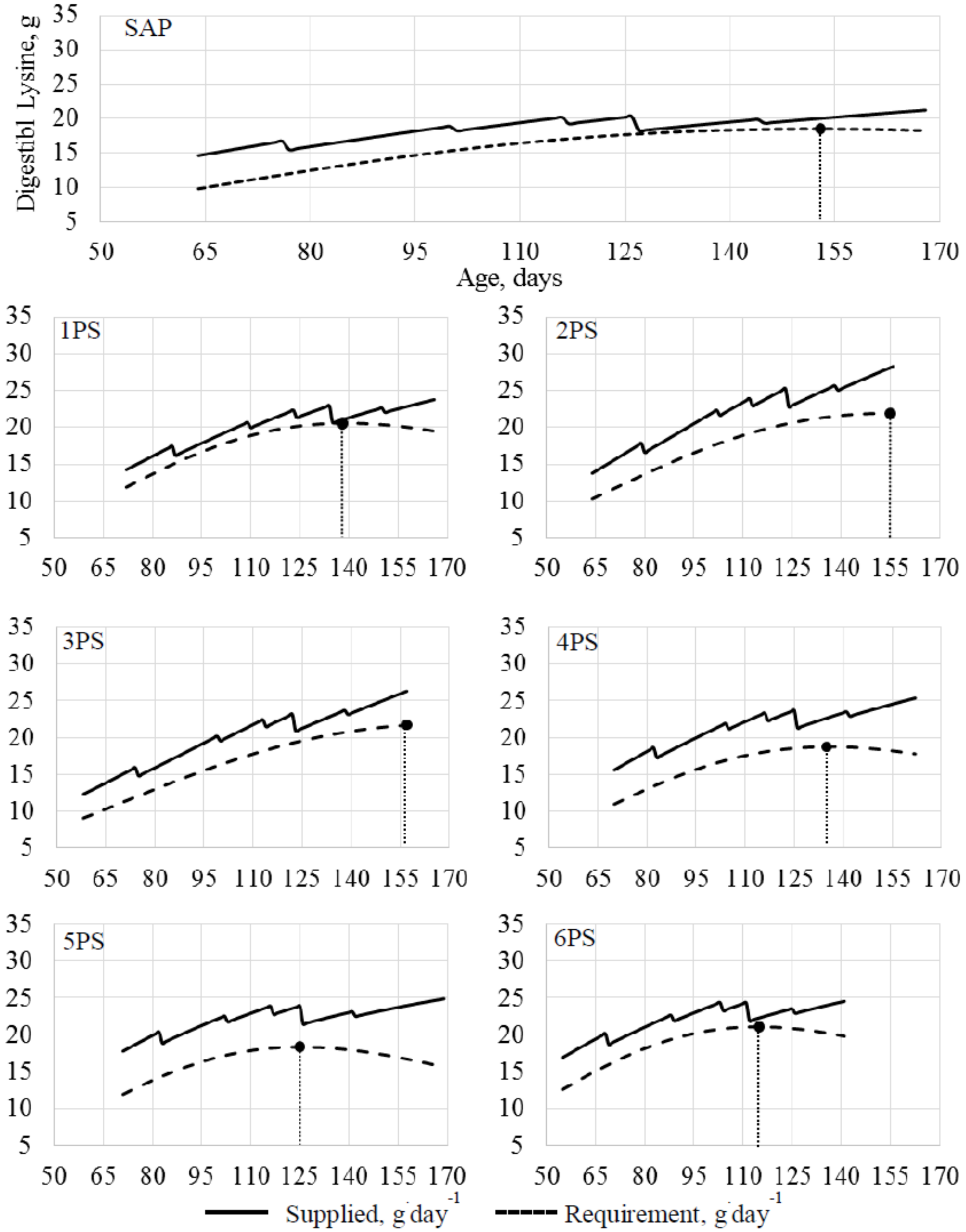

Figure 1 - Daily supplied levels and digestible lysine requirements and turning points for the Standard Animal Profile (SAP) and Production Scenarios (PS).

CONCLUSION

The production scenarios studied differed for performance, supply and nutrient requirements for pigs in the growing and finishing phases. Modeling is a tool that can be used to describe and compare the characteristics of each production scenario.

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