GUSTAVO FREIRE RESENDE LIMA

EFFECT OF FEEDING CURVES IN PERFORMANCE AND CARCASS CHARACTERISTICS OF SWINE

Dissertation submitted to the Animal Science Graduate Program of the Universidade Federal de Viçosa, as partial fulfillment of the requirements for the degree of *Magister Scientiae*.

VIÇOSA
MINAS GERAIS - BRASIL
2018

Ficha catalográfica preparada pela Biblioteca Central da Universidade Federal de Viçosa - Câmpus Viçosa

T

Lima, Gustavo Freire Resende, 1984-

L732e Effect of feeding curves in performance and carcass
2018 characteristics of swine / Gustavo Freire Resende Lima. – Viçosa, MG, 2018.

viii, 31 f. : il. ; 29 cm.

Texto em inglês.

Orientador: Melissa Izabel Hannas.

Dissertação (mestrado) - Universidade Federal de Viçosa.

Referências bibliográficas: f. 14 -16.

1. Suínos - Alimentação e rações. 2. Suínos - Crescimento. 3. Suínos - Carcaças. 4. Suínos - Registros de desempenho. I. Universidade Federal de Viçosa. Departamento de Zootecnia. Programa de Pós-Graduação em Zootecnia. II. Título.

CDD 22. ed. 636.4085

GUSTAVO FREIRE RESENDE LIMA

EFFECT OF FEEDING CURVES IN PERFORMANCE AND CARCASS CHARACTERISTICS OF SWINE

Dissertation submitted to the Animal Science Graduate Program of the Universidade Federal de Viçosa, as partial fulfillment of the requirements for the degree of *Magister Scientiae*.

APPROVED: November 30th, 2018.

Francisco Carlos de Oliveira Silva

Fabyano Fonseca e Silva

Melissa Izabel Hannas
(Adviser)

À minha esposa e filho Gisele e Heitor,

Cidália Freire de Carvalho "*In Memoriam*" e a José

Augusto de Freitas Lima que sempre me apoiaram,

DEDICO

ACKNOWLEDGEMENTS

The present work was funded by The Genetic Company Agroceres PIC, Rio Claro – SP, Brazil.

I would like to acknowledge The Cooperative Frísia for providing the animals, building, feed and technical support for this research as well as The Swine Production Coordinator Dr. Ricardo Josue Cogo, The Swine Production Technician Vanderson Nogueira and the producer Renan Habbers for providing staff support.

I would like to thank Dr. Melissa Izabel Hannas and Dr. Fabyano Fonseca e Silva for the guidance and technical support. Furthermore, I would like to recognize and thank The Graduate Students Jéssica S. Soares, from University of Uberlândia-MG, Rodrigo de Lima, from University of Lavras-MG and Rosiel M. Cavalcante Filho, from University of Goiás-GO, for all the hard work and technical support as well.

Finally, I would like to recognize and show my love and respect for Heitor and Gisele, son and wife that, through the unconditional love, supported me during this lack of time to be father and husband. Always, I must show my gratefulness to Glícia and Cidália, "*In Memoriam*" (Mother and Grandma) for give the example of straight conduct, as well to my uncle José Augusto de Freitas Lima (retired professor at University of Lavras-MG) for the professional influence and to show the right path to be a great Animal Scientist.

SUMMARY

ABSTRACT

LIMA, Gustavo Freire Resende, M.Sc., Universidade Federal de Viçosa, November, 2018. **Effect of feeding curves in performance and carcass characteristics of swine.** Adviser: Melissa Izabel Hannas.

This study aimed to evaluate the effect of feeding curves on the performance and carcass characteristics on grow to finish pigs. One thousand two hundred crossbred barrows weighing 25.32 ± 0.7Kg with 68 to 69 days of age, were randomly allotted to 1 of 4 weekly feeding curves throughout the growing period. The control feeding curve was calculated to meet or exceed the requirements for PIC's genotype following an estimated daily growth curve (PIC 2016) for a cumulative average daily gain of 0.965Kg/day. The treatment control -5% was the amount of feed from the control feeding curve (control curve), minus 5% throughout the 96 days on feed. The treatment control +5% was the amount of feed from the control feeding curve (control curve), plus 5% throughout the 96 days on feed, and then the treatment *Ad libitum* access where the feeder coverage was managed at 30%. On the cumulative average daily gain, the control -5% fed pigs and the *Ad Libitum* fed pigs were the slowest and the fastest pigs all the grow to finish pigs respectively ($p<.05$). At day on feed 96 the *Ad Libitum* fed pigs grew 8.69% faster than control, followed by 2.2% faster growth than control by curve control +5%, but feeding curve control -5% pigs grew 3.96% slower that control ($p<.05$). Differences were found in feed conversion that the control -5% had the best feed conversion rate, -1.55% less than control, followed by control +5% and *Ad Libitum* access, +2.54% and +7.65% then control respectively. The *Ad Libitum* access had the heaviest hot carcass weight followed by control +5%, control and control -5% feeding curves ($p<.05$). There was a tendency ($p<.10$) that the *Ad libitum* access had a deeper loin than control +5% and there was a difference in loin depth between control -5% and control ($p<.05$). The control -5% had backfat thickness lower than control, control +5% and *Ad Libitum* access ($p<.05$). *Ad libitum* access feeding curve had thickest backfat among those feeding curves but control and control +5% did not show any difference ($p>.05$). For lean content, the *Ad Libitum* access feeding curve had the lowest (worst) lean content ($p<.05$) but there no differences between control -5%, control and control +5%. The control -5% produced the most efficient pig in feed conversion but the slowest in growth, lowest in backfat thickness and loin depth. Control feeding strategies alter the performance and carcass characteristics of grow to finish pigs. It can be an effective feeding practice, once the nutrients intake

requirements are met, to improve feed conversion rate and it can be a tool to manage growth rate.

RESUMO

LIMA, Gustavo Freire Resende, M.Sc., Universidade Federal de Viçosa, novembro de 2018. **Efeito de curvas de arraçoamento sobre o desempenho e características de carcaça de suínos.** Orientador: Melissa Izabel Hannas.

Objetivou-se avaliar o efeito de curvas de alimentação no desempenho e características de carcaça de suínos em crescimento e terminação. Mil e duzentos suínos híbridos castrados com peso de 25,32 ± 0,7Kg entre 68 e 69 dias de idade foram alocados em 1 de 4 curvas de arraçoamento semanais durante os períodos de crescimento e terminação em blocos casualizados. A curva de arraçoamento controle foi calculada para atender ou exceder as exigências nutricionais de genótipos PIC (PIC 2016) seguindo uma curva de crescimento estimada para o ganho de peso diário acumulado na fase de 0,965Kg/dia. O tratamento controle -5% foi a quantidade de ração arraçoada na curva de arraçoamento controle (curva controle), menos 5% por 96 dias de fase. O tratamento controle +5% foi a quantidade de ração arraçoada na curva de arraçoamento controle mais 5% na fase e o tratamento acesso *Ad Libitum* foi gerenciamento do comedouro com cobertura de ração a 30%. O ganho de peso diário acumulado da curva controle -5% e do acesso *Ad Libitum* foram as piores e melhores respectivamente ($p<,05$). Além disso os suínos em acesso *Ad Libitum* cresceram 8,69% a mais que o controle, seguidos de 2,2%, e os suínos do tratamento controle -5% foram 3,96% mais lentos que a controle ($p<,05$). Houve diferenças em conversão alimentar onde a curva de arraçoamento controle -5% foi 1,55% melhor que controle, seguidas de 2,54% e 7,65% piores que controle das curvas controle -5% e acesso *Ad Libitum*, respectivamente. Suínos que tiveram acesso *Ad Libitum* à ração tiveram carcaças mais pesadas seguidas dos tratamentos controle +5, controle e controle -5% ($p<,05$). Houve uma tendência ($p<,10$) dos suínos em acesso *Ad Libitum* apresentarem maior profundidade de lombo que controle +5% e houve diferenças significativas entre controle -5% e controle ($p<,05$). O tratamento controle -5% apresentou uma menor espessura de toucinho que o controle, controle -5% e acesso Ad Libitum ($p<,05$). Além disso, o acesso Ad libitum produziu suínos com maior espessura de toucinho que todas as curvas de arraçoamento ($p<,05$) e não houve diferença entre as curvas controle e controle +5%. Em teor de carne magra, suínos da curva de arraçoamento Ad Libitum apresentaram o pior teor de carne magra ($p<,05$) porém não

houve diferença entre os tratamentos controle -5%, controle e controle +5% quando ao teor de carne magra (p>,05). O tratamento controle -5% produziu os suínos mais eficientes, porém com um crescimento mais lento, baixa espessura de toucinho e profundidade de lombo. Estes efeitos devem ser levados em consideração quando da escolha da estratégia de arraçoamento correta na análise econômica total da produção de suínos. Estratégias de arraçoamento alteram o desempenho e as características de carcaça de suínos em crescimento e terminação. Esta pode ser efetiva, se os consumos de nutrientes forem atendidos, para a melhoria de conversão alimentar e no gerenciamento da taxa de crescimento.

INTRODUCTION

The integrated swine production system, where the packing plant has its own production flow through contracted sow units, nurseries and growers, represents over 1,000,000 sows on the Brazilian herd (Agroceres PIC, 2017). On this type of production, a three sites production, feeding costs represents 52% of the total cost per kg of a live pig followed by 39% of a feeder pig and 16% of building cost (Embrapa Aves e Suínos, 2014).

Therefore, there is a production focus of minimizing the feeding cost, besides the ratio cost itself, due controlling the amount of feeding fed for each pig within a pen. Those feeding strategies aims a better control of the production cost mainly because it can optimize the average daily again according with a stocking cost a day. Cost of feeder pig and if the production is based, either on fixed time (lack of grow to finish space), nor fixed weight (varying the days on feed to achieve a target slaughter weight).

Strategies of controlled feeding for pigs applying treatments with 15% of the Ad Libitum feed intake throughout the grow to finish period (100 days), or 30% of the Ad Libitum feed intake three days a week for the same amount of days on feed has showed to be significant to reduce feed intake as well as weight gain mainly after the eighth week of the grow to finish period (Hyun, Ellis, & McCkeith, 1997).

Pigs fed varying 1,935 to 2,651 Kcal/kg of net energy with initial weight of 35Kg showed a quadratic response of average daily gain and a linear response of feed intake. Those responses showed that there was an improvement in feed efficiency due an energy intake within a certain range in pigs, between 35 to 107Kg, of live weight (Quiniou & Noblet, 1997).

Moreover, in adjustments of feed intake on growing beef cattle for a given average daily gain on a mid-live weight. Koch et al., 1963 has found that animals on constant average daily gain and mid live weight had lower or higher feed intakes showing differences on feed efficiency between them. The difference between an observed feed intake and a predicted feed intake, as function of the requirements for gain and maintenance, is so called "Residual Feed Intake".

In a research with selected genetics lines for low and high residual feed intake, Boddicker et al., 2011 worked with 40 surgically castrated pigs of each genetic line distributing in treatments Ad Libitum, 75% of Ad Libitum or 55% of Ad Libitum intake. The results showed that pigs selected for low residual feed intake had lower feed intake for the same average daily gain in Ad Lib access to feed, but, with a restriction on feed intake, there were no differences on feed intake and weight gain between these genetic lines.

The present work aimed to evaluate growth curves, grow to finish performance and carcass characteristics of different feeding strategies focusing in neither weight gain nor feed conversion rate.

MATERIAL AND METHODS

Animals and housing

The experimental protocol has followed the ethical principles in animal research (CONCEA, 2016) and was approved by the Ethical Committee on Animal Use of Universidade Federal de Viçosa (UFV) [protocol no. 021/2017]. This dissertation was written following The Journal of Animal Science format.

One thousand two hundred crossbred barrows (AGPIC 337 x Camborough® - Agroceres PIC, Rio Claro-SP, Brazil-) weighing 25.32 ± 0.7Kg with 68 to 69 days of age, were randomly allotted to 3x10m concrete-floored pens at a commercial facility of The Cooperative Frísia (Carambeí-PR, Brazil) in two days using a randomized block design. Each pen housed 30 pigs (1m²/pig) and had a 10m long trough type feeder sideways in the pen (0.33m/pig) and three hanging nipple type drinkers (10 pigs/drinker). Pigs were fed four times a day (8:00, 11:00, 14:00 and 17:00) and had free access to water throughout a 96-day feeding trial.

Experimental design and diets

Pens were randomly assigned in two days to 1 of 4 weekly feeding curves. A pen with 30 pigs was considered as the experimental unit and there were 10 replicates per treatment using a randomized block design. Five diets were formulated to meet or exceed the nutritional requirements of 23 to 125Kg for barrows (NRC, 2012) throughout the grow to finish period as a five diets phase feeding program (Table 1) with no use of ractopamine.

The control feeding curve was calculated to meet or exceed the requirements for PIC's genotype following an estimated daily growth curve (PIC 2016) for a cumulative average daily gain of 0.965Kg/day on a 105-day period named treatment control. The treatment control -5% was the amount of feed from the control feeding curve (control curve), minus 5% throughout the 96 days on feed. The treatment control +5% was the amount of feed from the control feeding curve (control curve), plus 5% throughout the 96 days on feed, and then the treatment *Ad libitum* access where the feeder coverage was managed at 30%, as described in Table 2.

Performance and carcass characteristics assessments

Throughout the trial, the pens were fed considering the amount of feed budgeted per pig within a pen and being adjusted by every dead or removed pig following Table 2 resulting in an energy intake (Kcal/day) and a digestible lysine intake (g/day) as shown on Tables 3 and 4. The feed was weighed four times a day and the amount of feed fed per pen was distributed sideways on the trough giving the same condition for every pig eating side by side to each other.

The pens of pigs were weighed as a group every 21 days on feed in two days following the block design, in total experimental period of 105 days. Half of the barn stocked on day one and the other half stocked on day two were weighed in the morning, and then, pens were fed afterwards following the four times feeding process. The weighing process followed the same pen number order through every weighing day.

For the first weighing, pigs were first randomly assigned into the pens and then a two-day resting period was given for each block, 20 pens in each day. On this resting period, all pigs were fed the control feeding curve. By this, the first phase on the trial had 19 days instead a 21 days period.

For the calculated performance, the total feed fed, and the weight produced within a period were considered. For live weight produced, a death or removal was not considered as a weight produced and the amount of feed given per pen was adjusted for remain pigs. By doing this, a dead or removed pig impacted the period and overall performance of a given experimental unit.

Thus, the performance traits measured were feed intake (FI), weight gain (WG), average daily feed intake (ADFI), average daily gain (ADG) and feed conversion rate (FCR) by phase and accumulated.

On the last weighing, pigs were fed with no fasting period as the previous weighing and were sent to slaughter two days after the end of the trial following the fasting procedure 6 hours at the barn, during those days after weighing, all pens were fed with a respective feeding program/treatment.

The carcass traits measured were hot carcass weight, backfat thickness, loin depth, lean percentage, using a UltraFom 300, Caromatec Food Technology, carcass grading and carcass weight variation as a within pen variation coefficient. The measurements were taken on individual carcass as a normal grading process at Alegra Foods Packing Plant, Castro-PR, Brazil. All the carcasses were individually identified with the original pen number and then the grading information was average by the respective pen, then the experimental unit for carcass traits was still a pen of pigs.

Data analysis

Data were analyzed as repeated measures block design using The Mixed procedure of SAS (SAS Inst., Inc., Cary, NC) where the feeding curve and the weighing age was used as a fixed effect and the stocking day, day one or two, were used as a random effect for live weight. For performance data as ADFI, ADG and FCR, feeding phase were used as a fixed effect as well as the days on feed, day one or two, were used as a random effect.

An unstructured variance-covariance matrix was used to account for the correlated residuals within and between phase using the REPEATED statement where the same pen nested within block throughout phase was considered in the matrix. Means within and between phase were compared using Tukey-Kramer test.

A pen of 30 pigs was used as experimental unit for all parameters analyzed and, for all statistical procedures, probability values lower than 0.05 were considered statistically different and probability values lower than 0.10 were considered as a trend.

The estimated values of live weight and energy feed intake for each feeding curve was fitted as a nonlinear model and compared to each other by the respective confidence interval where estimates within a 95% confidence interval were considered not significant and the chosen criteria for the best fitted function was based on the lowest overall residual standard error of the model as well as the coefficient of determination using The Non-Linear procedure of SAS (SAS Inst., Inc., Cary, NC).

To fit the best fit curve, The Logistic function (Robertson, 1908), Gompertz function (Gompertz, 1825), von Bertalanffy function (Bertalanffy, 1957), Brody function (Brody, 1945), Richards function (Richards, 1959) and Michaelis-Menten (Michaelis e Menten, 1913) was fitted as shown in table 5.

RESULTS

Grow to finish performance

The Logistic, Gompertz and von Bertalanffy models were the only functions that were compared because their convergence criterion were met. The Gompertz growth curve was chosen as the best fit non-linear model for modeling the growth of the different feeding curves due the smallest residual standard deviation as there were similarities on the coefficient of determination of all models.

The residual standard deviation of the control feeding curve was the highest followed by the *Ad libitum* access curve, control -5% and control +5% showing that there was a difference on variability explained between subjects of the different treatments.

The standard error of the parameter means with biological sense a, the asymptotic weight, or weight at maturity were lower for the control +5% feeding curve, followed by *Ad libitum* access, control -5% and control feeding curves.

There were no differences ($P>0.05$) on the estimated weight at maturity (parameter a) between control, control +5 and *Ad Libitum* access feeding curves studied but a difference ($P<0.05$) was found between control and control -5% feeding curve.

Furthermore, there were differences ($P<0.05$) on the estimated parameter c (maturity rate) where *Ad Libitum* feeding curve showed higher maturity rate than control +5, followed by the control curve but no difference ($P>0.05$) was observed between control and control -5% as shown in table 6 and figure 1.

A linear model approach was fitted, and it is described in table 7, with the live weight in each grow to finish phase considered as a repeated measure, after nineteen days on feed, the live weight of control -5% fed pigs was lighter than those other pigs from control, control +5 and *Ad Libitum* access feeding curves. Moreover, Ad libitum access fed pigs was higher ($P<0.05$) than the other three curves.

The control -5% fed pigs were the lightest finished ($P<0.05$), the control and control +5% feeding curve pigs were not different to each other on live weight finished ($P>0.05$) and the *Ad Libitum* fed pigs were the heaviest pigs finished ($P<0.05$).

On the cumulative average daily gain, the control -5% fed pigs and the *Ad Libitum* fed pigs were the slowest and the fastest pigs all the grow to finish pigs respectively ($P<0.05$). Moreover, from phase 1 at 19 days on feed, all the feeding curves started to differentiate themselves. At day on feed 96 the *Ad Libitum* fed pigs grew 9,52% faster than control, followed by 1.90% faster growth than control by curve control +5%.

However, feeding curve control -5% pigs grew 3.81% slower that control ($P<0.05$) as shown in table 8.

On the cumulative feed intake, that has been controlled, there were differences throughout the grow to finish where the *Ad Libitum* fed pigs consumed 18%% more feed on the entire period than control, followed by control +5% and control -5% that consumed +4.79% and -4,97% feed than control respectively (table 9). That resulted in 2.102, 2.212, 2.318 and 2.610 kilograms of feed consumed daily of feeding curve control -5%, control, control +5% and *Ad Libitum*, respectively, as shown in table 10.

Thereby, the feeding curves had a metabolizable energy intake of 8906, 9396, 9837 and 10742 kcal per day for the control -5%, control, control +5% and *Ad Libitum* feeding curve respectively as described in table 11. However, when modeling the energy intake as a function of the live weight by the von Bertalanffy function, the best fit model, there were no differences between control and control -5%, control -5% and *Ad Libitum* access in energy intake at maturity, but differences were found between control, control +5 and *Ad Libitum* access (table 12 and figure 2). Moreover, there were no differences between energy intake relative to live weight maturity rate.

In a comparison between lysine consumption por kilogram of gain, the control -5% had lower lysine consumed por kilogram of gain in all phase ($P<0.05$) except on phase 4 and 5 ($P>0.05$). The *Ad Libitum* access feeding curve had the higher lysine consumption per kilogram of gain in all phase except to phase 3 and 5 ($P>0.05$) as shown in table 13.

Differences were found in feed conversion that the control -5% had the best feed conversion rate ($P<0.05$), -1.55% less than control, followed by control +5% and *Ad Libitum* access, +2.54% and +7.65% then control respectively ($P<0.05$), as described in table 14.

At phase 1, 19 days on feed, the average daily gain from control -5 and control were different from control +5 that differed from *Ad Libitum* access ($P<0.05$). At phase 2, between day on feed 19 and day 40, there were no differences observed between control and control +5% ($P>0.05$) but differences were found between control -5%, control and *Ad Libitum* access ($P<0.05$). At phase 3, between 40 to 61 days on feed, there were differences of *Ad Libitum* access, control +5 and control ($P<0.05$), however with no differences between control and control -5% ($P>0.05$). At phase 4, between 61 to 82 days on feed, there were no differences between the treatments ($P>0.05$) and then, difference between control +5 and control -5% was found ($P<0.05$) and, besides *Ad Libitum* access had better daily gain at phase 5.

As it was design for, the phase daily feed intake throughout the growing period were different on those feeding curves. The average differences between control, control -5% and control +5% were 5% between each feeding curve indeed ($P<0.05$). In comparison between the *Ad Libitum* access feeding curve and control, at phase 1 the daily feed intake was 18% higher ($P<0.05$), at phase 2 this difference was 16% ($P<0.05$), at phase 3 was 20% ($P<0.05$), followed by 16% and 14% at phase 4 and 5 respectively ($P<0.05$) as shown in table 16.

At phase 1, the feed conversion rate was the lowest for control -5% and next to lowest for control ($P<0.05$). However, the control +5% and *Ad Libitum* access feeding did not show any difference ($P>0.05$). At phase 2, the same pattern was observed but at phase 3 only control -5% had lower values comparing to others feeding curves ($P<0.05$). Furthermore, at phase 4, there was no differences between control -5% and control, but differences were found between control +5 and *Ad Libitum* access feeding curve ($P<0.05$). Lastly, there were no differences ($P>0.05$) on feed conversion for the all treatments at the growing phase 5.

Carcass characteristics

Carcass characteristics traits was described as hot carcass weight, backfat thickness, loin depth, percentage of lean content and carcass weight variability as the coefficient of variation within subject (Table 18).

The *Ad Libitum* access had the heaviest hot carcass weight followed by control +5%, control and control -5% feeding curves ($P<0.05$). There was a tendency ($P<.10$) that the *Ad libitum* access had a deeper loin than control +5% and there was a difference in loin depth between control -5% and control ($P<0.05$).

The control -5% had backfat thickness lower than control, control +5% and *Ad Libitum* access ($P<0.05$). Moreover, *Ad libitum* access feeding curve had thickest backfat among those feeding curves but control and control +5% did show any difference ($P>0.05$). For lean content, the *Ad Libitum* access feeding curve had the lowest (worst) lean content ($P<0.05$) but it did not differ between control -5%, control and control +5%.

Further, the hot carcass variability, measured as a within subject (pen) coefficient of variation, showed at the lowest level at control feeding curve ($P<0.05$) but not different than control -5 ($P>0.05$). Nevertheless, there were no differences between control -5%, control +5% and *Ad Libitum* access feeding curve.

DISCUSSION

Grow to finish performance

A decrease of 21.36% and 20.99% on growth when 25% of the *Ad Libitum* feed intake was applied on low residual feed intake selected pigs and randomly selected control line, respectively, was reported by Boddicker et al., 2011. Furthermore, Cho et al., 2006 reported 5.38% lighter pigs on a 10-week trial where the feed restriction was applied as a 90% feeding for every two weeks calculated from the *Ad Libitum* feed intake from the previous 2 week feeding period.

The difference in live weight between *Ad libitum access*, control +5% and control feeding curve was 5.6% and 7.11%, respectively, but very different from control -5% feeding curve's results, that restrict 10% of the *Ad Libitum* growth, these results were similar to those from Cho et al., 2006. It might be because of the energy intake level that were -7%, -4%, 0% and +10% for control -5%, control, control +5% and *Ad Libitum* access feeding curves, respectively, when comparing to NRC 2012's energy requirements based on the actual live weight within treatments. The daily lysine consumptions were met for all feeding curves where it goes from 14.8 to 18.3 grams per day on the growing phase, varying from 25 to 135Kg pigs.

The effects of nutrient restriction on performance, apparent total tract digestibility, and an immune biomarker in grow-to-finish pigs was evaluated by Barnett at el., 2016. Pigs were kept at 50% of the *Ad Libitum* intake for one week or 25% for two to eight weeks, being the *Ad Libitum* feeding to meet or exceed NRC (2012) requirements. Overall, average daily gain and feed intake decreased in restriction compared to *Ad Libitum* feeding regimen by 22% and 30%, respectively. This impact on average daily feed intake was greater than on those from restriction feeding applied on this current trial even though the average daily feed intake was very close on both studies. Our results showed a 13.85% difference of average daily gain for control -5% curve and *Ad Libitum* feed intake curve for 24.17% apart in average daily feed intake.

The energy intake requirements based on performance has been described as function of live weight, for energy requirement from maintenance estimations, and a quadratic response/equation estimating the energy requirement for production that, in this case, is based on average daily gain (Rostagno et al., 2017). Pigs from all those 4 treatments were below those energy intake requirements when applied this equation on the actual live and gain weight, being around 10% below the requirement for all those controlled curves and being only 5% for the *Ad Libitum* access feeding curve.

Based on the expected value of energy intake from NRC 2012 metabolizable energy intake model as a function of live weight, the *Ad Libitum* access feeding curve was 2, 5, 11, 12 and 12% over fed at phases 1, 2, 3, 4 and 5 respectively. Moreover, control +5% was under fed at phase 1 and 2, control feeding curve was under fed all phase except phase 5 and control -5% was under fed in energy for all phase. Those patterns of control and control +5% might be due the initial energy restriction that resulted in a limited growth and lower the energy intake requirement in further phases on trial period.

This patterns of lowering the differences between expected values of energy intake and actual energy intake might be due the reduction of live weight because of early phases feed restriction impacting the energy requirement for maintenance resulting in more energy available for production or growth since Lovatto et al., 2006 stated that the basis of compensatory growth is not due an improved efficiency of nutrient utilization.

The standard ileal digestible lysine intake requirements in grams per day also based on performance has been described as function of live weight and a quadratic response/equation estimating the requirements for production (Rostagno et al., 2017). Pigs from all those 4 treatments were above those lysine intake requirements on average of 16% of estimated lysine consumption.

A standardized ileal digestible lysine requirement model to predict the lysine consumptions for high lean pigs being 13, 13.5, 14, 14.5, and 15g/day for 25, 50, 75, 100 and 125Kg pigs, respectively, was predicted by Schinckel et al., 2003. Furthermore, NRC 2012 predicted 14, 15, 16, 17.5 and 18.5g/day at the same live weight range and even thought, those predicted values are below those achieved on this trial.

Following the PIC's standardized ileal digestible lysine requirement model to predict the lysine consumptions, the average digestible lysine intake on average should be 16.82, 19.35, 20.01, 20.12 and 20.36g/day for phase 1, 2, 3 4 and 5, considering a weight gain of 0.83, 0.90, 1.02, 0.98 and 0.91Kg/day, respectively. Also, given a lysine requirement specific for PIC genotype, the current trial treatments insure those predicted daily lysine intakes.

There are linear responses in average daily feed intake and gain to feed ratio (feed efficiency) as the Lys:calorie ratio increases with a tendency to be quadratic for both parameters (De La Llata et al., 2007). Those responses were linear for lysine intake in grams per day as the energy intake remained flat, showing a response to amino acids intake itself with no changings in feed intake.

To model growth in pigs, there are several parameters need, cited as the daily whole-body protein accretion potential, partitioning of energy intake over maintenance between protein and lipid accretion, maintenance requirement for energy and daily feed intake (Schinckel. P. and de Lange, 1996).

Due the lack of those input parameters on this under commercial conditions trial, a modeling of the total energy intake was applied as function of live weight growth throughout the grow-to-finish phase. Those results showed the same energy intake related to body weight to any of those feeding curves applied.

In this current work, the increase on average daily gain in higher feed intake curves might be due an increase of energy intake because, even in the most restricted feeding curve, there were no limitations in lysine intake throughout the growth period. All the feeding curves had over fed lysine/amino acids and a limited metabolizable energy feed intake.

Carcass characteristics

There was no interaction between feeding programs, *Ad Libitum*, 75% of *Ad Libitum*, 55% of *Ad Libitum* and body weight stasis with residual feed intake select genetic line and control genetic line observed by Boddicker et al., 2011. So, they found a treatment effect in backfat depth at day on feed 42 and loin eye area being the restriction feeding lowering those carcass characteristics in both genetic populations.

Moreover, there was a linear response in dressing percentage as a function of energy intake in Mcal of metabolizable energy/day for barrows and an energy intake effect in backfat only when using ractopamine in barrows with no effect in loin eye area (Willian et al., 1994). Furthermore, Cho et al., 2008 did not find any effect of energy intake, 1.8- or 3-times maintenance, in the weight of lean tissue in kg, final body weight and empty body weight but there was a carcass weight, due a better dressing percentage, and there was a heavier fat tissue in pigs fed 3 times maintenance. Yet, Cho et al., 2006 did not find any effect in carcass backfat depth and loin eye area in pigs fed different restriction feeding programs being 10% of restriction for 28 days, 56 days, 84 days or *Ad libitum* programs for growing pigs.

The Pearson correlation coefficients between metabolizable energy intake, heat production, protein deposition, lipid deposition, protein:lipid deposition rate, muscle and viscera as percentage of metabolic weight were 0.95, 0.476, 0.877, -0.5, -0.001 and -0.537, respectively (Noblet et al., 1999). That can explain the lack of effects between energy intake on backfat and loin eye depth and the effects on fat tissue deposition and dressing percentage once the metabolizable energy intake, lean deposition and viscera content are highly correlated, positively or negatively.

Our results showed that differences in carcass weight might be due the differences in growth rate throughout the growing to finishing phase once the dressing plus transport weight loss were very close. Furthermore, these growth effect might have impacted the loin depth between control, control +5% because the magnitude of impact are proportional, but it doesn't between control -5%, control and Ad Libitum access showing that the protein:lipid deposition rate may have been different on these treatments.

CONCLUSION

Control feeding strategies alter the performance and carcass characteristics of grow to finish pigs. It can be an effective feeding practice, once the nutrients intake requirements are met, to improve feed conversion rate and it can be a tool to manage growth rate and finishing space, neither the production system are lack in space (fixed time slaughter strategy) nor with plenty finishing space (fixed weight strategy).

ACKNOWLEDGMENTS

To Agroceres PIC, Rio Claro – SP for the financial support.

REFERENCES

Agroceres PIC. *Customer Relationship Management Report. Rio* Claro - SP: Agroceres PIC, 2017.

A. P. Schinckel, N. Li, B. T. Richert, P. V. Preckel, M. E. Einstein; Development of a model to describe the compositional growth and dietary lysine requirements of pigs fed ractopamine, *Journal of Animal Science*, Volume 81, Issue 5, 1 May 2003, Pages 1106–1119, https://doi.org/10.2527/2003.8151106x

Barnett, S. M., Moore, K. C., Trenhaile, M. D., Desaulniers, A. T., Li, Y. S., van Sambeek, D. M., ... & Burkey, T. E. (2016). 195 Effect of energy restriction on feed efficiency, nutrient digestibility, and immune biomarkers of growing/finishing pigs. *Journal of Animal Science*, *94*(supplement2), 92-93.

Bertalanffy, L. v. (1957). Quantitative laws for metabolism and growth... *Quart. Rev. Biol.,* pp. 32:217-232.

Boddicker, N., N. K. Gabler, M. E. Spurlock, D. Nettleton, and J. C. M. Dekkers. "Effects of ad libitum and restricted feed intake on growth performance and body composition of Yorkshire pigs selected for reduced residual feed intake." *J. Anim. Sci.*, 2011: 40-51.

Brody, S. (1945). Bioenergetics and growth. *New York: Reinhold Publishing Corp.*

CONCEA. *Diretriz brasileira para o cuidado e a utilização de animais em atividades de ensino ou de pesquisa científica - DBCA.* 2016. http://www.mct.gov.br/upd_blob/0238/238684.pdf (acesso em 18 de Fevereiro de 2017).

Cho, S. B., S. H. Cho, S. S. Chang, I. B. Chun J. S. Lim, D. Y. Kil and Y. Y. Kim. 2006. Effects of restricted feeding on performance, carcass quality and hormone profiles in finishing barrows. *Asian-Aust. J. Anim. Sci.* 19(11):1643-1648.

Cho, S. B., Kim, D. W., Baek, K. H., Lee, B. S., Chung, I. B., Chung, W. T., & Choi, N. J. (2008). Effects of dietary energy intake levels on growth performance and body composition of finishing barrows and gilts. *Asian-Australasian Journal of Animal Sciences*, *21*(10), 1516-1521.

De La Llata, M., Dritz, S. S., Tokach, M. D., Goodband, R. D., & Nelssen, J. L. (2007). Effects of Increasing Lysine to Calorie Ratio and Added Fat for Growing-

Finishing Pigs Reared in a Commercial Environment: I. Growth Performance and Carcass Characteristics1. *The Professional Animal Scientist*, *23*(4), 417-428.

Embrapa Aves e Suínos. "Relatório UPST Conab 2014." *Conab.* 26 de Fevereiro de 2017. http://www.conab.gov.br/conteudos.php?a=1562&t=2.

Gompertz, B. (1825). On nature of the equation expressive of the law of human mortality, and on a new mode of determining the value of life contingencies. . *Phil. Trans. Roy. Soc.* , pp. 115:513-585.

Hyun, Y, M Ellis, e F.K McCkeith. "Feed intake pattern of group-housed growing-finishing pigs monitored using a computerized feed intake recording system." *J. Anim. Sci.*, 1997: 1443-1451.

Koch, R. M., L. A. Swiger, D. Chambers, and K. E. Gregory. "Efficiency of feed use in beef cattle..." *J. Anim. Sci.*, 1963: 22:486-494.

Lovatto, P. A., Sauvant, D., Noblet, J., Dubois, S., & Van Milgen, J. (2006). Effects of feed restriction and subsequent refeeding on energy utilization in growing pigs. *Journal of animal science*, 84(12), 3329-3336.

Michaelis, L., and M. L. Menten. 1913. Die Kinetik der Invertinwirkung. Biochemische Zeitschrift 49:334–336.

Noblet, J., Karege, C., Dubois, S., & Van Milgen, J. (1999). Metabolic utilization of energy and maintenance requirements in growing pigs: effects of sex and genotype. *Journal of Animal Science*, *77*(5), 1208-1216.

NRC. *Nutrient Requirements of Swine.* Washington, D.C: National Academic Press, 1998.

NRC. *Nutrient Requirements of Swine.* Washington, D.C: National Academic Press, 2012.

PIC. *Nutrient specification manual.* Hendersonville, 2016.—. *Nutrient Specifications Manual.* Hendersonville, 2016.

Quiniou, N, e J Noblet. "Effect of the dietary net energy concentration on feed intake and performance of growing-finishing pigs housed individually." *J. Anim. Sci.,* 1997: 1443-1451.

Richards, F. J. (1959). A flexible growth equation for empirical use. J. Exp. Bot. pp. 10:290-300.

Robertson, T. B. (1908). On the normal rate of growth of an individual, and its biochemical significance. *Archiv für Entwicklungsmechanik der Organismen*, *25*(4), 581-614.

Rostagno, H. S.; albino, l. F. T.; Hannas, M.I.; Donzele, J.L.; Sakomura, N.K.; Perazzo, F.G.; Saraiva, A.; Teixeira, M.V.; Rodrigues, P.B.; Oliveira, R.F.; Barreto, S.L.T.; Brito, C.O. Tabelas brasileiras para aves e suínos: composição de alimentos e exigências nutricionais. 4a edição. Viçosa, mg: Departamento de Zootecnia, Universidade Federal de Viçosa, 2017. 488p.

SAS Institute. (1999). *SAS Procedures Guide: Version 8* (Vol. 1). SAS Institute.

Schinckel. P. and de Lange, C.F.M. "Characterization of growth parameters needed as inputs for pig growth models." *Journal of Animal Science*, 1996: 74:2021-2036.

Williams, N. H., Cline, T. R., Schinckel, A. P., & Jones, D. J. (1994). The impact of ractopamine, energy intake, and dietary fat on finisher pig growth performance and carcass merit. *Journal of animal science*, *72*(12), 3152-3162.

TABLES

Table 1. Calculated composition (% as fed) of experimental diets, as fed.*

Nutrients	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Crude protein, %	18.53	18.05	17.55	17.01	15.50
Crude fiber, %	3.13	3.18	3.07	3.16	3.40
Fat, %	6.39	5.14	4.31	4.97	5.28
Metabolizable energy, Kcal/kg	3,505	3,437	3,404	3,390	3,391
Ash, %	4.80	5.02	4.93	5.41	4.90
Sodium, %	0.25	0.25	0.25	0.25	0.24
Total calcium, %	0.89	0.89	0.86	0.89	0.82
Total phosphorus, %	0.42	0.43	0.41	0.39	0.39
Available phosphorus, %	0.40	0.40	0.38	0.36	0.35
Lysine SID, %	1.20	1.10	1.02	0.95	0.82
Methionine SID, %	0.38	0.35	0.32	0.32	0.25
Methionine + Cysteine SID., %	0.72	0.68	0.64	0.64	0.55
Threonine SID, %	0.78	0.72	0.67	0.62	0.54
Tryptophan SID, %	0.24	0.22	0.20	0.19	0.17
Arginine SID, %	1.11	1.09	1.05	1.04	0.93
Valine Total., %	0.91	0.89	0.86	0.85	0.78

*NRC, 2012

Table 2. Feeding curves (Kg) as function of the days on feed on the grow to finish pigs.*

Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access
0	1.138	1.198	1.258	
7	1.359	1.430	1.502	
14	1.559	1.641	1.723	
21	1.733	1.825	1.916	
28	1.883	1.982	2.081	
35	2.012	2.118	2.224	
42	2.126	2.238	2.350	
49	2.229	2.347	2.464	
56	2.324	2.446	2.568	
63	2.408	2.535	2.662	
70	2.482	2.613	2.743	
77	2.544	2.678	2.812	
84	2.595	2.732	2.869	
91	2.639	2.778	2.917	
98	2.679	2.820	2.961	
105	2.717	2.860	3.003	

*Control was fed to meet or exceed the requirements for PIC's genotype (PIC 2016). The treatment "Control -5%" was the control minus 5% throughout the grow to finish, "Control +5" was the control plus 5% and then the *Ad Libitum* access was an *Ad libitum* feeding where

Table 3. Metabolizable energy (Kcal/day) fed as function of the days on feed on the grow to finish pigs.*

Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access
0	3,988	4,198	4,408	
7	4,761	5,012	5,262	
14	5,463	5,750	6,038	
21	5,957	6,271	6,584	
28	6,471	6,811	7,152	
35	6,914	7,277	7,641	
42	7,236	7,617	7,998	
49	7,588	7,988	8,387	
56	7,910	8,326	8,742	
63	8,164	8,593	9,023	
70	8,413	8,856	9,299	
77	8,623	9,077	9,531	
84	8,801	9,264	9,728	
91	8,950	9,421	9,892	
98	9,085	9,563	10,042	
105	9,214	9,699	10,184	

*Control was fed to meet or exceed the requirements for PIC's genotype (PIC 2016). The treatment "Control -5%" was the control minus 5% throughout the grow to finish, "Control +5" was the control plus 5% and then the *Ad Libitum* access was an *Ad libitum* feeding where the feeder coverage was managed at 30%.

Table 4. Lysine SID (g/day) fed as function of the days on feed on the grow to finish pigs.*

Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access
0	13.7	14.4	15.1	
7	16.4	17.2	18.1	
14	18.8	19.8	20.7	
21	19.1	20.1	21.1	
28	20.8	21.9	23.0	
35	22.2	23.4	24.5	
42	21.7	22.9	24.0	
49	22.8	24.0	25.2	
56	23.7	25.0	26.2	
63	22.9	24.1	25.3	
70	23.6	24.8	26.1	
77	24.2	25.4	26.7	
84	21.3	22.4	23.5	
91	21.6	22.8	23.9	
98	22.0	23.1	24.3	
105	22.3	23.5	24.6	

*Control was fed to meet or exceed the requirements for PIC's genotype (PIC 2016). The treatment "Control -5%" was the control minus 5% throughout the grow to finish, "Control +5" was the control plus 5% and then the *Ad Libitum* access was an *Ad libitum* feeding where

Table 5. Functions considered for modeling the growth curve and energy intake of different feeding curves.[1]

Model	Equation	Reference
Logistic	W = a/(1+b*exp(-c*t))	Robertson (1908)
Gompertz	W = a*exp(-b*exp(b-(c*t))	Gompertz (1825)
von Bertalanffy	$W = [((a/b)-(a/(b-W_0 1/3))*exp-1/3*b*t]^3$	Bertalanffy (1957)
Brody	W = a*(1-b*exp(-c*t))	Brody (1945)
Richards	W = a/(1+b*exp(-c*t))1/m	Richards (1959)
Michaelis-Menten	W = (a*t)/(c+t)	Lopez (2000)

[1]Parameter a: Asymptotic weight or weight at maturity. Parameter b: Integration parameter with no biological meaning. Parameter c: Maturity rate. Parameter m: Inflection point where Brody (m=-1), von Bertalanffy (m=-1/3), Gompertz (m=0) and Logistic (m=1). t: Age, days.

Table 6. Parameters of different growth curves fitted on different feeding curves with 95% confidence limits.[1]

Model	Equation	Parameter	Feeding Curve	Estimate	SE	Lower 95% CL	Upper 95% CL	RSD	R^2
Logistic	W = a/(1+b*exp(-c*t))	a	Control -5%	136.50	1.19	134.10	138.80	0.70	0.99
			Control	141.10	1.54	138.00	144.20	0.86	0.99
			Control +5%	139.30	1.34	136.70	142.00	0.89	0.99
			Ad Libitum access	140.90	1.12	138.60	143.10	0.92	0.99
		c	Control -5%	0.0287	0.0003	0.0280	0.0293	-	-
			Control	0.0290	0.0004	0.0282	0.0298	-	-
			Control +5%	0.0299	0.0004	0.0291	0.0306	-	-
			Ad Libitum access	0.0325	0.0004	0.0317	0.0333	-	-
Gompertz	W = a*exp(-b*exp(b-(c*t))	a	Control -5%	177.90	1.20	175.50	180.30	0.27	0.99
			Control	185.20	2.21	180.70	189.60	0.47	0.99
			Control +5%	178.90	1.00	176.80	180.90	0.26	0.99
			Ad Libitum access	174.40	1.04	172.30	176.50	0.36	0.99
		c	Control -5%	0.0142	0.0001	0.0140	0.0144	-	-
			Control	0.0143	0.0002	0.0139	0.0146	-	-
			Control +5%	0.0150	0.0001	0.0148	0.0152	-	-
			Ad Libitum access	0.0168	0.0001	0.0166	0.0171	-	-
von Bertalanffy	W = [((a/b)-(a/(b-W01/3))*exp-1/3*b*t]3	a	Control -5%	219.20	2.53	214.10	224.30	0.30	0.99
			Control	229.80	4.14	221.50	238.20	0.46	0.99
			Control +5%	217.20	1.17	214.90	219.60	0.17	0.99
			Ad Libitum access	204.90	2.29	200.30	209.50	0.47	0.99
		c	Control -5%	0.0093	0.0001	0.0091	0.0096	-	-
			Control	0.0093	0.0002	0.0090	0.0097	-	-
			Control +5%	0.0100	0.0001	0.0099	0.0101	-	-
			Ad Libitum access	0.0116	0.0002	0.0113	0.0119	-	-

1Parameter a: Asymptotic weight or weight at maturity. Parameter b: Integration parameter with no biological meaning. Parameter c: Maturity rate. Parameter m: Inflection point where Brody (m=-1), von Bertalanffy (m=-1/3), Gompertz (m=0) and Logistic (m=1). t: Age, days.

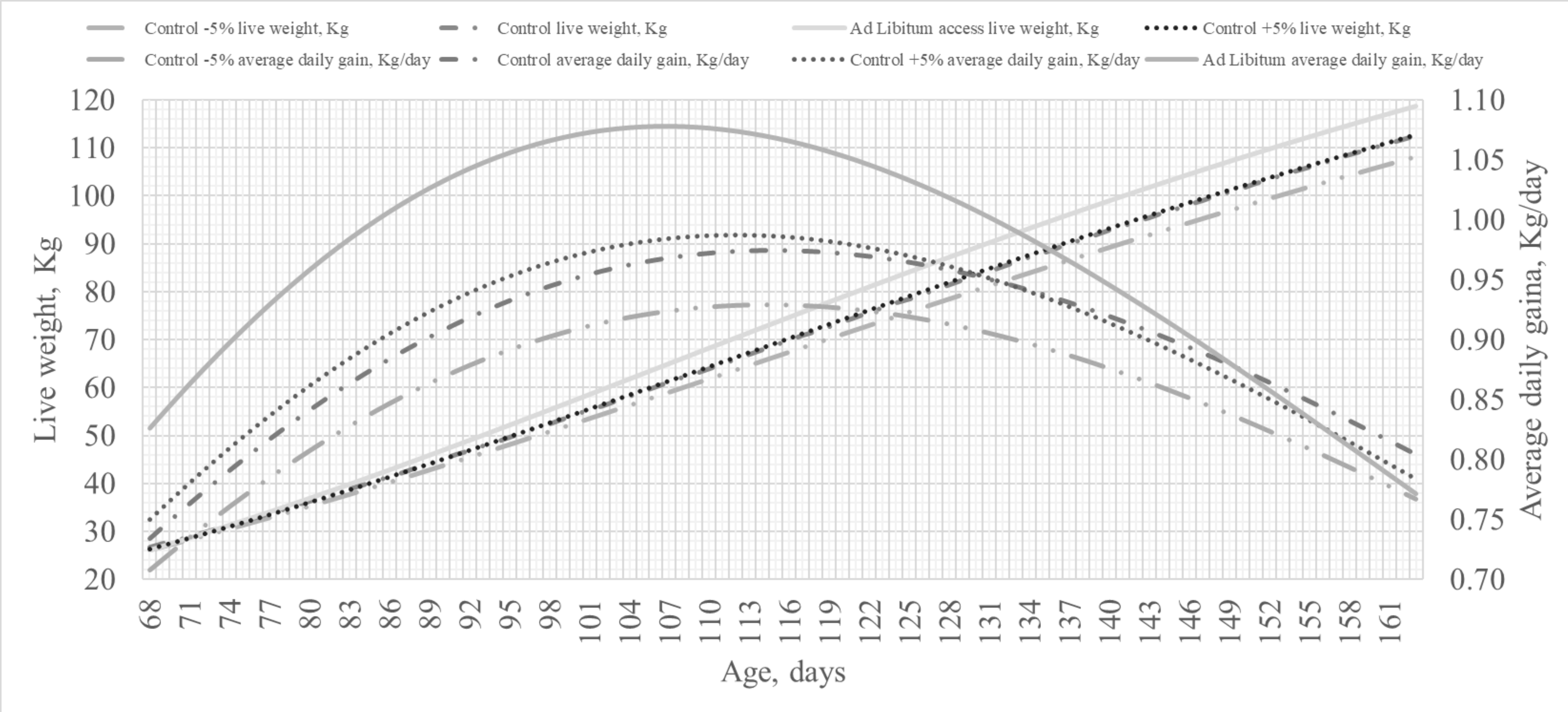

Figure 1 Gompertz growth curve for different grow to finish feeding curves

Table 7. Effect of different feeding curves on live weight (Kg) on finishing pigs.[1,2]

Phase	Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access	SEM[3]
0	0	25.25a	25.55a	25.17a	25.31a	0.171
1	19	40.09a	41.23b	41.42b	43.03c	0.236
2	40	58.82a	60.47b	61.33b	64.93c	0.259
3	61	77.92a	80.28b	81.32c	87.8d	0.200
4	82	97.12a	101.37b	100.93b	106.34c	0.284
5	96	107.76a	111.29b	112.52b	119.2c	0.269

[1]Mixed effect model where feeding curves and trial phase were considered as fixed effect, stocking day as a block factor was consider a random effect and pen number nested within block was considerer the subject to account for the correlated error within and between phases. [2]Different subscribed letters within a row statistically differs at $p<.05$ by the Tukey-Kramer test.[3]Standard error of the mean for phase as the fixed effect.

Table 8. Effect of different feeding curves on the cumulative average daily gain (Kg/day) on finishing pigs.[1,2]

Phase	Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access	SEM[3]
1	19	0.781a	0.825b	0.855c	0.933d	0.0039
2	40	0.839a	0.873b	0.904c	0.991d	0.0025
3	61	0.863a	0.897b	0.921c	1.024d	0.0020
4	82	0.876a	0.925b	0.924b	0.988d	0.0031
5	96	0.859a	0.893b	0.91c	0.978d	0.0023

[1]Mixed effect model where feeding curves and trial phase were considered as fixed effect, stocking day as a block factor was consider a random effect and pen number nested within block was considerer the subject to account for the correlated error within and between phases. [2]Different subscribed letters within a row statistically differs at $p<.05$ by the Tukey-Kramer test.[3]Standard error of the mean for phase as the fixed effect.

Table 9. Effect of different feeding curves on the cumulative total feed intake (Kg) on finishing pigs.[1,2]

Phase	Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access	SEM[3]
1	19	26.11a	27.54b	28.85c	32.48d	0.017
2	40	65.73a	69.02b	72.4c	80.98d	0.083
3	61	112.76a	118.47b	124.07c	140.39d	0.166
4	82	165a	173.67b	181.89c	204.7d	0.234
5	96	201.77a	212.32b	222.5c	250.59d	0.282

[1]Mixed effect model where feeding curves and trial phase were considered as fixed effect, stocking day as a block factor was consider a random effect and pen number nested within block was considerer the subject to account for the correlated error within and between phases. [2]Different subscribed letters within a row statistically differs at $p<.05$ by the Tukey-Kramer test.[3]Standard error of the mean for phase as the fixed effect.

Table 10. Effect of different feeding curves on the cumulative daily feed intake (Kg/day) on finishing pigs.[1,2]

Phase	Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access	SEM[3]
1	19	1.374a	1.449b	1.519c	1.71d	0.0025
2	40	1.643a	1.725b	1.81c	2.025d	0.0031
3	61	1.848a	1.942b	2.034c	2.301d	0.0034
4	82	2.012a	2.118b	2.218c	2.496d	0.0037
5	96	2.102a	2.212b	2.318c	2.61d	0.0042

[1]Mixed effect model where feeding curves and trial phase were considered as fixed effect, stocking day as a block factor was consider a random effect and pen number nested within block was considerer the subject to account for the correlated error within and between phases. [2]Different subscribed letters within a row statistically differs at $p<.05$ by the Tukey-Kramer test.[3]Standard error of the mean for phase as the fixed effect.

Table 11. Effect of different feeding curves on the daily energy intake (Kcal/day) on finishing pigs.[1,2]

Phase	Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access	SEM[3]
1	19	4771a	5033b	5273c	5936d	7
2	40	6485a	6797b	7127c	7885d	11
3	61	7602a	7994b	8362c	9614d	21
4	82	8470a	8944b	9357c	10371d	23
5	96	8906a	9396b	9837c	10742d	25

[1]Mixed effect model where feeding curves and trial phase were considered as fixed effect, stocking day as a block factor was consider a random effect and pen number nested within block was considerer the subject to account for the correlated error within and between phases. [2]Different subscribed letters within a row statistically differs at $p<.05$ by the Tukey-Kramer test.[3]Standard error of the mean for phase as the fixed effect.

Table 12. Parameters of energy feed intake fitted as a function of live weight of different feeding curves with 95% confidence limits.[1]

Model	Equation	Parameter	Feeding Curve	Estimate	SE	Lower 95% CL	Upper 95% CL	RSD	R^2
Brody	W = a*(1-b*exp(-c*t))	a	Control -5%	10693	191	10307	11079	86	0.99
			Control	11306	254	10793	11819	105	0.99
			Control +5%	12180	188	11800	12559	73	0.99
			Ad Libitum access	12664	302	12053	13275	157	0.98
		c	Control -5%	0.0175	0.0010	0.0155	0.0195	-	-
			Control	0.0166	0.0012	0.0143	0.0190	-	-
			Control +5%	0.0150	0.0007	0.0137	0.0164	-	-
			Ad Libitum access	0.0169	0.0013	0.0142	0.0196	-	-
Logistic	W = a/(1+b*exp(-c*t))	a	Control -5%	9619	97	9423	9816	102	0.99
			Control	10130	123	9882	10378	120	0.99
			Control +5%	10752	96	10557	10946	93	0.99
			Ad Libitum access	11530	121	11284	11775	140	0.99
		c	Control -5%	0.0362	0.0013	0.0336	0.0388	-	-
			Control	0.0349	0.0014	0.0320	0.0378	-	-
			Control +5%	0.0329	0.0009	0.0310	0.0348	-	-
			Ad Libitum access	0.0339	0.0013	0.0313	0.0366	-	-
Gompertz	W = a*exp(-b*exp(b-(c*t))	a	Control -5%	10001	125	9749	10253	93	0.99
			Control	10546	161	10220	10871	112	0.99
			Control +5%	11245	122	11000	11490	93	0.99
			Ad Libitum access	11941	177	11583	12299	147	0.99
		c	Control -5%	0.0268	0.0011	0.0245	0.0290	-	-
			Control	0.0257	0.0013	0.0231	0.0283	-	-
			Control +5%	0.0239	0.0008	0.0223	0.0255	-	-
			Ad Libitum access	0.0253	0.0013	0.0226	0.0280	-	-
von Bertalanffy	W = [((a/b)-(a/(b-W01/3))*exp-1/3*b*t]3	a	Control -5%	10183	140	9899	10466	90	0.99
			Control	10745	182	10376	11114	109	0.99
			Control +5%	11485	136	11211	11760	78	0.99
			Ad Libitum access	12134	207	11716	12553	150	0.99
		c	Control -5%	0.0236	0.0011	0.0215	0.0258	-	-
			Control	0.0227	0.0012	0.0202	0.0251	-	-
			Control +5%	0.0209	0.0007	0.0194	0.0224	-	-
			Ad Libitum access	0.0225	0.0013	0.0198	0.0252	-	-

1Parameter a: Asymptotic weight or weight at maturity. Parameter b: Integration parameter with no biological meaning. Parameter c: Maturity rate. Parameter m: Inflection point where Brody (m=-1), von Bertalanffy (m=-1/3), Gompertz (m=0) and Logistic (m=1). t: Age, days.

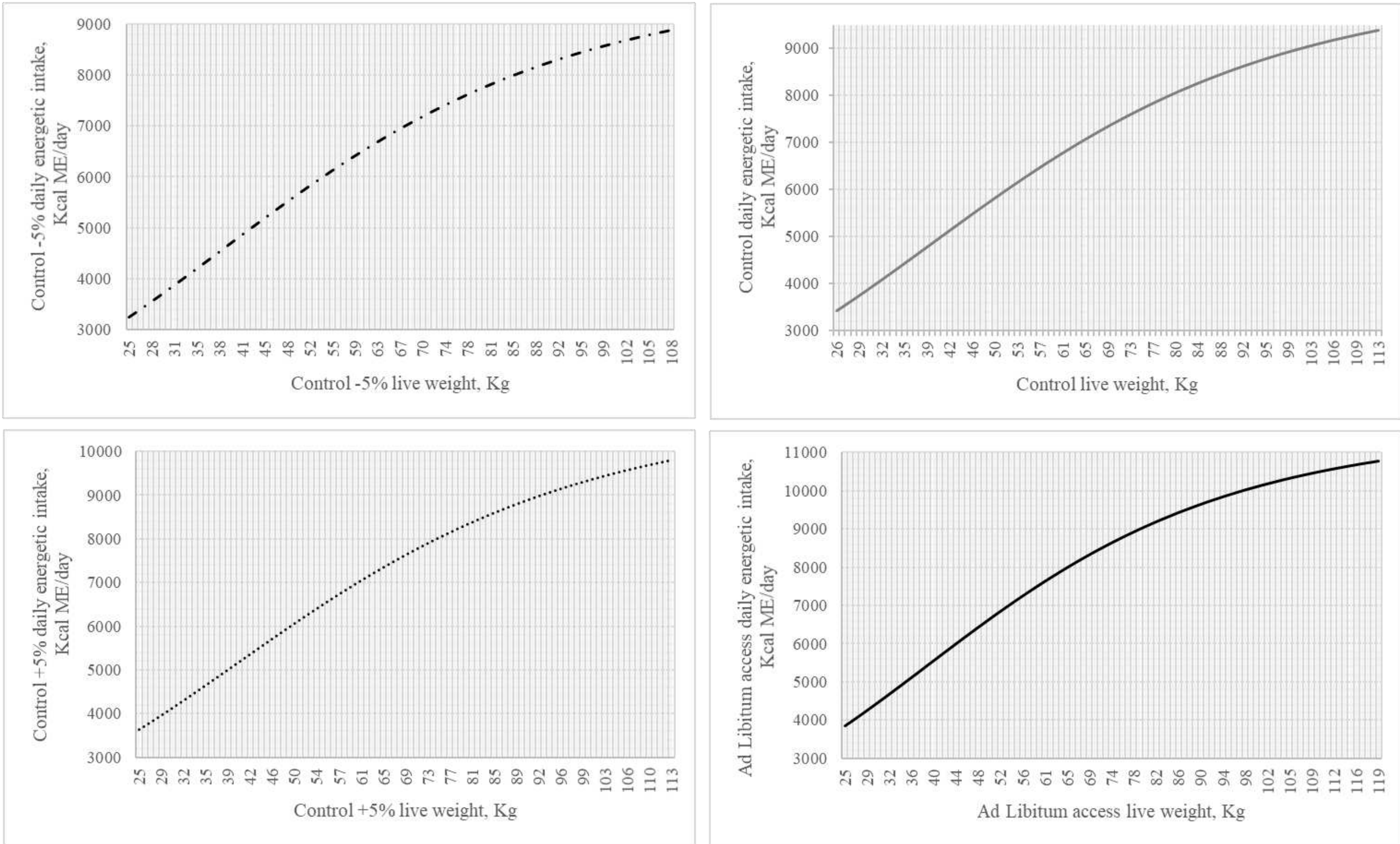

Figure 2: von Bertalanffy function modeling energy intake, Kcal ME/Kg, as function of live weight by feeding curve.

Table 13. Effect of different feeding curves on the lysine consumption per weight gain (g/Kg*day^{-1}) on finishing pigs.[1,2]

Phase	Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access	SEM[3]
1	19	20.24a	20.32bc	20.57c	21.24cd	0.19
2	40	23.12a	23.64b	23.92c	24.29c	0.17
3	61	24.73a	25.31b	25.82b	25.98b	0.25
4	82	26.32a	25.48a	28.4b	32.79c	0.28
5	96	28.57a	29.00a	29.03a	28.23a	0.43

[1]Mixed effect model where feeding curves and trial phase were considered as fixed effect, stocking day as a block factor was consider a random effect and pen number nested within block was considerer the subject to account for the correlated error within and between phases. [2]Different subscribed letters within a row statistically differs at p<.05 by the Tukey-Kramer test.[3]Standard error of the mean for phase as the fixed effect.

Table 14. Effect of different feeding curves on the cumulative feed conversion rate (Kg/Kg) on finishing pigs.[1,2]

Phase	Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access	SEM[3]
1	19	1.749a	1.756bc	1.778c	1.836d	0.009
2	40	1.946a	1.964ab	1.998b	2.045c	0.006
3	61	2.137a	2.16b	2.207c	2.248d	0.004
4	82	2.296a	2.294a	2.399b	2.537c	0.007
5	96	2.445a	2.483b	2.546c	2.673d	0.006

[1]Mixed effect model where feeding curves and trial phase were considered as fixed effect, stocking day as a block factor was consider a random effect and pen number nested within block was considerer the subject to account for the correlated error within and between phases. [2]Different subscribed letters within a row statistically differs at p<.05 by the Tukey-Kramer test.[3]Standard error of the mean for phase as the fixed effect.

Table 15. Effect of different feeding curves on the phase average daily gain (Kg/day) on finishing pigs.[1],[2]

Phase	Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access	SEM[3]
1	19	0.786a	0.826a	0.855b	0.932c	0.008
2	40	0.901a	0.924b	0.957b	1.043c	0.006
3	61	0.903a	0.929a	0.952b	1.089c	0.009
4	82	0.91a	1.006a	0.934a	0.895a	0.012
5	96	0.76a	0.798ab	0.828b	0.926c	0.013

[1]Mixed effect model where feeding curves and trial phase were considered as fixed effect, stocking day as a block factor was consider a random effect and pen number nested within block was considerer the subject to account for the correlated error within and between phases. [2]Different subscribed letters within a row statistically differs at p<.05 by the Tukey-Kramer test.[3]Standard error of the mean for phase as the fixed effect.

Table 16. Effect of different feeding curves on the phase daily feed intake (Kg/day) on finishing pigs.[1],[2]

Phase	Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access	SEM[3]
1	19	1.374a	1.449b	1.519c	1.71d	0.002
2	40	1.887a	1.978b	2.074c	2.294d	0.003
3	61	2.237a	2.352b	2.46c	2.829d	0.006
4	82	2.492a	2.632b	2.753c	3.051d	0.007
5	96	2.626a	2.771b	2.901c	3.168d	0.007

[1]Mixed effect model where feeding curves and trial phase were considered as fixed effect, stocking day as a block factor was consider a random effect and pen number nested within block was considerer the subject to account for the correlated error within and between phases. [2]Different subscribed letters within a row statistically differs at p<.05 by the Tukey-Kramer test.[3]Standard error of the mean for phase as the fixed effect.

Table 17. Effect of different feeding curves on the phase feed conversion rate (Kg/Kg) on finishing pigs.[1],[2]

Phase	Days on feed	Control -5%	Control	Control +5%	*Ad Libitum* access	SEM[3]
1	19	1.749a	1.756b	1.778c	1.836c	0.018
2	40	2.095a	2.141b	2.166c	2.201c	0.017
3	61	2.478a	2.536b	2.587b	2.603b	0.027
4	82	2.742a	2.654a	2.959b	3.415c	0.030
5	96	3.476a	3.528a	3.531a	3.434a	0.053

[1]Mixed effect model where feeding curves and trial phase were considered as fixed effect, stocking day as a block factor was consider a random effect and pen number nested within block was considerer the subject to account for the correlated error within and between phases. [2]Different subscribed letters within a row statistically differs at $p<.05$ by the Tukey-Kramer test.[3]Standard error of the mean for phase as the fixed effect.

Table 18. Effect of different feeding curves on carcass characteristics on finishing pigs.[1,2]

Item	Control -5%	Control	Control +5%	*Ad Libitum* access	RSD[3]
Hot carcass weight, Kg	77.95a	80.22b	81.36c	86.92d	1.27
Loin depth, mm	60.85a	62.54ab	63.18b*	65.07c*	2.26
Backfat thickness, mm	15.23a	16.19ab	16.37b	18.09c	1.07
Lean content, %	59.04a	58.67a	58.72a	57.96c	0.64
Hot carcass weight coefficient of variation, %	9.61ab	8.4a	10.22b	9.03ab	1.44

[1]Mixed effect model where feeding curves was considered as fixed effect and stocking day as a block factor was consider a random effect. [2]Different subscribed letters within a row statistically differs at $p<.05$ by the Tukey-Kramer test. *Differences between Control +5% and Ad Libitum access was tendency ($p<.10$).[3]Residual standard deviation od the model.