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UNIVERSIDADE ESTADUAL PAULISTA - UNESP

CÂMPUS DE JABOTICABAL

SISTEMA DE ALIMENTAÇÃO SEQUENCIAL COM AJUSTES NUTRICIONAIS PARA SUÍNOS EM CRESCIMENTO E TERMINAÇÃO DE DUAS LINHAGENS GENÉTICAS SUBMETIDOS A CONDIÇÃO DE ESTRESSE CÍCLICO POR CALOR

Alícia Zem Fraga

Zootecnista

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CERTIFICADO DE APROVAÇÃO

TÍTULO DA DISSERTAÇÃO: SISTEMA DE ALIMENTAÇÃO SEQUENCIAL COM AJUSTES NUTRICIONAIS PARA SUÍNOS EM CRESCIMENTO E TERMINAÇÃO DE DUAS LINHAGENS GENÉTICAS SUBMETIDOS A CONDIÇÃO DE ESTRESSE CÍCLICO POR CALOR

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Jaboticabal, 23 de fevereiro de 2018

DADOS CURRICULARES DO AUTOR

ALÍCIA ZEM FRAGA – Nascida em Muriaé, Minas Gerais, no dia 20 de Março de 1993. Em 2011 ingressou no curso de graduação em Zootecnia da Universidade Federal de Viçosa, onde obteve o título de destaque na apresentação e defesa da Monografia “Piglets' behavior in maze with glass walls in function of weaning age” orientada pelo Dr. Aloísio Soares Ferreira e defendida no ano de 2016. Nesse mesmo ano iniciou o Mestrado na Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista “Júlio de Mesquita Filho” (FCAV–UNESP), Campus de Jaboticabal, orientada pelos professores Dr. Luciano Hauschild e Dr. Paulo Henrique Reis Furtado Campos (coorientador). No Mestrado foi bolsista da Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), com período sanduíche no Instut National de la Recherche Agronomique França (INRA UMR PEGASE), sob supervisão da phD. Nathalie Le Floc'h.

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Dedico

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SUMÁRIO

CERTIFICADO DA COMISSÃO DE ÉTICA NO USO DE ANIMAIS

UNIVERSIDADE ESTADUAL PAULISTA
"JÚLIO DE MESQUITA FILHO"
Câmpus de Jaboticabal

CERTIFICADO

Certificamos que o Projeto intitulado **"Sistema de alimentação sequencial com ajustes nutricionais para suínos em crescimento e terminação de duas linhagens genéticas submetidos a condição de estresse cíclico por calor"**, protocolo nº 18.077/16, sob a responsabilidade do Prof. Dr. Luciano Hauschild, que envolve a produção, manutenção e/ou utilização de animais pertencentes ao Filo Chordata, subfilo Vertebrata (exceto o homem), para fins de pesquisa científica (ou ensino) - encontra-se de acordo com os preceitos da lei nº 11.794, de 08 de outubro de 2008, no decreto 6.899, de 15 de junho de 2009, e com as normas editadas pelo Conselho Nacional de Controle da Experimentação Animal (CONCEA), e foi aprovado pela COMISSÃO DE ÉTICA NO USO DE ANIMAIS (CEUA), da FACULDADE DE CIÊNCIAS AGRÁRIAS E VETERINÁRIAS, UNESP - CÂMPUS DE JABOTICABAL-SP, em reunião ordinária de 14 de dezembro de 2016.

Vigência do Projeto	15/02/2017 a 15/05/2017
Espécie / Linhagem	Suínos
Nº de animais	78
Peso / Idade	15 aos 120 kg
Sexo	Macho e fêmea
Origem	Granja Comercial Parceira

Jaboticabal, 14 de dezembro de 2016.

Profª Drª Lizandra Amoroso
Coordenadora – CEUA

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RESUMO

SISTEMA DE ALIMENTAÇÃO SEQUENCIAL COM AJUSTES NUTRICIONAIS PARA SUÍNOS EM CRESCIMENTO E TERMINAÇÃO DE DUAS LINHAGENS GENÉTICAS SUBMETIDOS A CONDIÇÃO DE ESTRESSE CÍCLICO POR CALOR

RESUMO: Objetivou-se com esse estudo avaliar o sistema de alimentação sequencial como uma ferramenta para atenuar os efeitos do estresse cíclico por calor em suínos de duas linhagens genéticas nas fases de crescimento e terminação. Oitenta suínos machos castrados de 22kg (± 2,5) PV foram distribuídos em um delineamento experimental inteiramente casualizado, em esquema fatorial 3x2 (3 programas de alimentação e 2 linhagens genéticas; 3 PA e 2 LG) sendo o animal a unidade experimental. Os PA foram: Controle (**CON**), alta-gordura/baixa-proteína bruta (**AG/BP**) e Alimentação Sequencial [**SEQ**, de 1800 às 1000 h dieta controle (Tempo-Período 1, TP1) e de 1000 às 1800 h dieta AG/BP (TP2)]. A temperatura foi 22.3 ± 0.4ºC para TP1 e 30.2 ± 0.5ºC para TP2. A duração do período experimental foi de 84 dias subdividido em três fases: crescimento 1 (0 a 20 dias), crescimento 2 (21 a 48 dias) e terminação (49 a 83 dias). O consumo de ração foi registrado em tempo real pelo sistema automático de alimentação (AIPF). Os animais foram pesados no início e no término de cada fase experimental e nos dias 0, 35 e 75 foi mensurada a composição corporal. Houve interação entre LG e Tempo-Período (TP) para consumo médio de ração (CMR) por hora ($P < 0,05$). A 22ºC o CMR não se diferiu entre linhagens ($P > 0,05$) contudo, a 30ºC foi maior para linha B ($P < 0,05$). Houve interação ($P < 0,05$) entre PA e LG para custo energético de ganho de massa magra. De 35 a 75 dias, SEQ apresentou similar custo para ganho de massa magra para linha A quando comparado com CON ($P > 0,05$). No entanto para ambas as linhas, SEQ apresentou maior custo em relação ao CON ($P < 0.05$). Nas fases de crescimento 1 e 2 não houveram diferenças ($P> 0,05$) entre AG/BP e CON para CDR e GDP. Porém na fase de terminação maiores resultados para essas variáveis, além de maior custo de energia para ganho de peso, foram observados para AG/BP ($P < 0,05$). Na fase de crescimento 2, SEQ apresentou maior GDP ($P = 0,04$) com similar custo de energia para ganho ($P = 0,24$) quando comparado com programa CON. Na terminação, a alimentação SEQ permitiu reduzir o consumo de EL ($P < 0,01$), mas com GDP semelhante ($P > 0,05$) ao AG/BP. Além disso, SEQ apresentou custo de ganho de energia similar ao CON ($P > 0,05$) nessa fase. Massa gorda e ganho de massa gorda foram semelhantes entre SEQ e AG/BP ($P > 0,05$) e ambos maiores que CON ($P < 0,05$). O fornecimento de diferentes dietas ajustadas à variação da temperatura ao longo do dia é uma abordagem eficiente para atenuar o efeito do estresse térmico, mas com subsequente carcaças mais gordas. Além disso, em relação à eficiência energética para a deposição de massa magra, a alimentação sequencial é um programa eficiente a ser aplicado para a linha genética menos tolerante ao estresse térmico.

Palavras-chave: genótipo, nutrição, temperatura ambiente

ABSTRACT

SEQUENTIAL FEEDING SYSTEM WITH NUTRITIONAL ADJUSTMENTS FOR PIGS GROWING AND FINISHING PHASES OF TWO GENETIC LINES SUBMITTED TO CYCLICAL HEAT STRESS

ABSTRACT: This study aimed at evaluating the sequential feeding system as a tool to attenuate the effects of cyclic heat stress in two genetics of growing-finishing pigs. Eighty 22kg (± 2.5) BW barrows were assigned in a completely randomized experimental design, in factorial scheme 3x2 (3 feeding programs and 2 genetic lines; 3FP and 2GL) being the animal the experimental unit. The FP were: Control (**CON**), high-fat/low-crude protein (**HF/LP**) and Sequential Feeding **[SEQ**, from 1800 to 1000 h control diet (Time-Period 1, TP1) and from 1000 to 1800 h HF/LP diet (TP2)]. The temperature was 22.3 ± 0.4ºC for TP1 and 30.2 ± 0.5ºC for TP2. The experimental period lasted 84 days subdivided into three phases, growing 1 (0 to 20d), growing 2 (21 to 48d), and finishing phase (49 to 83d). Feed intake was recorded using Automated Feeder System. Pigs were weighed at beginning and end of each experimental phase and on days 0, 35 and 75 were measured the body composition. There was interaction between GL and time-period (TP) for average feed intake (AFI) per hour ($P < 0.05$). At 22ºC the AFI did not differ between lines ($P > 0.05$), but at 30ºC the line B pigs had higher values than line A ($P < 0.05$). There was interaction ($P < 0.05$) between FP and GL for energy cost of lean gain. From 35 to 75d, SEQ had similar energy cost of lean gain for line A compared to CON ($P > 0.05$). However, for both lines, SEQ had higher the energy cost of lean than CON ($P < 0.05$). In growing 1 e 2 there was not difference ($P > 0.05$) between HF/LP and CON for ADFI and ADG. But in finishing phase, higher results for these variables and energy cost for gain were observed for HF/LP ($P < 0.05$). In growing 2, SEQ had higher ADG ($P = 0.04$) and similar energy cost of gain ($P = 0.24$) compared to CON program. In finishing phase, the SEQ allowed reducing NE intake ($P < 0.01$) and had a similar ADG ($P > 0.05$) than HF/LP. In addition, SEQ had similar energy cost of gain compared to CON ($P > 0.05$) in this phase. Fat mass and fat mass gain were similar between SEQ and HF/LP ($P > 0.05$), but both higher than CON ($P < 0.05$). In conclusion, the supply of different diets adjusted to the variation of the temperature over the day is an efficient approach to attenuate the heat stress effect, but with subsequent fatter carcasses. In addition, regarding energy efficiency for lean deposition the sequential feeding is an efficient program to be applied for the genetic line less tolerant to heat stress.

Keywords: ambient temperature, genotype, nutrition

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INTRODUCTION

Pig production has considerably increased in tropical and subtropical areas to support the greater global demand for animal products (FAO, 2010). However, high ambient temperature significantly limits pig production productivity and efficiency in these areas due to its negative effects on pig feed intake, metabolism and growth rate (Campos et al., 2017). Therefore, a myriad of genetic (Renaudeau et al., 2007), environmental (Shaffer et al., 2017) and nutritional strategies have been evaluated to attenuate the effects of heat stress in pigs. Regarding nutritional strategies, increasing dietary energy and reducing crude protein content (Renaudeau et al., 2012) in the diets have been shown to attenuate feed intake and growth depression in growing-finishing pigs reared under high ambient temperature conditions.

However, on the one hand these studies were usually performed in pigs exposed to constant high ambient temperature and individually housed in experimental pens or metabolic crates (Renaudeau et al., 2011) that do not represent the environmental conditions under which pigs are commercially raised. In tropical and subtropical areas, pigs are usually group-housed in semi-open buildings and then often exposed to daily fluctuation in ambient temperature (i.e. high ambient temperature during the day and moderate temperature during the night period). On the other hand, these studies did not consider adjusting the nutritional content of diets according to ambient temperature variation throughout the 24-h day period. The technique of alternating different diets over the day is known as sequential feeding (Bouvarel et al., 2008). In this regard, this study aimed to evaluate if adjusting the diet composition according to daily variation in ambient temperature could be a strategy to attenuate the negative effects of cyclic heat stress in pig production.

DISCUSSION

Overview of the cyclic stress condition by heat and sequential feeding system

The study aimed to evaluate if adjusting the nutritional content of diets according to daily ambient temperature variation could be a strategy to attenuate the effects of cyclic heat stress in pigs. For that pigs, room ambient temperature was maintained at 22ºC from 1800 to 1000 h and at 30ºC-period from 1000 to 1800 h, and pigs were assigned to one of the three feeding programs: CON, HF/LP or SEQ. The technique of altering diets in the SEQ feeding program was possible due to the use of the Automatic and Intelligent Precision Feeders. Our first hypothesis was that the increase of dietary energy content would compensate the reduced feed intake in pigs exposed to diurnal high ambient temperatures; and the reduction of dietary crude protein content would decrease the thermic effect of feeding contributing then to attenuate the diurnal effects of high ambient temperature. Secondly, we hypothesized that feeding pigs a HF/LP diet exclusively on the periods of high ambient temperature (instead of during the entire day) would reduce the costs of this nutritional strategy contributing to its effective implementation on commercial production systems.

Effect of a high-fat/low-crude protein sequential feeding on pig performance and body composition

According to our results, feeding programs had negligible effects on pig performance during growing-phase 1 (Figure 1), suggesting that the cyclic heat stress was not critical in this phase. In fact, the magnitude of high ambient temperature effects increases as body weight increases in association with a greater metabolic rate and feed consumption (Renaudeau et al., 2011). In the growing-phase 2, SEQ fed pigs had similar ADG and better energy cost of gain compared to HF/LP fed pigs (Figures 1B and 1E). As di and tripeptides are more efficiently absorbed by basolateral membrane than the free amino acids (Frenhani & Burini, 1999), the absence of the best performance of HF/LP fed pigs may be due a reduction dietary protein that may limit peptide availability to gut cells for synthesis of intestinal constitutive proteins (Otto et al., 2003). Therefore, although the mechanism is still unclear, it seems that the supplementation of the diets with industrial amino acids may compromise the performance of pigs mainly in growing phases by do not provide all requirements of crude protein.

In this experimental phase, when compared to those fed control diet, SEQ fed pigs had higher ADG (10%) and similar energy cost of gain. As mentioned anteriorly, these results cannot be explained by the effect of dietary protein reduction (HF/LP) on animal response in a caloric stress condition. It could be hypothesized that the SEQ program affected ADG by having influence on the hormonal secretion cyclic variation over the day. Greater circulating levels of insulin in the first hour of the day was observed (Koopmans et al., 2005). In this sense, there is a nonnegligenciable variation in insulin-stimulated AA and glucose utilization during the day-cycle which is characterized by greater efficiency of nutrient metabolism in the first hours of the day (Koopmans et al., 2006). In addition, protein diet variation over the day (higher protein diet level in the morning and lower in the evening) increase insulin levels in the morning with consequent better body weight gain (Xie et al., 2015). Due to different CP diet levels for

the SEQ programs (17% less for HF/LP than CON diet), we understand that the supply of different concentrations of CP together with hormonal variation throughout the day, might have improve the efficiency of nutrient utilization with consequence effect on ADG.

In the finishing phase, the results of the present study confirm that using HF/LP diets compared to CON improve feed intake (+12%) and weight gain (+10%) for pigs raised under high ambient temperatures (Figures 1A and 1B). These results are consistent with previous literature (Spencer et al., 2001) who also reported performance improvement in heat-stressed finishing pigs fed high-fat diets. Between this diets, the difference of NE intake was 20% (19.23 vs. 24.11 MJ/d) which also resulted in higher values of fat mass and fat mass gain for HF/LP program (Figures 1A and 1B; period 2 and the entire period). These results are in agreement with those obtained by Campbell et al. (1988) and Le Bellego et al. (2001), who observed higher deposition of fat in the carcass with increase of NE levels in the diets. However, the literature shows great variability of results related to NE intake and pig carcass composition. Possibly factors such as genetic, age at slaughter, environmental temperature and condition of housing (group or individual) may interfere in the composition of the carcass. In addition, the HF/LP diet was formulated for higher NE content (see Table 1) which possibly accentuated these results. Although fed pigs HF/LP had better ADG and ADFI, different NE content of the diet should be better evaluated in other studies to try to optimize energy cost of gain compared to control diet. However, understanding how pigs housed group respond for energy in heat stress may not be simple due many factors that can affect it (animal competition for feed, space, sanitary conditions, etc.).

In this finishing phase, in contrast to our results where the feed efficiency was not affected by feeding programs, Le Bellego et al. (2002) observed better feed conversion (6.5%) for pigs of 64 to 100 kg BW fed with low CP and high NE diets compared to control diet under temperature of 29°C. In another study, Kerr et al. (2003) did not observe difference in feed

efficiency between diets varying CP and EM content (16% CP; 12% CP + AA and 12% CP) for pigs kept at a constant temperature of 33°C. In fact, many factors affected feed efficiency and diet energy concentration is only one of them (Patience, 2012). Thus, this seems to be more pertinent to define feed efficiency in terms of net energy cost of gain (Patience, 2012).

In our experimental conditions, a worst energy cost of gain was observed for fed pigs HF/LP diet (+14%) compared to CON (Figure 1E; finishing phase). This is consequence of the lower increased of ADG compared to ADFI (10 vs 12%) associated with the greater NE intake (+25%) for HF/LP fed pigs, which also resulted in greater fat mass e gain for this program (Figures 2A and 2B; last and entire periods). This worst energy cost for fed pigs HF/LP diet disagrees with previous results of Le Bellego et al. (2002), who reported identical values for energy cost compared control diet (protein and energy) for pigs housed individually in an constant temperature over the day (29°C). The present results of this study were obtained with pigs housed in group and, unlike of Le Bellego et al. (2002), the ADFI for pigs fed HF/LP improved compared to those fed CON diet (Figure 1A). It should be noted that pigs housed individually compared to group showed different performances (Bornett et al., 2000) and this difference may become more evident in a limiting conditions (temperature, nutrition, health challenge, etc). As the animals at high temperature have their consumption regulated by the heat dissipation capacity, the higher ADFI of the pigs when fed by the HF/LP diet can be explained by the lower caloric increment of the lipid besides the increase of the palatability of the feed with the inclusion of soybean oil (Wolp et al., 2012; Kerr et al. 2015). In addition, sequential feeding allowed reducing NE intake (-12%) and had a similar ADFI, ADG and energy cost of gain in relation to HF/LP program for finishing phase (Figure 1). This better result on NE intake can be explained by the simple fact of fed pigs with different diets over the 24h period (control diet at 22ºC and HF/LP at 30ºC period; SEQ) which allowed reducing it for whole period.

In relation to lean mass and gain, results of this study showed that were not affect by feeding programs. This results agree with previous result of Silva et al. (2017), who reported similar lean mass gain for pigs fed higher AA diet content in the morning (from 1200h pm to 1200h am) and lower in the evening (from 1200h am to 1200h pm) compared to control diet over the day. Consequently similar results for lean mass and gain obtained in our study for HF/LP and CON programs, indicating that reduction of up to 4% CP with adequate amino acid supplementation does not affect the lean composition of the pig carcass under cyclic heat stress.

Effect of a genetic line on performance and body composition of pig exposed to a cyclic heat stress

The results of this study showed that genetic lines responded differently to cyclic thermal stress. The higher AFI per hour at 30ºC and higher final BW (11%) could suggest that line B is more tolerant to heat stress. Indeed the difference between lines was accentuated over the experimental period, with higher ADFI, ADG, NE intake and consequently, higher values of fat mass and gain for line B. Therefore, the lower capacity of thermoregulation of line A associated to the different CP level of feeding programs, may have determined the interaction for CP intake in finishing phase. The different results of CP intake between programs only for line A in this experimental phase, may be due to their lower heat tolerance and consequently, their greater sensitivity to composition of diets.

In relation to body composition, although lean gain was similar between lines in periods 1 and 2, higher loin depth was observed in the period 2 for the animals of the line A indicating that the genetic potential of this line (higher % Pietrain) was expressed although of ambient temperature oscillations. In the entire period was observed higher lean mass gain for line B (+ 7%), but this may have occurred due to the higher performance and adaptation to the experimental condition of this line.

Regardless of the genetic line, fed pigs SEQ presented higher final body weight (+ 4.0 kg per animal) compared to CON, but with a significant effect on fat mass and gain. Despite this, the SEQ could be an interesting economic advantage in the pork market which benefits the total BW instead of leaner meat. However, studies are needed to evaluate the dynamics of the feeding behavior of pigs fed SEQ program, in order to better understand how the variation of NE and CP during day could contribute with the composition of the pig carcass under heat stress. In relation to HF/LP, due the similarity of the performance results, the present experiment confirms that the supply of different diets adjusted to the variation of the temperature and hormonal secretion along the day (SEQ feeding system), can attenuate the negative effects of cyclic heat in pig production. As feed represents great part of the cost in pig production, sequential program could also be economically advantageous compared to HF/LP because it allow reduce the NE diet concentration (less oil).