Effects of State of Boar on Nutrients Digestibility, Nitrogen Balance, Backfat Measurements, Cut-up Parts and Organ Weights of Finishing Pigs

Chiemeka Promise NJOKU (✉)
Olajide A. ADEYEMI
Olajide Mark SOGUNLE
Ayobami B. Joseph AINA
Oluseyi Olutosin ODUGUWA

Summary

A study was conducted to determine the nutrients digestibility, backfat composition, cut-up parts and organ weights of intact and castrated finishing pigs. Forty eight Large White male pigs with initial average weight of 36.82±0.45 kg were randomly assigned to two treatments with each treatment consisting of three replicates of eight pigs each. Twenty four of the experimental animals were castrated while the remaining twenty four were left intact. Four pigs per replicate were selected and housed in metabolic cages to determine nutrient digestibility and carcass evaluation was performed when the pigs in each experimental group attained an average weight of 70 kg in order to verify the backfat composition, cut-up parts and organ weights. The experiment was arranged in a Completely Randomised Design. Dry matter intake, excreted faeces/dry matter intake, dry matter digestibility, crude protein digestibility, nitrogen intake, absorption and retention were significantly ($P<0.05$) influenced by state of boar. Castrated boars had higher mean values in these parameters except in excreted faeces/dry matter. Intact boars had higher significant ($P<0.05$) mean values in liver (1.98%), kidney (0.20%) and heart (0.22%) weights in comparison with the corresponding values (1.57, 0.12 and 0.12%, respectively) recorded for castrated boars. Subcutaneous fat depth and fat free index were significantly ($P<0.05$) influenced by state of boars. Intact boar recorded better value (49.07) for fat free index when compared to 43.46 obtained by the castrated boar. It was concluded that state of boar had effect on nutrient digestibilities, organ weights (liver, kidney and heart weights) and backfat deposits (subcutaneous fat depth and fat free index) of finishing pigs.

Key words

castrated, digestibility, intact, nutrient, subcutaneous fat

Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
✉ e-mail: ncfred0859@yahoo.co.uk

Received: October 29, 2013 | Accepted: June 5, 2014

Introduction

Attaining and sustaining food security are among the major goals of world leaders across the globe. About 842 million people in the world were unable to meet their nutritional requirements in 2013 (FAO *et al*, 2013). Governmental programmes, policies and projects are therefore aimed at ensuring regular food supply (especially those with high biological values like animal protein), local availability of food stuffs, food safety, affordability and accessibility. These goals have mounted pressure on livestock industries in devising means of increasing productivity and as well meeting the consumers' preference. Consumer preferences are changing on regular basis and demand is moving away from traditional heavily fatted breeds of livestock to light leaner breeds.

High demands for lean pork and producers' interest in attaining production efficiency have inspired the pork industry to look into new strategies to improve lean accretion in pigs meant for pork production. Castration of male piglets is one of the management practices done way back to human domestication of animals (Xue *et al.*, 1997). It is done in most parts of the world for several reasons including control breeding, removal of boar taint, increased docility and increasing utility in pork consumption by meeting up with consumers' preference. About 75% of consumers find boar taint offensive due to its unpleasant smell and taste (Banon *et al.*, 2004). Androstenone (largely secreted in the testis) and skatole (produced by bacteria in the intestine of pigs) are compounds primarily responsible for boar taint which are stored in the fat tissues of the pigs (Xue and Dial, 1997).

Literature is dotted with growth performance and carcass characteristics differences between castrated and intact boars. It has been documented that intact boars have reduced feed intake, improved feed efficiency, less backfat and leaner carcass when compared with their castrated counterparts (Njoku *et al.*, 2013). The improved growth performance and carcass characteristics of intact boars are primarily due to the anabolic effects of androgens and estrogens produced in the testes (Hancock *et al.*, 1991; Sawyer and Barker, 1988). Although, adequate information exist in literature on growth performance and carcass characteristics differences between castrated and intact boars, yet only a hand full of information exist on nutrient digestibility and organ weight of castrated and intact boars. Hence, this study is aimed on investigating the differences in nutrient digestibility, cut-up parts, backfat deposition and organ weights of castrated and intact boars.

Materials and methods

Experimental animals and their management

This study protocol was approved and conducted in accordance with the Animal Ethics Committee guidelines of the Federal University of Agriculture, Abeokuta, Nigeria. It was carried out at the piggery unit of the Directorate of University Farms, Teaching and Research Section of the University. Forty-eight (48) weaner Large White male pigs with mean body weight of 36.82±0.45 kg were assigned to two treatments in a completely randomized design. The pigs were grouped based on weight equalization to two treatments (castrated and intact) of twenty four (24) pigs each. Each treatment was replicated thrice to consist of eight pigs per replicate. Twenty four of the experimental animals were castrated by surgical method while the other twenty four were left intact. The pigs were housed in a naturally ventilated individual pen with floor size area of 2 m^2 and were individually fed. Fresh water was supplied daily *ad libitum*.

Table 1. Composition of experimental diet (%)

Ingredients	Fattener ration
Maize	47.00
Groundnut cake	14.00
Wheat offal	24.00
Palm kernel cake	12.50
Bone meal	2.00
Premix*	0.20
Common salt	0.20
Lysine	0.05
Methionine	0.05
Total	100.00
Analysis results	
Crude protein (%)	16.48
Crude fibre (%)	6.48
Calcium (%)	0.54
Phosphorus (%)	0.25
ME (Kcal DE kg)	2986.70

*To supply the following per kg diet: Vit. A 12600 IU; Vit. D_3 2800 IU; Vit. E 49 IU; Vit. K_3 2.8 mg; Vit. B_1 1.4 mg; Vit. B_2 5.6 mg; Vit. B_6 1.4 mg; Vit. B_{12} 0.014 mcg; Niacin 21 mg; Pantothenic Acid 14 mg; Folic Acid 1.4 mg; Biotin 0.028 mcg; Choline Chloride 70 mg; Manganese 70 mg; Zinc 140 mg; Iron 140 mg; Copper 140 mg; Iodine 1.4 mg; Selenium 0.28 mg; Cobalt 0.7 mg; Antioxidant 168 mg.

Dietary treatment

Feeding was carried out at 07:00 and 13:00 hours each day throughout the experimental period. The carcass analysis was carried out when the pigs attained the average slaughtering weight of ≥70 kg. Diets were formulated to meet the body requirements of growing pigs. The ration contained 16.48% crude protein and metabolisable energy of 2986.70 kcal DE/kg (Auto Feed Formulator Master, NRC) as shown in Table 1. The diet was based on feed composition used for finishing pigs at Teaching and Research Farm of Federal University of Agriculture, Abeokuta that was developed in line with the recommendation of Merck (2011).

Digestibility study

Four pigs with average body weights of 56.82±0.45 kg from each replicate were selected and arranged in clean, disinfected metal metabolic cages in between the experiment. A 7-day adaptation period followed a 5-day of quantification of feed intake, excreted faeces and urine. Faeces and urine were collected quantitatively and stored in a freezer until analyzed. To avoid ammonia losses, urine was collected into bottles with H_2SO_4 (20%, v/v) to keep pH below 3. After the collection periods, faeces and urine were thawed and homogenized separately. Faeces were dried in a forced air cabinet. Sub samples of 200 g (faeces) and 50 ml (urine) were taken and stored frozen until analyzed. The oven-dried faeces and feed materials were milled to 2 mm particle size and analysed for their proximate constituents. Following AOAC (2005) protocols, the dry matter of the samples was determined by drying at 105°C for 4 hours. The crude protein (CP) concentration of samples was determined by the Kjeldahl method and the ether extract by a Soxhlet apparatus. The crude fibre (CF) concentration was determined using trichloroacetic acid digestion reagent, and concentration of ash was determined by incinerating samples at 550ºC for 5.5 hours.

Cut parts, organ weights and backfat measurements of intact and castrated boars

For the evaluation of above parameters, two pigs with average body weight of 70 kg per replicate were selected and slaughtered in order to determine the cut parts, organ weights and backfat composition at the end of the experiment. The pigs were fasted for 16 hours, and the fasted weight of each pig meant for slaughtering was taken before they were stunned by percussion method and bled by incision using a sharp knife cutting through the jugular vein between the skull and the atlas. Complete bleeding and dehairing were done. The stomach of the pigs was opened along the greater curvature and emptied. The head was removed by section at the occipito-atlas joint and the feet by sawing through the hock joint at a right angle to the long axis of the leg. The carcass was divided longitudinally. The left half of the carcass was dissected as described by Barca *et al.* (2006). Ham was separated by locating the division between the 2nd and 3rd sacral vertebrae and saw perpendicularly along axis of the ham. Shoulder of the pig was separated from the loin and belly by a straight cut between the second and third ribs and a straight cut 2.5 cm ventral to the ventral edge of the scapula. The parts were weighed and recorded. The visceral organs were removed and weighed using digital sensitive scale. Back-fat depth was taken at the last rib using vernier calliper. The fat-free index was estimated using the formulae postulated by National Pork Producers Council (2000). Fat-free index = 50.767 + (0.035 x hot carcass weight, kg) – (8.979 x last rib midline back-fat on hot carcass, cm).

Statistical analysis

Studentized t-test at 5% significant level was used to compare means between variables.

Results

Effect of state of boar on nutrient digestibility of finishing pigs

Feed intake, dry matter intake, excreted faeces/dry matter intake, dry matter digestibility, crude protein digestibility, ether extract, crude fibre digestibility and ash were significantly (P<0.05) different as depicted in Table 2.

The castrated boar recorded higher mean values on feed intake (1.67 kg/day), dry matter intake (1.56 kg/day), dry matter digestibility (74.32), crude protein digestibility (79.64), ether extract (78.04), crude fibre (53.83) and ash (46.45) while their lower corresponding values 1.25 kg/day, 1.18 kg/day, 68.84%, 76.72%, 61.53%, 32.51% and 36.13%, respectively were noted for the intact boar. The higher excreted faeces/dry matter intake of 0.67 kg was noted for the intact boars while the castrated had a lower value of 0.57 kg.

Effect of state of boar on nitrogen balance of finishing pigs

The nitrogen intake, nitrogen absorption and nitrogen retention were significantly (P<0.05) influenced by the state of boar (Table 3). Castrated boar had higher value of 39.77 g/day of nitrogen intake compared to 34.68 g/day of the intact boar.

Table 2. Effect of state of boar on nutrient digestibility of finishing pigs

Measurements	Intact boar	Castrated boar	SEM
Feed intake (kg)	1.25b	1.67a	0.06
Dry matter intake (kg)	1.18b	1.56a	0.06
Excreted faeces (kg)	0.79	0.88	0.03
Faecal dry matter output (kg)	0.35	0.38	0.02
Excreted faeces/dry matter intake	0.67a	0.57b	0.03
Dry matter digestibility (%)	68.84b	74.32a	1.78
Crude protein digestibility (%)	76.72b	79.64a	1.64
Ether extract (%) of faeces	61.53b	78.04a	6.49
Crude fibre digestibility (%)	32.51b	53.83a	4.11
Ash (%) of faeces	36.13b	46.45a	2.02

ab - means within rows followed by different superscripts are significantly (P<0.05) different

Table 3. Effect of state of boar on nitrogen balance of finishing pigs

Measurements	Intact boar	Castrated boar	SEM
Urine output (g)	960.00	833.33	123.54
Nitrogen intake (g/day)	34.68b	39.77a	1.41
Faecal nitrogen (g/day)	7.06	8.01	0.42
Urinary nitrogen (g/day)	2.84	3.05	0.44
Nitrogen absorption (g/day)	27.63b	31.76a	1.10
Nitrogen absorption (%)	78.84	79.63	1.65
Nitrogen retention (g/day)	24.79b	28.70a	0.78

ab - means within rows followed by different superscripts are significantly (P<0.05) different

The higher nitrogen absorption (31.76%) and nitrogen retention (28.70%) were obtained by the castrated boar while the intact boars had 27.63% and 24.79% in that order.

Effect of state of boar on back fat composition of finishing pigs

As depicted in Table 4, subcutaneous fat depth "C" and "K" and fat free index were significantly (P<0.05) influenced by state of boar. The castrated boars recorded the highest subcutaneous fat depth "C" (1.37 cm) compared to 1.01 cm obtained for the intact boars. The subcutaneous fat depth "K" ranges from 1.54 cm (intact boars) to 2.55 cm (castrated boars). The intact boars had higher (P<0.05) fat free index value of 49.07 compared to 43.46 of castrated boars. Castrated boars recorded higher longissimus dorsi muscle "A" (7.70 cm) when compared to 7.08 cm noted for the intact boars. Also, higher numerical values were recorded among the castrates in longissimus dorsi muscle "B", fat at first and last ribs.

Cut-up parts and organ weights of castrated and intact finishing pigs

The effect of state of boar on cut parts and organ weights of finishing pigs is presented in Table 5. Fasted weight was significantly (P<0.05) affected by the boar type. Higher fasted weight (73.67, 67.00 kg) was recorded for the castrated boar. Similar statistical mean values (P>0.05) were observed in all the parameters

Table 4. Effect of state of boar on back fat composition of finishing pigs

Measurements	Intact boar	Castrated boar	SEM
Live weight (kg)	69.33	76.17	2.07
Hot carcass weight (kg)	54.58	59.55	2.16
Longissimus dorsi muscle 'A' (cm)	7.08	7.70	0.22
Longissimus dorsi muscle 'B' (cm)	3.70	4.34	0.20
Depth of fat at first rib (cm)	3.03	4.14	0.14
Depth of fat at last rib (cm)	1.67	2.24	0.14
Subcutaneous fat depth 'C' (cm)	1.01b	1.37a	0.09
Subcutaneous fat depth 'K' (cm)	1.54b	2.55a	0.10
Fat free index	49.07a	43.46b	0.49

ab - means within rows followed by different superscripts are significantly (P<0.05) different; "A" (cm) Maximum width of the longissimus dorsi muscle at the widest point; "B" (cm) Maximum of the longissimus dorsi muscle at the greatest depth and perpendicular to the point A measurement; "C" (cm) Subcutaneous fat depth immediately above the B measurement; "K" (cm) Subcutaneous fat depth at the dorso-lateral edge of the Longissimus dorsi muscle

Table 5. Effect of state of boar on carcass characteristics of finishing pigs

Measurements	Intact boar	Castrated boar	SEM
Cut parts (% Live weight)			
Head weight (%)	9.47	9.24	0.34
Ham weight (%)	12.76	11.99	0.45
Shoulder weight (%)	10.46	10.57	0.46
Fore-leg weight (%)	0.83	0.73	0.05
Hind-leg weight (%)	1.14	1.06	0.04
Offal weight (% Live weight)			
Liver weight (%)	1.98a	1.57b	0.04
Lung weight (%)	0.79	0.79	0.03
Kidney weight (%)	0.20a	0.12b	0.01
Heart weight (%)	0.22a	0.12b	0.01
Spleen weight (%)	0.18	0.09	0.03

ab- means within rows followed by different superscripts are significantly (P<0.05) different

considered for cut parts of intact and castrated boars. Higher numerical value of 10.57% was noted for castrated boars' shoulder weight in comparison with 10.46% documented for their intact counterparts. Intact boars had higher numerical values in head, ham, fore-leg and hind-leg. Also, higher significant values (P<0.05) in liver (1.98 %), kidney (0.20%), and heart (0.22%) weights were documented for the intact boars when compared to their corresponding values (1.57, 0.12 and 0.12%, respectively) recorded for castrated boars.

Discussion

Castrated boars had a higher rate of feed consumption, resulting into higher dry matter intake. This might be due to the energy requirement of castrated boars that is higher than that of intact boars; since the energy requirement for fat accretion is more than the energy required for protein accretion. This observation is in agreement with the findings of Ravi *et al.* (1999) and Balaji *et al.* (2006) who reported that the average daily dry matter intake was more in castrated boars than the intact ones. It contradicted the findings of Niba *et al.* (2005) who reported no significant difference in daily dry matter intake of castrated and intact boars.

Several factors have been investigated as influencing digestive indices in pigs. Some of these factors include sex, body weight, age (Everts *et al.*, 1986; Noblet *et al.*, 1993a), genotype and diets (Boorman, 1980). Result of nutrient digestibility coefficients in this study showed that significant differences existed between castrated and intact boars in dry matter, crude protein, ether extract, crude fibre digestibilities, excreted faeces/dry matter intake and ash. The higher digestibility coefficients noticed in dry matter might be attributed to the weight difference between the castrated and intact boars, as it has been well documented that dry matter digestibility increased with higher body weight gain in pigs (Lemus *et al.,* 2010; Morel *et al.*, 2006; Le Goff and Noblet, 2001; Noblet *et al.*, 1993b). Also, higher digestibility values in crude fibre, ether extract, crude protein and ash in castrated than intact boars might be traced to increased weight of castrated boars (Noblet and Le Goff, 2001) or an increased size of the hindgut with increasing live weight and feed intake of the animals, leading to a lower rate of digesta passage and increased degradation of undigested carbohydrates in the large intestine (Noblet and Le Goff, 2001). These changes will improve the ability of the pigs to digest dietary fibre and consequently energy and protein, which are the primary need of the pig for growth. The findings in this study contradicted the observation of Wenk and Morel (1985) who observed no changes of importance between castrated and intact boars when digestibility coefficient was evaluated.

There was no significant difference between castrated and intact boars for faecal nitrogen and urinary nitrogen output. This might be due to the same diet fed to the animals that had no variability in composition. Ly (2008) also did not find any effect of sex on faecal nitrogen and urinary nitrogen output. The significant difference observed in nitrogen intake between castrated and intact boars might be linked to the level of feed intake, as the slightest increase in feed intake will invariably increase the crude protein intake by pig. Hansen and Lewis (1993) reported that nitrogen intake increased linearly as dietary level increased for all sexes, and there was an increase in nitrogen intake as the pigs gained weight. It was observed that the castrated boars had higher nitrogen absorption when compared with intact boar. This could be linked with increase in nitrogen digestibility that was observed in the castrated boars during the growing period. There is a positive relationship between nitrogen digestibility and nitrogen absorption, so the higher the nitrogen digestion, the higher the absorption (Fuller and Chamberlin, 1983; Hansen and Lewis, 1993). The higher nitrogen retention in the castrated boar than in the intact might stem from the corresponding increase in endogenous nitrogen losses (Blank, 2009) that were more in castrated boar than in the intact boar. Endogenous nitrogen have been defined as digestive secretions and sloughed epithelial cells released in the lumen of the intestine of pigs, and almost one quarter of which is not reabsorbed before reaching the end of the ileum (Souffrant, 1991).

From the digestibility study of this current experiment, intact boar had higher tendency of retaining nitrogen over a period of time than castrated boar (barrow) from the diet formulated. It has been documented that barrows had inherent lower capacity for protein deposition and a higher rate of fat accretion, and require less dietary protein and amino acids to support maximum growth than intact boars (Xue *et al*., 1997; Yen *et al*., 1986 a, b; Campbell *et al*, 1985; Williams *et al*., 1984). The result obtained from this study is in agreement with these findings. The barrows had higher numerical values in fat at first and last ribs, though not significant. Significant values obtained in the subcutaneous fat (C and K) with castrates having higher values could indicate the fact that absence of sexual hormones would have favoured the deposition of fat (Niba *et al*., 2005). Several other authors (Latorre *et al*., 2004; Hamilton *et al*., 2000; Ellis *et al*., 1996; Leach *et al*., 1996) reported that carcasses from barrows were fatter when compared to the carcasses from gilts. Xue *et al*. (1997) stated that amino acid requirements for lean accretion are higher for intact boars than barrow littermates. Since, intact boars and barrows were fed the same diet; the intact boars must have utilized the protein and energy components of the diet more efficiently for lean accretion than the barrows. This attests to the significant value obtained in fat free index. Xue *et al*. (1997) documented that the improvements in growth and carcass characteristics of intact boars were primarily due to anabolic effects of androgens and estrogens produced in the testis.

All measurements for primal cuts were largely similar with the intact boars having higher numerical values in head, ham, fore-leg and hind-leg weights. The higher values could indicate the implication of sexual hormones in the growth and development of muscle and bone metabolism (Niba *et al*., 2005). Likewise, the internal organs like the liver, kidney and heart weights were significantly influenced by sex, with the higher values documented for the intact pigs. The greater values in the internal organs could be a result of compensatory growth that occurs principally in internal organs (Heyer and Lebret, 2007; Bikker *et al*., 1996; Mersmann *et al*., 1987). This compensatory growth is due to an improved feed conversion ratio that occurred without an increased feed intake (Oksbjerg *et al*., 2002; Therkildsen *et al*., 2004). This could explain the similar carcass weight obtained in this study.

Conclusion

Better nutrient digestibilities (dry matter, crude protein, ether extract, crude fibre digestibilities, nitrogen intake, absorption and retention) were recorded for castrated boars while intact boars had better visceral organs, subcutaneous fat (fat depth and fat free index) in this present study. Hence, castrated boars can be slaughtered at lighter body weight and age for leaner carcass since it has better nutrient digestibilities than their intact counterparts.

References

A.O.A.C. 2005. Official Method of Analysis of AOAC International. Official Method, 18th edition, AOAC International, Gaithersburg, MD 982.30 (a,b,c)

Balaji, N.S., Sivaraman, T., Sivakumar, T. and Ramesh, V. 2006. Influence of castration on growth rate and body measurements in Large White Yorkshire pig. *Indian J. Anim. Research* 40(2): 123-126

Banon, S., Andreu, C. and Laencina, J. 2004. Fresh and eating pork from entire and castrate heavy males. *Food Quality and Preference* 3: 293-300

Barca, R., Nieto, R., Lara, L., Garcia, M.A., Vilchez, M.A., Aquilera, J.F. 2006. Effects of dietary protein content and feeding level on carcass characteristics and organ weights of Iberian pigs growing between 50 and 100 kg liveweight. *Animal Science* 82: 405-413

Bikker, P., Verstegen, M.W.A., Kemp, B. and Bosch. M.W. 1996. Performance and body composition of finishing gilts (45 to 85 kilograms) as affected by energy intake and nutrition in earlier life: I. Growth of the body and body components. *Journal of Animal Sci*ence 74: 806–816.

Blank, B. 2009. Studies on the threonine requirement in growing pigs. PhD Thesis, University of Kiel, Germany

Boorman, K.N. 1980. Dietary constraints on nitrogen retention. In: Buttery, P.J. and Lindsay, D.B. (Ed.) Protein Deposition in Animals. Pp. 147-166

Campbell, R. G., Taverner, M.R. and Curic, D.M. 1985. Effects of sex and energy intake between 45-90 kg live weights on protein deposition in growing pigs. *Animal Production* 40: 497-503

Ellis, M., Webb, A.J., Avery, P.J. and Brown, I. 1996. The influence of terminal sire genotype, sex, slaughter weight, feeding regime and slaughter-house on growth performance and carcass and meat quality in pigs and on the organoleptic properties of fresh pork. *Anim. Sci*. 62: 521-530.

Everts, J., Smits, B. and Jongbloed, A.W. 1986. Effects of crude fibre, feeding level and body weight on apparent digestibility of compound feeds by swine. *Netherland Journal of Agricultural Science* 34: 501-503

FAO, IFAD and WFP. 2013. The State of Food Insecurity in the World 2013. The multiple dimensions of food security. Rome, FAO. www.fao/docrep/018/i3434e.pdf

Fuller, M.F. and Chamberlin, A. G. 1983. Protein requirements of pigs. In: Recent advances in animal nutrition (W. Haresign ed.) Butterworths. London Pp. 175-186

Hamilton, D. N., M. Ellis, K. D. Miller, F. K. Mckeith, and D. F. Parret. 2000. The effect of the halothane and Rendement Napole genes on carcass and meat quality characteristics of pigs. *Journal of Animal Science* 78: 2862–2867.

Hancock, D.L., Wagner, J.F. and Anderson, D.B. 1991. Effects of estrogens and androgens on animal growth. In Pearson A.M. and Dutson T.R. (ed), Advances in Meat Research: Growth Regulation in Farm Animals. Elservier Applied Science Publisher, Essex, UK. 7: 255-297.

Hansen, B.C. and Lewis, A.J. 1993. Effects of dietary protein concentration (corn:soybean

meal ratio) on nitrogen balance of growing boars, barrows and gilts: mathematical descriptions. *Journal of Animal Science* 71: 2110-2121

Heyer, A. and Lebret, B. 2007. Compensatory growth response in pigs: Effects on growth performance, composition of weight gain at carcass and muscle levels, and meat quality. *Journal of Animal Science* 85: 769-778.

Latorre, M.A., R. Lázaro, D.G. Valencia, P. Medel, and G.G. Mateos. 2004. Effect of gender and slaughter weight on the growth performance, carcass traits, and meat quality characteristics of heavy pigs. *Journal of Animal Science* 82: 526-533.

Leach, L. M., Ellis, M., Sutton, D. S., McKeith, F. K. and Wilson, E. R. 1996. The growth performance, carcass characteristics, and meat quality of Halothane carrier and negative pigs. *Journal of Animal Science* 74: 934–943.

Le Goff, G and Noblet, J. 2001. Comparative total tract digestibility of dietary energy and nutrients in growing pigs and adult sows. *Journal of Animal Science* 79:2418-2427

Lemus, C., Huerta, R., Grageola, F., Ramirez, H., Diaz, C. and Ly, J. 2010. Effect of body weight and sex on rectal digestibility of nutrients and faeces output in Mexican Cuino pigs. Zootecnia Trop. 28(2): 213-219.

Ly, J. 2008. Studies on factors affecting faecal output in growing pigs. An approach to the effect of level of feed intake and of sex. Revista Computadorizada de Produccion Porcina 15(3): 255-260

Mersmann, H.J., MacNeil, M.D., Seideman, S.C., Pond, W.G., 1987. Compensatory growth. in finishing pigs after feed restriction. *Journal of Animal Science* 64: 752–764

Morel, P. C., J. C. McIntosh, and J. A. M. Janz. 2006. Alteration of the fatty acid profile of pork by dietary manipulation. *Asian-Australian Journal of Animal Science* 19: 431–437.

National Pork Producers Council, 2000. Pork composition and quality assessment procedures. Edited by Dr. Eric Berg; published by National Pork Producers Council, Des Moines, Iowa 515: 223-2600

Niba, A.T., Boukila, B., Fontheh, F.A., Djoukam, J., Tchoumboue, J. and Ngoua, F.N. 2005. Effect of castration and protein level of diet on the growth performance of piglets. *Cameroon Journal of Experimental Biology* 1: 15-20

Njoku, C.P., Aina, A.B.J., Sogunle, O.M and Idowu, Oduguwa, O.O. 2013. Growth performance, linear body measurements and carcass characteristics of intact and castrated growing pigs. Indian Journal of Animal Science 83(6): 636-640

Noblet, J. and Le Goff, G. 2001. Effect of dietary fibre on the energy value of feeds for pigs. *Animal Feed Science Technology* 90: 35-52

Noblet, J., Shi, X. S. and Dubois, S. 1993a. Metabolic utilization of dietary energy and nutrients for maintenance energy requirements in sows: basis for a net energy system. *British Journal of Nutrition* 70: 407-419.

Noblet, J., Shi, X. S. and Dubois, S. 1993b. Energy cost of standing activity in sows. *Livestock Production Science* 34: 127-136.

Oksbjerg, N., Sorensen, M. T. and Vestergaard, M. 2002. Compensatory growth and its effect on muscularity and technological meat quality in growing pigs. Acta Agriculture and Scandinavica Animal Science 52(2): 85-90

Ravi, A., Rao, D. S., Reddy, K. K. And Rao, Z. P. 1999. Growth response and carcass characteristics of crossbred barrows fed rations containing urad (Phaseolus mungo) chuni. Cheiron, 28 (4): 102-106

Sawyer, G.J. and Barker, D.J. 1988 Growth promotants in cattle in Australia. *Austr Vet Journal* 65: 101-108.

Souffrant, W. 1991. Endogenious nitrogen losses during digestion in pigs. In: Verstegen, M., Huisman, J., Den Hartog, L. (Eds), Digestive Physiology in Pigs. EAAP Publication, Rome 54: 147-166

Therkildsen, M., Vestergaard, M., Busk, H., Jensen, M. T., Riis, B., Karlsson, A. H.,

Kristensen, L., Ertbjerg, P. and Oksbjerg, N. 2004. Compensatory growth in slaughter pigs–in vitro muscle protein turnover at slaughter, circulating IGF-I, performance and carcass quality. *Livestock Production Science* 88: 63–75.

Williams, W.D., Crowwell, G.L., Stahly, T.S. and Overfield, J.R. 1984. The lysine requirement of the growing boar versus barrow. *Journal of Animal Science* 58: 657-665

Wenk, C. and Morel, P. 1985. Genetic variation of the digestibility of the growing pig. In: Proc. 3rd Sem. Digest. Physiol. Pigs. Just, A., Jorgensen, H. and Fernandez, J.A. (Ed.) Copenhagen, Pp. 396-399

Xue, J.L. and Dial, G.D. 1997. Raising intact male pigs for meat: Detecting and preventing boar taint. *Swine Health and Production* 5(4): 151-158

Xue, J., Dial, G.D. and Pettigrew, J.E. 1997. Performance, carcass and meat quality

advantages of boars over barrows: A literature review. *Swine Health and Production* 5(1): 21-28

Yen, H.T., Cole D.J.A. and Lewis, D. 1986a. Amino acid requirements of growing pigs. The response of pigs from 25 to 55 kg live weight to dietary ideal protein. *Animal Production* 43:141-154

Yen, H.T., Cole D.J.A. and Lewis, D. 1986b. Amino acid requirements of growing pigs. The response of pigs from 50 to 90 kg live weight to dietary ideal protein. *Animal Production* 43:155-165

---

acs79_30