Growth response and nutrient digestibility of growing pigs to qualitative and quantitative feed restriction

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Abstract

Feed restriction is a relevant management tool use in modification of livestock growth patterns by reducing their maintenance requirement, leading to improved feed efficiency and utilization. This study assessed the effect of qualitative and quantitative feed restriction on growth parameters and nutrients digestibility of growing pigs. Fifty four (54) mixed breed pigs with initial body weight of 6.72 ± 0.38 kg were arranged in a 3x3 factorial arrangement for a 150-day study: Factor A consists of 3 levels of qualitative feed restriction (20%, 18% and 16% crude protein) and Factor B consists of 3 levels of quantitative feed restriction (ad-libitum, 90% and 80% of ad-libitum feed offered). The experimental animals were grouped on weight equalization into 9 treatment groups of 3 replicates of 2 pigs per replicate. Growth performance data were collected on weekly basis and nutrient digestibility was carried out on the 11th week of the experiment. Data obtained were subjected to two-way analysis of variance. Final body weight, daily weight gain and daily feed intake were significantly ($p < 0.05$) influenced by increment in dietary crude protein. The pigs fed 20% crude protein recorded the best FCR of 1.36. Quantitative feed restriction had no influence on the growth parameters studied. Feed quality and quantity offered had significant ($P < 0.05$) influence on excreted faeces, faecal dry matter output, excreted faeces/dry matter intake, dry matter digestibility, crude protein digestibility, ether extract, crude fibre digestibility and ash. Similar ($P > 0.05$) mean values of excreted faeces, faecal dry matter output, excreted faeces/dry matter intake, crude protein digestibility, crude fibre digestibility, ash and ether extract were recorded for pigs fed 18% and 16% of crude protein respectively. It can be concluded from this study that a combination of qualitative and quantitative restriction (at 18% crude protein with 80% of ad libitum feed offered) can be used as management tool to improve feed utilization in growing pigs.

Keywords: Qualitative, quantitative, restriction, growth, nutrients, pigs

Introduction

Nutrients requirement is defined as the minimum amount of nutrients that is integrated into ration to meet the daily requirement of a normal healthy animal (Scott *et al.*, 1989). Nutrient remains the most vital single factor under the environment which plays a significant role since it accounts for 70-75% of total

variable cost of production of poultry, rabbits and pigs (Njoku *et al.*, 2013). Nutrition entails the process of supplying the body cells of an animal with the quota of the external environment required for optimum functioning of metabolic chemical reaction requisite for growth and development. A balanced nutrient is a key to a successful livestock production as it provides animal with energy and nutrients

that are essential for health and efficient production. Feeding livestock with incorrect or unbalanced nutrient will result to a negative influence on final body weight, feed efficiency and carcass fat that might lead to processing difficulties. Feed intake is phenotypically positively correlated with other important economic traits such as growth rate and backfat composition (Caiet *al.*, 2008; Hoqueet *al.*, 2009). Genetic improvement has resulted to loss of sensitivity to regulate feed intake especially in fast growing farm animals like pigs and broiler chickens. Richards (2003) postulated that livestock species selected for rapid weight gain and muscular mass deposition do not regulate their voluntary feed intake under *ad libitum* feed management; they show irrational appetite and excessive fat accumulation.

Management practices leading to improve feed efficiency in pig production is essential, as profitability in pig industry is dependent on the efficiency of feed conversion, price of feed, pig genotype and the price for market pigs at a particular time. Feed restriction is one of the management practice used to modify the patterns of livestock growth by reducing their maintenance requirement leading to improved feed efficiency. It is the act of denying fast growing animal full access to nutrient required for tissue growth and development. It helps to reduce the problem of sudden death syndrome (Gonzales *et al.*, 1999), decreased back fat composition, lower cost of production and feed conversion ratio (Njoku *et al.*, 2012). Feed restriction includes quantitative and qualitative restriction, i.e. a quantitative restriction involves limiting the amount of daily feed offered to an animal whereas a qualitative restriction is related to nutrient dilution in the ration

(Lesson and Zubar, 1997). To date, studies on feed restriction were mostly conducted in the temperate region of the world, with little information on the tropical hot humid environment. The purpose of this study was to validate the effects of quantitative and qualitative feed restriction on the growth performance and nutrients digestibility of growing pigs raised under hot humid environment.

Materials and Methods

The experimental protocols involving the use of animals were in compliance with the animal welfare requirements for care and management of experimental animal and was approved by the Animal Welfare Committee of the Federal University of Agriculture, Abeokuta

Experimental Site

The experiment was carried out at the Piggery Unit of the Teaching and Research Farms Directorate (TREFAD), Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The farm lies within latitude 7°10'N, longitude 3°2'E and altitude 76 mm. It is located in the derived savannah zone of South-Western Nigeria. It has a humid climate with mean annual rainfall of about 1037 mm and temperature of about 34.7°C. The relative humidity ranges from 63 to 96% in the rainy season (late March to October) and from 55 to 82% in the dry season (November to early March) with an annual average of 82%. The seasonal distribution of annual rainfall is approximately 44.96 mm in the late dry season (January-March); 212.4 mm in the early wet season (April-June); 259.3 mm in the late wet season (July-September) and 48.1 mm in the early dry season (October-December) as documented by Federal University of Agriculture, Abeokuta Meteorological Station.

Experimental Animals and Management

A total of fifty four (54) mixed breed pigs weighing 6.72 ± 0.38 kg were bought from reputable farm within Abeokuta metropolis. The pigs were grouped on weight equalisation into (9) treatments with 3 replicate of 2 pig per replicate. The floor of the housing unit was washed with detergent and disinfectant, the pen was repaired and put into good working conditions before the arrival of the experimental animals. On arrival the pigs were given water and feed containing anti-stress and multi-vitamins. The pigs were injected with ivomec® (ivermectine) against endo and ecto-parasites and allowed to acclimatize for one week (7days) before the commencement of the experiment. The pen has a floor area of 3 m by 2 m, equipped with concrete feeding and watering trough. The pens are half-walled of about 1.4-1.6 m high and the rest are open-sided for proper ventilation. Daily routine management practices were carried out on daily basis, fresh water was supplied *ad libitum* throughout the 150 days experimental period.

Experimental Design

The experimental design was a 3x3 factorial arrangement with factor A consisting of three (3) levels of qualitative feed restriction (20%, 18% and 16% crude protein) and factor B involving quantitative feed restriction (*ad libitum*, 90% and 80% of *ad-libitum* feeding). Treatment 1 consists of pigs fed *ad libitum* with daily ration containing 20% crude protein, group 2 was fed *ad libitum* with daily ration containing 18% crude protein, group 3 was fed *ad libitum* with daily ration containing 16% crude protein, group 4 consists of pigs on 90% of *ad-libitum* feeding with 20% crude protein ration, group 5 was fed 90% of *ad-libitum* feeding with 18% crude protein ration, group 6 was fed with 90% of *ad-*

libitum feeding with 16% crude protein ration, group 7 consists of pigs on 80% of *ad-libitum* feeding with 20% crude protein ration, group 8 was fed 80% of *ad-libitum* feeding with 18% crude protein ration, and group 9 was fed 80% of *ad-libitum* feeding with 16% crude protein ration.

Experimental Diets

Three experimental diets were formulated to meet the body requirements of growing pigs as shown in Table 1. The ration contained 20%, 18% or 16% crude protein and metabolisable energy of 2530.50, 2474.39 or 2403.30 kcal DE/kg (Auto Feed Formulator, NRC) for diets 1,2 and 3 respectively. Feed was offered to the experimental pigs at 08:00 hour daily throughout the experimental period.

Data Collection

Initial body weight of the pigs were taken using weighing scale with a 0.05 g precision at the beginning of the experiment and weekly records of change in body weight were subsequently taken and documented. Feed intake was determined daily by subtracting the feed left-over from the feed supplied. The feed conversion ratio was calculated as:

Feed Conversion Ratio

$$= \frac{\text{Average Feed Intake (kg/pig)}}{\text{Average Daily Weight Gain (kg/pig)}}$$

Digestibility Study

On the 11th week of the experiment, the animals were moved into metabolic cages already cleaned and disinfectant for determining their nutrients digestibility. A 7-day adaptation period followed by a 5-day of quantification of feed intake and excreted faeces. Faeces were collected quantitatively and stored in a freezer until analyzed. After the collection periods, faeces were thawed, homogenized and dry in a forced cabinet. Sub-samples of

Table 1: Percentage composition of experimental diets

Ingredients	Diet 1	Diet 2	Diet 3
Maize	29.00	40.00	45.50
Groundnut cake	18.00	13.00	8.00
Wheat offal	30.00	20.00	19.05
Palm kernel cake	19.65	23.65	24.10
Bone meal	2.60	2.60	2.60
Salt	0.35	0.35	0.35
Lysine	0.05	0.05	0.05
Methionine	0.05	0.05	0.05
*Premix	0.30	0.30	0.30
Total	100.00	100.00	100.00
Determined Analysis (%)			
Crude protein	20.30	18.00	16.16
Fat	6.81	7.34	7.26
Crude fibre	5.09	4.47	4.25
Calcium	0.77	0.79	0.84
M.E (Kcal/kg feed)	2677.50	2870.09	2932.37

*To supply the following per kg diet: Vit A 12600 IU; Vit. D3 2800 IU; Vit E 49 IU; Vit K3 2.8 mg; Vit B1 1.4 mg; Vit B2 5.6 mg; Vit. B6 1.4mg; Vit B12 0.014mcg; Niacin 21 mg; Pantothenic Acid 14 mg; Folic Acid 1.4 mg; Biotin 0.028 mcg; Choline Chloride 70 mg; Manganese 70mg; Zinc 140 mg; Iron 140 mg; Copper 140 mg; Iodine 1.4 mg; Selenium 0.28 mg; Cobalt 0.7 mg; Antioxidant 168 mg.

200g(faeces) were taken and stored frozen until analyzed. The frozen faeceswerethawed and oven-dried, the oven dried faeces and feed materials were milled to 2mm particle size and analyzed for their proximate constituents following AOAC(2005) protocols, the dry matter of the samples was determined by drying at 105°C for four 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 wasdetermined by incinerating samples at 550°C for 5.5 hours. The data obtained from digestibility studies wasused for the calculation of dry matter, crudeprotein, ether extract, ash and crude fibre digestibilities. The digestibility of dry matter and nutrients was calculated using the following formula:

Dry matter digestibility is thus calculated as:

Dry matter digestibility (kg) =

$$= \frac{\text{Feed intake (kg/Dm)} - \text{Faecal output (kg/Dm)}}{\text{Feed intake (Kg/ DM)}}$$

Nutrient digestibility (%)

$$= \frac{\text{Nutrient in feed} - \text{Nutrient in faeces} \times 100}{\text{Nutrient in feed}}$$

Statistical Analysis

The experimental layout was a 3x3 factorial arrangement. Data generated weresubjected to a two-way Analysis of Variance using SAS (2000). Significantly (P<0.05) different means among the variables were separated using New Duncan Multiple Range Test as contained in the same statistical package.

Results

Effect of qualitative feed restriction on growth performance of growing pigs

Table 2 shows the effect of qualitative feed restriction on performance of growing pigs. Significant (p<0.05) differences were observed across all parameters considered. Pigs on 20% dietary protein had the highest final weight value of 43.00kg compared to 38.44kgand 35.22kg documented for those on 18% and 16% dietary protein levels, respectively. Pigs on 20% protein restriction level recorded the highest weight

Table 2: Effect of qualitative restriction on growth performance of growing pigs

Parameters/Qualitative Restriction	20%	18%	16%	SEM
Initial weight (kg/pig)	6.78	6.83	6.56	±0.38
Final weight (kg/pig)	43.00 ^a	38.44 ^{ab}	35.22 ^b	±1.91
Weight gain (kg/pig)	36.22 ^a	31.61 ^{ab}	28.67 ^b	±1.74
Daily weight gain (g/pig)	345.00 ^a	301.06 ^{ab}	273.02 ^b	±0.02
Feed intake (kg/pig)	55.81 ^a	43.39 ^b	40.17 ^b	±3.60
Daily feed intake (g/pig)	531.56 ^a	413.21 ^b	382.54 ^b	±0.03
FCR	1.36 ^b	1.40 ^{ab}	1.53 ^a	±0.05

^{ab}- Values with different superscripts within rows are significantly different (P<0.05)

gain of 36.22kg while the least value of 28.67 kg was documented for pigs on 16% dietary protein. Similar statistical values were observed for feed intake and daily feed intake of pigs fed 16% and 18% dietary protein level which differed significantly (P<0.05) from the value obtained for pigs on 20% dietary protein level. Feed conversion ratio decreased significantly (P<0.05) with increase in dietary protein, with the best value of 1.36 noted for pigs on 20% dietary protein while the worst value of 1.53 was documented for pigs on dietary crude protein level of 16%.

Effect of quantitative restriction on growth performance of growing pigs

The final weight, weight gain, daily weight gain, feed intake, daily feed intake were not significantly (p>0.05) influenced by quantitative feed restriction as depicted in Table 3. Initial body weight was not significant.

Interaction between qualitative and quantitative feed restriction on performance of growing pigs

Table 4 shows the interaction between the qualitative and quantitative feed restriction on growth performance. Final weight, weight gain, daily weight gain were not significantly (p<0.05) influenced by the interaction between quantitative and qualitative feed restriction while feed intake, daily feed intake and FCR were significantly (p<0.05) influenced. The pigs fed 20% dietary protein at *ad libitum* recorded highest values of feed intake, daily feed intake and FCR.

Effect of Qualitative Feed Restriction on Nutrient Digestibility of Growing Pig

Effect of qualitative feed restriction on nutrient digestibility is shown in Table 5. Feed intake and dry matter intake were not significantly (P>0.05) influenced by the

Table 3: Effect of quantitative restriction on growth performance of growing pigs

Parameters/Quantitative Restriction	<i>Ad-libitum</i>	90% <i>ad libitum</i>	80% <i>ad libitum</i>	SEM
Initial weight(kg)	6.44	7.00	6.72	±0.38
Final weight(kg)	39.56	39.44	37.67	±1.91
Weight gain(kg)	33.11	32.44	37.67	±1.74
Daily weight gain(kg)	315.34	308.99	294.71	±0.02
Feed intake (kg/pig)	49.46	47.48	42.23	±3.40
Daily feed intake (g)	471.02	454.06	402.22	±0.03
FCR	1.46	1.46	1.37	±0.05

S.E.M= Standard error of mean

Growth response of growing pigs to qualitative and quantitative feed restriction

Table 4: Interaction between qualitative and quantitative feed restriction on the performance of growing pigs

Qualitative Restriction (%) Parameters/Quantitative Restriction	Qualitative x Quantitative Restriction									SEM
	Ad libitum	20 90% ad libitum	80% Ad libitum	Ad libitum	18 90% Ad libitum	80% Ad libitum	Ad libitum	16 90% Ad libitum	80% Ad libitum	
Initial weight(kg)	6.67	6.67	7.00	6.67	7.00	6.83	6.00	7.33	6.33	±0.66
Final weight(kg)	44.33	44.33	40.33	39.00	39.00	37.33	35.33	35.00	35.33	±3.31
Weight gain(kg)	37.67	37.67	33.33	32.33	32.00	30.50	29.33	27.67	29.00	±3.01
Daily weight gain(kg)	358.73	358.73	317.46	307.94	304.76	290.48	279.37	263.49	276.19	±0.03
Feed intake(kg)	62.84 ^a	56.98 ^{ab}	47.62 ^{ab}	44.68 ^{ab}	47.00 ^{ab}	38.48 ^b	40.85 ^b	39.05 ^b	40.60 ^b	±6.23
Daily feed intake (g)	598.48 ^a	542.67 ^{ab}	453.52 ^{ab}	425.52 ^{ab}	447.62 ^{ab}	366.48 ^b	389.05 ^b	371.90 ^b	386.67 ^b	±0.06
FCR	1.66 ^a	1.51 ^{ab}	1.43 ^{ab}	1.35 ^b	1.47 ^{ab}	1.26 ^b	1.37 ^b	1.41 ^{ab}	1.41 ^{ab}	±0.08

^{ab}- Values with different superscripts within rows are significantly different (P<0.05)

Table5: Effect of qualitative feed restriction on nutrient digestibility of growing pigs

Parameters/ Qualitative	20% C.P.	18% C.P.	16% C.P.	S.E.M
Feed Intake(kg)	1.55	1.36	1.19	±0.03
Dry matter Intake(kg)	1.49	1.29	1.11	±0.03
Excreted faeces(kg)	1.11 ^a	0.74 ^b	0.67 ^b	±0.06
FaecalDry matter output(kg)	0.81 ^a	0.45 ^b	0.31 ^b	±0.04
Excreted faeces/ dry matter intake (%)	0.7 ^a	0.59 ^b	0.58 ^b	±0.05
Dry matter digestibility (%)	73.63 ^a	71.99 ^{ab}	66.94 ^b	±2.70
Crude protein digestibility (%)	79.92 ^a	78.91 ^a	76.42 ^b	±1.51
Ether extract (%)	60.59 ^b	73.30 ^{ab}	76.46 ^a	±2.37
Crude fibre digestibility (%)	61.76 ^a	57.97 ^a	49.98 ^b	±2.87
Ash (%)	40.29 ^b	58.55 ^a	63.60 ^a	±2.04

^{ab}Means on the same row having different superscripts are significantly different (p<0.05).

level of qualitative feed restriction but the excreted faeces, faecal dry matter output, excreted faeces/ dry matter intake, dry matter digestibility, crude protein digestibility, ether extract, crude fibre digestibility and ash were significantly ($P < 0.05$) influenced with the level of qualitative restriction. Feed intake value ($P > 0.05$) of 1.55kg was recorded for pigs fed with 20% crude protein diet while those fed with 18% and 16% crude protein had feed intake of 1.36kg and 1.19kg, respectively. Similar ($P > 0.05$) values of dry matter digestibility, crude protein and crude fibre digestibility were observed for pigs fed 20% and 18% dietary protein, these differed significantly from the values documented for pigs on 16% dietary protein diet. Highest ($p < 0.05$) mean values in excreted faeces/dry matter intake, dry matter digestibility and faecal dry matter output were recorded for pigs fed 20% crude protein.

Effect of Quantitative Feed Restriction on Nutrient Digestibility of Growing Pigs

Effect of quantitative feed restriction on nutrient digestibility of growing pigs is shown in Table 6. Feed intake and dry matter were not significantly ($P > 0.05$) influenced by the level of restriction while excreted faeces, faecal dry matter output,

excreted faeces/dry matter intake, dry matter digestibility, crude protein, ether extract, crude fibre digestibility and ash were significantly ($P < 0.05$) affected by the levels of restriction. Excreted faeces values (1.01, 0.80 and 0.71 kg) decreased significantly with decreasing level of feed intake. Excreted faeces values of pigs fed 90% and 80% *ad-libitum* were statistically similar ($P > 0.05$). Comparable ($P > 0.05$) mean values of dry matter digestibility (78.11, 78.69%), ether extract (77.42, 77.66%) and crude fibre digestibility (61.65, 61.65%) were recorded for pigs fed 80% and 90% of *ad libitum* respectively which differed statistically ($p < 0.05$) from the values (55.77, 55.28 and 46.40%, respectively) obtained for pigs fed *ad libitum*. Highest ($P > 0.05$) value of crude protein digestibility (85.60%) was recorded for pigs fed 90% of *ad-libitum*.

Interaction between Qualitative and Quantitative Feed Restriction on Nutrient Digestibility of growing pigs

Table 7 shows the interaction between qualitative and quantitative feed restriction on nutrient digestibility of growing pigs. The interaction between qualitative and quantitative restriction had no significant ($P > 0.05$) effect on nutrients digestibility parameters of growing pigs considered.

Table 6: Effect of quantitative feed restriction on nutrient digestibility of growing pigs

Parameters/Quantitative	Ad-libitum	90% Ad-libitum	80% Ad-libitum	S.E.M
Feed Intake(kg)	1.38	1.37	1.34	±0.03
Dry Matter Intake(kg)	1.32	1.30	1.28	±0.04
Excreted Faeces (kg)	1.01 ^a	0.80 ^b	0.71 ^b	±0.07
Faecal Dry matter output(kg)	0.65 ^a	0.54 ^a	0.38 ^b	±0.10
Excreted Faeces/dry matter intake(kg)	0.76 ^a	0.61 ^b	0.55 ^b	±0.40
Dry matter digestibility (%)	55.77 ^b	78.11 ^a	78.69 ^a	±7.12
Crude protein digestibility (%)	72.03 ^c	85.60 ^a	78.60 ^b	±3.46
Ether extract (%)	55.28 ^b	77.42 ^a	77.66 ^a	±9.72
Crude fibre digestibility (%)	46.40 ^b	61.65 ^a	61.65 ^a	±5.22
Ash (%)	48.61 ^b	50.88 ^b	62.95 ^a	±5.71

^{abc} Means on the same row having different superscripts are significantly different ($P < 0.05$)

S.E.M: standard error mean

Growth response of growing pigs to qualitative and quantitative feed restriction

Table 7: Interaction between qualitative and quantitative feed restriction on nutrient digestibility of growing pigs

Qualitative	20%			18%			16%			
Quantitative	Ad-libitum	90% ad-libitum	80% ad-libitum	Ad-libitum	90% ad-libitum	80% ad-libitum	Ad-libitum	90% ad-libitum	80% ad-libitum	S.E.M
Parameters/ Treatments	1	2	3	4	5	6	7	8	9	
Feed Intake(kg)	1.60	1.30	1.25	1.50	1.36	1.26	1.55	1.41	1.06	±0.10
Dry matter Intake(kg)	1.54	1.24	1.17	1.44	1.30	1.18	1.49	1.35	0.99	±0.95
Excreted faeces(kg)	1.29	0.90	0.82	1.09	0.65	0.66	0.04	0.68	0.52	±0.05
Faecal dry matter output(kg)	1.10	0.43	0.44	0.78	0.57	s0.27	0.55	0.37	0.23	±0.01
Excreted faeces/ dry matter intake (%)	0.84	0.73	0.70	0.76	0.50	0.56	0.62	0.50	0.52	±0.02
Dry matter digestibility (%)	44.50	63.55	59.25	77.1	75.25	81.99	79.22	77.18	79.66	±0.50
Crude Protein digestibility (%)	67.01	76.27	72.82	85.93	67.02	86.16	72.59	79.94	80.44	±0.50
Ether extract (%)	30.83	72.95	62.17	79.08	67.01	86.16	72.59	79.94	80.44	±0.72
Crude Fiber digestibility (%)	34.83	49.05	55.32	63.21	63.80	57.94	51.89	61.05	72.01	±0.68
Ash (%)	25.99	56.05	63.78	37.94	54.67	60.04	56.95	64.92	66.98	±0.81

Discussion

Pigs fed higher dietary protein consumed more feed and gained more weight than those on less protein diets. The variation in feed intake and weight gain could be attributed to more amino acid intake by the pigs on higher plane of nutrition. The growth of pig is related to the voluntary feed intake which supports the evidence that the weight gain of fast growing animals could be inhibited by feed restriction (Lebret *et al.*, 2008). The pigs on lower crude protein diets could have been subjected to inadequate and non-essential amino acid leading to deterioration in their weight gain. Proteins are major component in muscle which is highly need at early than late phase of growth (Damgaard, 1997). The observed differences in feed intake and weight gain with increasing levels of dietary crude protein is in line with the studies of Nyachoti *et al.* (2006) and Nguyen *et al.* (2003) who reported a linear reduction in average daily feed intake and average daily weight gain of piglets with decreasing level of dietary crude protein. Temim *et al.* (2000) observed that increase in protein supply from 10 to 33% improved growth performance and carcass characteristics of boilers reared in a hot environmental condition at thermoneutrality. On the other hand, Le Bellego *et al.* (2002) found no adverse effect on piglet performance by lowering the crude protein level of diet from 22.4 to 16.9%. On the contrary, Forbes (1995) and Carpenter *et al.* (2004) reported a linear increase in feed intake to decreasing crude protein concentration. The differences in these studies may be due to the environment, genotype or breed or age of pigs used which differed. The results of this present study indicate that increase in dietary protein level resulted to increase in weight gain and a better feed conversion ratio of pigs. This result is in agreement

with that of De silva and Perera (1985) and Zhang *et al.* (2013) who stated that FCR decreased with increasing level of crude protein in the diet.

The obtained results of this experiment showed that body weight gain, feed intake and feed conversion ratio were not affected by quantitative feeding regimen. The pigs on 80 and 90% *ad libitum* feeding must have obtained sufficient nutrients required for maintenance and tissue growth, leading to comparable mean values in the growth parameters considered. In agreement with Daza *et al.* (2003), Bee *et al.* (2007) and Serrano *et al.* (2009) feed restriction did not affect growth indices in this study, indicating that moderate quantitative feed restrictions have little or no effect on growth performance traits. On the other hand, Daza *et al.* (2003), Njoku *et al.* (2013) and Omosebi *et al.* (2014) reported that severe feed restriction (46 or 40% of *ad libitum* feed offered) impaired the growth performance of pigs and broiler birds.

The digestibility of nutrients is an important measure of livestock production efficiency. The comparable mean values obtain for feed intake and dry matter intake in this present study are in line with the study of Sharifi *et al.* (2013), the feed intake and dry matter intake increased numerically with increasing level of dietary protein. It has been reported that feed intake increases with increase in dietary crude protein level in some ruminants (Huston *et al.*, 1988; Cheema *et al.*, 1991; Negesse *et al.*, 2001). However, the recent findings in this study corroborate the report of Hwangbo *et al.* (2009) that increasing crude protein levels from 14 to 20% had no significant effect on dry matter intake of Korean Black goats. The significant differences observed in total faeces excreted, faecal dry matter output and excreted faeces/ dry matter intake can be linked with the level of dry

matter intake which increased with increasing level of dietary crude protein. Kreuzer (1986) observed that faecal output and dry matter content of faeces increased with increasing dry matter intake. So faecal output can reflect nutrient manipulation of diets (Nyachoti *et al.*, 2006) and feed intake (Hsiah and Lu, 1989). In this study, the digestibility of dry matter, crude protein and crude fibre increased significantly with increase in crude protein content in diets. These observations are in line with the report of Zhang *et al.* (2013) who reported a decrease in dry matter, crude protein and crude fibre digestibility with decreasing dietary protein level. Szymeczko and Skrede (1991) reported a slight reduction in the crude protein digestibility of fox at a declining protein levels. The better crude protein digestibility in the diets containing high protein may be connected to the oxidation of amino acid excesses. A reduction in dietary crude protein has been reported to increase the relative amount of endogenous nitrogen secretion which might have led to reduction in apparent crude protein digestibility (Low, 1980; Baker, 1989). The increased in crude fibre digestibility could be linked to the level of crude fibre in the diets which increased with increasing crude protein level. The increasing dietary crude fibre could have a positive effect on the intestinal microflora and intestinal health of the pigs where it helps in providing substrate for beneficial microorganism which helps to improve intestinal lining, thus improving digestion and growth performance of animal (Michard, 2010; Kroismayr, 2011). A review by Whittemore *et al.* (2001) asserts that increasing diet crude fibre content will increase gut motor functionality, decrease transit time, increase water holding capacity and the proportion of digestible nutrients appearing in the large intestine. In

contrast to this study, Mohiti-Asli *et al.* (2012) reported increased crude fibre digestibility as the nutrition plane of dietary crude protein is reduced. Lipids are required by pigs as a source of available energy, as structural components of bio-membranes, carriers of fat-soluble vitamins, precursors to eicosanoids, hormones and vitamins, and as enzyme co-factors (Lovell, 1989). In this study, the ether extract digestibility decreased with increasing crude protein levels in the diet, this could be associated to the source and inclusion levels of dietary fat in the diets. This may indicate that crude fat from Groundnut cake were not fully available for the digestive enzymes of the pigs. Abu *et al.* (1984) reported that the level of ether extract digestibility increased as the level of oil palm slurry increased in the diets. Mateos and Sell (1980) enthused that high-oil diets contain extra-caloric effect produce a better fat metabolism.

The digestibility of nutrients improved with level of restriction, this is in agreement with previous studies by Tumova *et al.* (2003 and 2007). The improvement in the dry matter digestibility, ether extract, ash and crude fibre digestibility of pigs on limited feed offered could be associated with slower movement of digesta when feed quantity is reduced, allowing for a more complete and efficient digestion in the hindgut (Lewis and Dehority, 1985). Thacker (2009) and den Hartog *et al.* (1988) also asserted that improvements in nutrient digestibility have been generally attributed to delay in gastric emptying which was postulated to be the result of slow passage through the small intestine allowing more time for nutrients breakdown. Njoku *et al.* (2012) reported that when feed intake is reduced below maintenance level, animal tends to become more efficient in digestion and in utilizing the nutrients, this observation is also in line with Murphy *et al.* (1994) who reported that

increasing intake above maintenance level led to decrease in digestibility of varying degrees depending on type and quality of diet fed.

Conclusion

This study has shown that qualitative feed restriction influenced weight gain, feed intake and feed to gain ratio of growing pigs while quantitative restriction had no effect on growth indices of growing pigs. Also, all the nutrient digestibility parameters considered were influenced by quantitative and qualitative feed restriction of the pigs except feed intake and dry matter intake. Thus, nutrient intake limitation strategies (both qualitative and quantitative) should be used to improve the productivity of farm animals.

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