

# Effect of Slaughter Weight on Carcass Characteristics and Economics of Pig Production

Makauki<sup>1</sup>, A.F. and F.P. <sup>2</sup>Lekule\*

<sup>1</sup> Development Studies Institute, Sokoine University of Agriculture, P.O. Box 3024, Chuo Kikuu, Morogoro

<sup>2</sup> Department of Animal Science and Production, Sokoine University of Agriculture, P.O. Box 3004 Chuo Kikuu, Morogoro

## Abstract

*A study to evaluate the effect of slaughter weight on carcass characteristics of pigs was conducted using twenty four Landrace X Large White crossbred pigs. Twelve castrates and twelve gilts with average initial weight of  $35 \pm 4.4$  kg were randomly assigned to three targeted slaughter weights. Pigs were slaughtered at live weights of 60, 75 and 90 kg and measurements of carcass characteristics were taken. Cost effectiveness of each slaughter weight based on feed cost was determined. Slaughter weight of the pigs had significant ( $P < 0.05$ ) influence on carcass characteristics. Increase of slaughter weight from 60 kg to 90 kg caused a rise in killing out percentage, loin eye area, carcass length and back fat thickness from 65.0 to 69.1 %, 24 to 34 cm<sup>2</sup>, 85.1 to 92.3 cm and 2.2 to 3.3 cm, respectively. The proportion of kidney fat also increased with slaughter weight. Generally, the weights of carcass joints, fillet muscle (*M. psoas major*), liver and kidney as percent of carcass weight decreased with increasing slaughter weight of the pigs ( $P < 0.05$ ). Castrates had significantly heavier kidney fat and lighter shoulders than gilts but there was no significant sex difference in killing out percentage, carcass length, weights of liver, kidney, fillet muscle, ham, loin and belly, back fat thickness and loin eye area. The slaughter weight of 60 kg was found to be more cost effective than the rest of the slaughter weights and was therefore recommended for areas where there is demand for lean meat.*

**Key words:** Pigs, Slaughter weight, Carcass characteristics, Cost effectiveness

## Introduction

The preference for lean to fatty meat has been widespread throughout the world. This is due to the awareness that lean meat is generally healthier than fatty meat. It is evident that back fat thickness, and hence body fat content of pigs, increases with increasing weight at slaughter (Whittemore, 1980; Chertkov and Zaporozhets, 1985; Thomke *et al.*, 1995). In evaluating the effect of slaughter weight on carcass traits of swine, Christian *et al.* (1980) found that carcasses with less ham and loin percentages, larger loin eye area, increased carcass length, thicker back fat and higher dressing percentage were associated with heavy slaughter weights. It is therefore certain that, heavy slaughter weights of pigs lower carcass quality

due to excessive fattening. In the same line, Braude (1972) degraded fatty meat against lean meat thereby complying with the preference of pork consumers.

In Tanzania, pigs are mostly fed on food remnants, grass, roots not consumed by human beings and brewery by-products, with minimum or no supplementation with hominy feed and/or waste grains. In this kind of operation, there is no justification for economic considerations other than minimizing investment. As a result, such animals grow very slowly, resulting in unprofitable pig enterprises by the smallholder farmers (Sibuga *et al.*, 1993). What is more discouraging is that, in many parts of the country pigs are allowed to fatten excessively and may reach a liveweight of 150-200 kg before slaughter. Hence, there is a need to lower the slaugh-

\* Corresponding author

ter weight to a level that is both economical to the farmer and can meet consumers preferences (Makauki and Lekule, 1997).

Although there is ample information on the effect of slaughter weight of pigs on carcass characteristics, the economics of different slaughter weights of these animals under Tanzanian situation is little documented. The available literature is also deficient on information on the optimum slaughter weight of pigs under tropical management (Makauki and Lekule, 1997).

The objective of the present study was therefore to explore the effect of slaughter weight on carcass characteristics of pigs and determine the cost effectiveness of slaughtering pigs at different slaughter weights in Morogoro (Tanzanian) region.

## Materials and Methods

### Experimental procedure

Twenty four Landrace X Large White cross-bred pigs weighing  $35 \pm 4.4$  kg were housed in individual pens fitted with feeders and drinkers at the Department of Animal Science and Production, Sokoine University of Agriculture. A randomized complete block design was adopted and a total of four castrates and four gilts were randomly allocated to each of the three levels of slaughter weight (60 kg, 75 kg and 90 kg). There was a balance in initial body weight for each slaughter category. The pigs were fed twice a day at 0900 and 1500 h throughout the experimental period. The experimental diet composition (in percentages) was: hominy meal (69.5), cotton seed cake (25), fish meal (3), "pigmix" (1), limestone (1) and common salt (0.5). The pigmix consisted of vitamins and mineral premix whose contents (%) were Calcium (35), Phosphorus (6), Sodium (11), Iron (0.45), Copper (0.10), Manganese (0.80), Zinc (0.10), Iodine (0.015) Selenium (0.002), Nicotinic acid (0.15) and Pantothenic acid (0.10). Proximate analysis of feed ingredients and the diet was done according to standard procedures described by AOAC (1990). Samples were analyzed for contents of dry matter, crude protein, crude fibre, ether extract, ash, calcium and phosphorus. Methionine and cystine, lysine and digestible energy (DE) content of the diet were

calculated based on the potential of individual feed ingredients according to Pond and Maner (1974). Metabolizable energy (ME) content of the diet was calculated by using the formula developed by NRC (1988) by a well compounded pig ration; that is  $ME = 0.96DE$ .

The animals were weighed once per week but when weight was about 10 kg below the intended slaughter weight, the frequency of weighing was changed to daily. On reaching the liveweights of  $60 \pm 1$  kg,  $75 \pm 1$  kg and  $90 \pm 1$  kg, the pigs were slaughtered before being fed in morning session by rendering them insensitive by hitting the forehead with a steel pipe. After immediately bleeding the animal by cutting the throat, the head was detached at the atlas joint and its weight was recorded. Dehairing and suspension of the carcass were followed by evisceration and halving along the pelvis fusion and backbone.

Carcass characteristics were recorded from 8 pigs which were slaughtered at 60 kg, while for each of the slaughter weights of 75 and 90 kg the parameters were recorded from 7 pigs following death of two pigs which was caused by white muscle disease and peritonitis and *Pasteurella multocida* infection, respectively.

The two sides of the hot carcass were weighed and all carcass measurements were taken from the left side according to Danish standards (Clausen and Gerwing, 1958; Lekule *et al.*, 1988). Empty body weight was obtained as the weight of the carcass including the head but after removing the entrails. Carcass weight was obtained from the sum total of the weights of the two carcass halves exclusive of the head and the feet. The warm carcass expressed as a per cent of the liveweight, was recorded as killing out percentage. Using a steel measuring tape, carcass length was measured from the anterior edge of the aitch bone (*Os pubis*) to the atlas. Backfat thickness was measured in centimetres at five points, viz. at the thickest point near the first rib (over the shoulder), at the thinnest point near the last rib (loin) and at the anterior, mid- and posterior end of *M. gluteus medius* (in the lumbar region). Fillet muscle, liver, kidney and kidney fat were separated from the warm carcass and weighed. The left side of the carcass was partitioned into such carcass joints as shoulder (jowl), picnic shoulder

and boston butt), ham, loin and belly whose weights were recorded. The area of longissimus dorsi muscle was taken between the 11<sup>th</sup> and 12<sup>th</sup> rib by tracing on a translucent paper and measuring by using a planimeter.

## Statistical analysis

The data collected were statistically analyzed with the aid of a computer. General Linear Models (GLM) procedure of the Statistical Analysis Systems package (SAS, 1988) was adopted in which effects due to differences in sex and slaughter weight were compared. The parameters were corrected by the initial body weights of the pigs as a covariate. The statistical model used was:

$$Y_{ijk} = \mu + S_i + W_j + b(X_{ijk} - x) + e_{ijk},$$

where,

$Y_{ijk}$  = observation from  $k^{\text{th}}$  pig belonging to  $i^{\text{th}}$  sex (block) slaughtered at  $j^{\text{th}}$  weight

$\mu$  = overall mean

$S_i$  = effects due to  $i^{\text{th}}$  sex (block)

$W_j$  = effects due to  $j^{\text{th}}$  slaughter weight

$b$  = regression coefficient

$X_{ijk}$  = initial body weight of  $k^{\text{th}}$  pig of  $i^{\text{th}}$  sex slaughtered at  $j^{\text{th}}$  weight

$x$  = mean initial weight of all the experimental pigs

$e_{ijk}$  = residual effect peculiar to  $k^{\text{th}}$  pig of  $i^{\text{th}}$  sex slaughtered at  $j^{\text{th}}$  weight

## Results and Discussion

### Chemical composition of the experimental diet

Chemical composition of the diet used is shown in Table 1. The composition of the diet was in agreement with standard requirements of growing and finishing pigs recommended by ARC (1981) and NRC (1988). Compared to the standards given, the diet of the present study was suitable not only for growing-finishing pigs but also for young growers of 10 kg liveweight. In terms of energy concentration, the diet had higher levels than the recommended concentrations of 13 MJ ME / kg DM (ARC, 1981) but was more or less similar to NRC (1988) recommendation of 13.7 MJ ME / kg diet.

### Carcass characteristics and cost effectiveness of the slaughter weights

The effect of slaughter weight on carcass characteristics of pigs is presented in Table 2. Killing out percentage and empty body weight per cent increased with increasing slaughter weight of the pigs. Pigs slaughtered at 60 kg liveweight had lower killing out percentage than those slaughtered at 75 kg ( $P < 0.05$ ) and 90 kg ( $P < 0.01$ ). The pigs had lower ( $P < 0.01$ ) empty body weight per cent than those slaughtered at 90 kg. Pigs slaughtered at 60 kg had lower empty body weight per cent than those slaughtered at 75 kg, but the difference was not statistically significant. Additionally, the pigs had shorter carcasses ( $P < 0.001$ ) and smaller cross sectional areas of the *longissimus dorsi* muscle ( $P < 0.01$ ) than pigs slaughtered at liveweights of 75 kg and 90 kg.

Pigs slaughtered at 75 kg liveweight had lower killing out and empty body weight percentages than those slaughtered at 90 kg but the difference was not statistically significant. The former had shorter carcasses ( $P < 0.05$ ) than those slaughtered at liveweight of 90 kg. The increase of slaughter weight from 60 to 90 kg caused the proportions of ham, shoulder and belly as per cent of carcass weight, to decrease from 13.6 to 11.6 %, 15.1 to 13.7 % and 10.5 to 9.9 %, respectively. However, the decrease in per cent of belly was not statistically significant. The decrease in proportions of carcass joints with slaughter weight observed in the present study, is in line with the previous work (Babatunde *et al.*, 1966; Christian *et al.*, 1980; Pond and Maner, 1974). Similar with carcass joints, the proportions of individual internal organs and fillet muscle decreased with increase in slaughter weight of the pigs. The proportion of fillet muscle decreased from 0.83 % to 0.76 % but the difference was not statistically significant. The proportions of kidney and liver were also found to decrease from 0.23 % and 3.0 % to 0.16 % and 2.5 %, respectively as the slaughter weight increased from 60 kg to 90 kg agreeing with Thomke *et al.* (1995).

Significant sex effect on carcass characteristics was observed only on the weights of shoulders and kidney fat, unlike all other parameters studied (Table 3). Gilts were found to have

Table 1: Chemical composition of feed ingredients and diet

Item	Hominy meal	Fish meal	Cotton seed cake	Diet	
				Analysed	Calculated
Dry matter, %	90.51	92.49	93.02	91.85	
<b>% of dry matter</b>					
Crude protein	13.6	62.31	34.48	19.27	19.94
Crude fibre	7.62	1.1	14.41	8.86	8.93
Ether extract	12.96	11.46	7.13	12.51	11.13
Ash	5.15	20.1	5.69	7.7	5.60
Nitrogen free extract	60.67	5.03	38.29	51.66	51.89
Calcium	0.59	4.58	0.24	0.81	0.61
Phosphorus	0.71	0.29	1.12	0.86	0.86
Lysine <sup>2</sup>	0.88	7.94	1.86		1.31
Methionine and cystine <sup>2</sup>	0.76	3.91	1.64		1.06
<b>Energy content<sup>2</sup></b>					
MJ DE/kg DM	16.21	13.84	12.04		14.56
MJ ME/kg DM					13.98

<sup>a</sup> calculated based on the potential of different feed ingredients (Pond and Maner, 1974) and the formula ME = 0.96DE for a compounded pig ration (NRC, 1988).

Table 2: Least square means ( $\pm$  s.e.) for carcass characteristics of pigs slaughtered at different weights

Parameter	Slaughter weight		
	60	75	90
Number of pigs	8	7	7
Average daily gain, g	702 $\pm$ 16 <sup>a</sup>	527 $\pm$ 14 <sup>b</sup>	511 $\pm$ 10 <sup>b</sup>
EBW per cent <sup>1</sup>	73.5 $\pm$ 0.7 <sup>a</sup>	75.4 $\pm$ 0.7 <sup>ab</sup>	77.1 $\pm$ 0.7 <sup>b</sup>
Killing out per cent	65.0 $\pm$ 0.6 <sup>a</sup>	67.5 $\pm$ 0.7 <sup>b</sup>	69.1 $\pm$ 0.7 <sup>b</sup>
Carcass length, cm	85.1 $\pm$ 0.5 <sup>a</sup>	89.7 $\pm$ 0.6 <sup>b</sup>	92.3 $\pm$ 0.6 <sup>c</sup>
<b>Weight of carcass joints, % of CW:</b>			
Shoulder	15 $\pm$ 0.2 <sup>a</sup>	12.5 $\pm$ 0.3 <sup>b</sup>	13.7 $\pm$ 0.3 <sup>c</sup>
Ham	13.6 $\pm$ 0.3 <sup>a</sup>	12.4 $\pm$ 0.3 <sup>b</sup>	11.6 $\pm$ 0.3 <sup>c</sup>
Loin	12.4 $\pm$ 0.3 <sup>a</sup>	14.8 $\pm$ 0.3 <sup>b</sup>	16.7 $\pm$ 0.3 <sup>c</sup>
Belly	10.5 $\pm$ 0.2	10.4 $\pm$ 0.2	9.9 $\pm$ 0.3NS
Backfat thickness, cm	2.2 $\pm$ 0.2 <sup>a</sup>	2.6 $\pm$ 0.2 <sup>ab</sup>	3.3 $\pm$ 0.2 <sup>b</sup>
Fillet muscle, % of CW	0.83 $\pm$ 0.04	0.71 $\pm$ 0.05	0.76 $\pm$ 0.05NS
<b>Weight of internal organs, % of CW</b>			
Liver	3.0 $\pm$ 0.09 <sup>a</sup>	2.5 $\pm$ 0.09 <sup>b</sup>	2.5 $\pm$ 0.09 <sup>b</sup>
Kidney	0.23 $\pm$ 0.01 <sup>a</sup>	0.17 $\pm$ 0.01 <sup>b</sup>	0.16 $\pm$ 0.01 <sup>b</sup>
Kidney fat	0.05 $\pm$ 0.01 <sup>a</sup>	0.09 $\pm$ 0.01 <sup>b</sup>	0.09 $\pm$ 0.01 <sup>b</sup>
Area of <i>longissimus dorsi</i> muscle, cm <sup>2</sup>	24 $\pm$ 1 <sup>a</sup>	31 $\pm$ 1 <sup>b</sup>	34 $\pm$ 1 <sup>b</sup>

CW = Carcass weight, EBW = Empty body weight, <sup>1</sup> as per cent of liveweight at slaughter NS = Not significantly different (P > 0.05), % = per cent, <sup>a,b,c</sup> Least square means with different superscripts in the same row are significantly (P < 0.05) dif-

Table 3: Least square means ( $\pm$  s.e) for the effect of sex on carcass characteristics of pigs

Parameter	Sex	
	Castrates	Gilts
Number of pigs	11	11
Average EBW, <sup>a</sup> kg	56.9 $\pm$ 0.44	56.5 $\pm$ 0.44 NS
EW percent <sup>b</sup>	75.5 $\pm$ 0.59	75.2 $\pm$ 0.59 NS
Carcas weight, kg	50.8 $\pm$ 0.41	50.3 $\pm$ 0.41NS
Killing out percentage	67.5 $\pm$ 0.57	66.9 $\pm$ 0.56 NS
Carcass length, cm	88.6 $\pm$ 0.49	89.4 $\pm$ 0.49 NS
<b>Weights of carcass joints, kg:</b>		
Shoulder	6.8 $\pm$ 0.07	7.0 $\pm$ 0.07*
Ham	6.2 $\pm$ 0.10	6.3 $\pm$ 0.10 NS
Loin	7.6 $\pm$ 0.15	7.5 $\pm$ 0.15 NS
Belly	5.3 $\pm$ 0.13	5.2 $\pm$ 0.13 NS
Backfat thickness, cm	2.7 $\pm$ 0.17	2.6 $\pm$ 0.17 NS
Weight of FLT <sup>c</sup> , g	398 $\pm$ 20	359 $\pm$ 20 NS
<b>Weight of internal organs, g</b>		
Liver	1350 $\pm$ 26.2	1295 $\pm$ 26.2 NS
Kidney	89 $\pm$ 4.7	94 $\pm$ 4.7 NS
Kidney fat	44 $\pm$ 1.9	33 $\pm$ 1.9*
Area of <i>longissimus dorsi</i> muscle, cm <sup>2</sup>	28.6 $\pm$ 1.05	30.8 $\pm$ 1.03 NS

<sup>a</sup> Empty body weight, <sup>b</sup> as percent of liveweight at slaughter; <sup>c</sup> Fillet muscle, NS = Non significant ( $P > 0.05$ ), \* = Significantly different ( $P < 0.05$ )

heavier shoulders ( $P < 0.05$ ) and lighter kidney fat ( $P < 0.01$ ) than castrates. The average weights of shoulder and kidney fat for gilts were 7.0 $\pm$ 0.07 kg and 33 $\pm$ 1.9, g while those of castrates weighed 6.8 $\pm$ 0.07 kg and 44 $\pm$ 1.9 g, respectively.

The results of the present study are in agreement with the previous work by Whittemore (1980), Thomke *et al.* (1995), Chertkov and Zaporozhets (1985) and Christian *et al.* (1980). All reported increasing loin eye area, carcass length, back fat thickness and dressing percentage (K.O.) with increasing slaughter weight of pigs. The killing out percentage of 65-69 % observed in the present study agrees well with Sibuga *et al.* (1993) who reported a range of 65-75 %.

The increasing killing out percentage implies that carcass components at heavy liveweights grow at a higher rate than gut components. From 60 kg to 90 kg, the pigs were in-

creasingly putting on more fat, whose growth coefficient is greater than one as opposed to lean which is generally equal to one, thereby resulting in increased killing out percentage and decreased per cent of internal organs. The increasing fattening of pigs was manifested by the decreasing efficiency of feed conversion (Table 4) and the increasing proportion of kidney fat. This shows that more energy is required for fat deposition than for protein deposition in the body. Additionally, at higher weights there are progressively greater costs of body maintenance.

Similar results were also reported by Shields and Mahan (1980) who observed significantly heavier shoulders for gilts than for castrates and the same K.O. for both sexes. Similar to the present study, Babatunde *et al.* (1975) observed no significant difference between castrates and gilts in average daily gain, K.O., backfat thickness, carcass length, weight of kidney and

Table 4: Economics analysis of slaughter weights

Parameter	Slaughter weight, kg		
	60	75	90
Number of pigs	8	7	7
Initial LW, kg	42.4	42.2	43.8
Final LW, kg	60.6	74.6	89.6
LW gain, kg/pig	18.2	32.4	45.8
Feed cost per kg diet, Tsh <sup>a</sup>	81.00	81.00	81.00
Feed conversion ratio (kg feed/kg gain)	3.07	3.66	3.79
Feed cost per kg LW gain, Tshs.	248.70	296.50	307.00
Carcass weight (CW), kg/pig	39.4	50.5	61.8
Feed cost per kg CW, Tsh.	382.50	438.00	445.10
Gross profit <sup>b</sup> per kg of meat <sup>c</sup> , Tsh.	617.50	562.00	554.90

<sup>a</sup> US \$ 1 = Tsh. 800, <sup>b</sup> based on feed cost only, <sup>c</sup> 1 kg of meat = Tsh. 1000, LW = Liveweight, No. = Number

weight of liver. The works also demonstrated higher shoulder weight for gilts than for castrates although the difference was not statistically significant. The significantly lighter kidney fat for gilts than for castrates observed in the present study is in agreement with Lekule *et al.* (1982). As adaptation to withstand mating, gilts have heavier hams than castrates, a fact which was observed in the present study although the difference was not statistically significant.

Since there was a trend of increasing back fat thickness with increasing slaughter weight of the pigs, the adoption of lighter slaughter weights (e.g. 60 kg) would be an option of choice where lean meat is preferred to fatty meat. The adoption of the slaughter weight of 60 kg is favoured by its high gross profit (Tshs. 618) per kg of meat relative to that of 75 kg (Tshs. 562) and that of 90 kg (Tshs 555) as shown in Table 4. A reverse trend was observed in terms of feed cost per kg of carcass weight. The slaughter weight of 60 kg was, therefore, more cost effective than that of 75 and 90 kg. However, where production of lard and/or fatty meat is aimed at, a heavier slaughter weight will likely be favoured.

## Conclusion

The slaughter weight of 60 kg was found to be the most profitable and is hence recommended for commercial producers of pigs in Tanzania, since it would satisfy the majority of pork consumers and provide a fast turn over rate. However, in practice, pigs at heavy are fed pig finisher meal which is cheaper than growers meal, a fact which was not considered in the present study as the pigs were fed the same diet throughout the experimental period. There is therefore a need to carry out further studies on the effect of slaughter weight on economics of pork production using cheap diets as weight increases.

## Acknowledgements

The authors wish to acknowledge the Norwegian Agency for Development Cooperation (NORAD), for funding the research and the Department of Animal Science and Production, Sokoine University of Agriculture for providing the experimental animals and pens.

## References

- Agricultural Research Council (ARC). 1981, Nutrient Requirements of Pigs. Technical Review by an Agricultural Research Council Working Party. pp 29, 40-42.
- AOAC. 1990, Official Methods of Analysis. Association of Official Analytical Chemists, 15th Edn., Arlington, Virginia.
- Babatunde, G.M. Pond, W.G. Van Vleck, L.D. Kroening, G.H. Reid, J.T. Stouffer, J.R. and Wellington, G.H. 1966. Relationships among some physical and chemical parameters of full- versus limited-fed Yorkshire pigs slaughtered at different liveweights. *J. of Anim. Sci.* 25: 526-531.
- Babatunde, G.M. Fetuga, B.L. and Oyenuga, V.A. 1975. Effects of feeding graded levels of cane molasses on the performance and carcass characteristics and organ weights of Yorkshire pigs in a tropical environment. *J. of Anim. Sci.* 40: 632-639.
- Braude, R. 1972 Feeding methods. In: D.J. Cole (Ed.) Pig Production, Proceedings of the 18<sup>th</sup> Easter School in Agricultural Science, University of Nottingham pp 279-291.
- Chertkov, D.D. and Zaporozhets, I.N. 1985 Changes in Carcass Characters of Pigs with Age. *Zhivotnovodstvo*, No. 11, 46 [Ru]. In: Pig News and Information, 1986. C.A.B. International, UK. Vol. 7 pp 58.
- Christian, L.L.; Strock, K.L. and Carlson, J.P. 1980. Effects of protein, breed cross, sex and slaughter weight on swine performance and carcass traits. *J. of Anim. Sci.* 51:51-58.
- Clausen, H. and , C. 1958. Pig breeding recording and progeny testing in European countries. *FAO Agric. Studies*, Rome, 44: 65-78.
- Lekule, F.P. Homb, T. and Kategile, J.A. 1982. Optimum inclusion of coconut meal in growing-finishing pig diets. *E. Afr. Agric. For. J.* 48: 19-24.
- Lekule, F.P. Mtenga, L.A. and Just, A. 1988. Total replacement of cereals by cassava and rice polishings in diets of growing-finishing pigs. *Trop. Agric (Trinidad)* 65(4): 321-324.
- Makauki, A.F. and Lekule, F.P. 1997 Effect of plane of nutrition on the performance of pigs slaughtered at different weights. In: R.L. Kurwijila, G.C. Kifaro, H. Whitall, A.M.V. Kakengi and E.E. Ndemaniho (Eds.) *The Livestock Sector in Tanzania: Livestock Production and the Environment*. Proc. 24<sup>th</sup> Sci. Conf. Tanzania Soc. Anim. Prod. TSAP, Morogoro pp 77-89.
- National Research Council (NRC). 1988, Nutrient Swine. Ninth Revised Edition, National Academy Press Washington, D.C.
- Pond, W.G. and , J.H. 1974, *Swine Production in Temperate and Tropical Environments*, W.H. Freeman and Co., San Fransisco 163 p.
- SAS. 1988, *SAS/STAT User's Guide*. Release 6.03, SAS Institute Inc. Carry, USA.
- Shields, R.G. and Mahan, D.C. 1980. Effect of protein sequencies on performance and carcass characteristics of growing-finishing swine. *J. of Anim. Sci.* 51:1340-1346.
- Sibuga, K.K., Lekule, F.P. and Kinala, T.Z. 1993, *Principles of Livestock Production in Tanzania*, Mzumbe Book Project, Morogoro, pp 25-28.
- Thomke, S., Alaviuhkola, T., Madsen, A., Sundstoft, F., Mortensen, H.P., Vangen, O. and Anderson, K. 1995. Dietary energy and Protein for Growing Pigs 2. Protein and Fat Accretion and Organ Weights of Animals Slaughtered at 20, 50, 80 and 110 kg Live Weight. *Acta. Agric. Scand. (Sect. A)*, *Anim. Sci.* 45:54-63
- Whittemore, C. 1980. *Pig Production. The Scientific and Practical Principles*. Longman, Hong Kong, 77, 78 p.
- Whittemore, C.T. 1993. *The Science and Practice of pig production*. Longman Group UK Limited. p 7.