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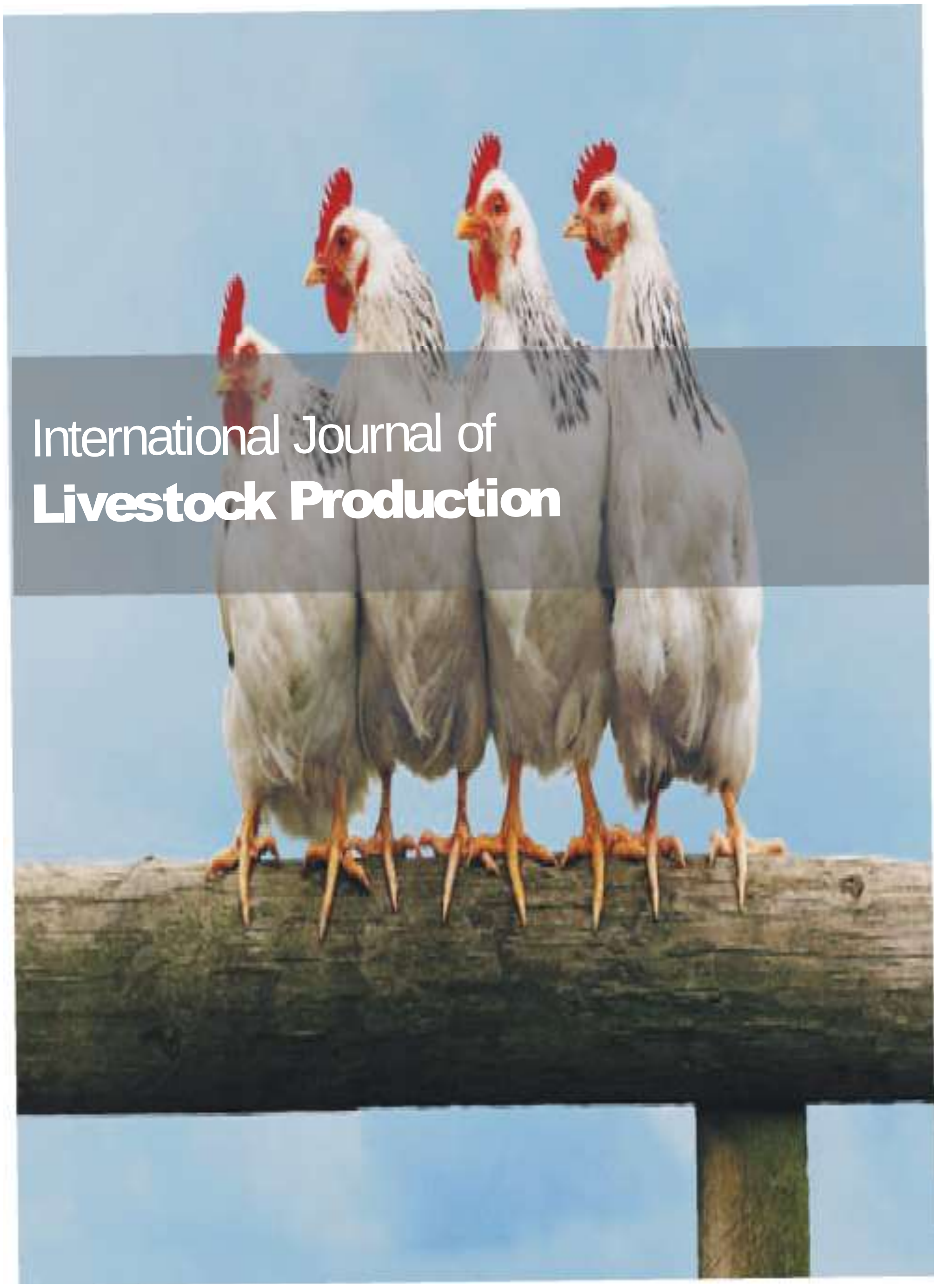

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International Journal of Livestock Production

Full Length Research Paper

Cost effectiveness of feeding cattle genotypes fed rice straw with graded levels of concentrate supplements

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Cattle genotypes and adoption of new feeding technology are necessary for improving beef cattle production and managing efficiently beef production costs. A study was conducted to determine the effects of cattle genotypes and levels of concentrate supplements on cost effectiveness of feedlot beef production in a Complete Randomized Block Design in 3×4 factorial arrangements with 4 replications. Feeds were urea-treated rice straw (UTRS: 4%, w/w) and concentrates made from decorticated cottonseed cake (66%) and maize bran (34%). The experimental animals were Ankole (A×A: n=16), Ankole × Friesian (A×F: n=16) and Ankole × Sahiwal (A×S: n=16) steers. Proxy indicators used to determine profitability and likelihood of economic viability were Initial and Final values of carcass existing abattoir price (RwF 1800/kg beef); Break-even scenarios using What-if Analysis in Excel, 2010; and Gross Margin (GM). Results suggested that cost effectiveness of feedlot beef did not differ ($p>0.05$) by genotype; but they differed ($p<0.05$) by diets. It is concluded that beef feedlots using UTRS was marginally economical at 500 g/day of concentrate supplements. A policy incentive to reduce Breakeven Price (BEP) is suggested. A confirmatory study using actual slaughters is recommended.

Key words: Feedlot beef production, cattle genotype, gross margin, what-if analysis.

INTRODUCTION

The annual per capita consumption of meat in Rwanda has been increasing by approximately 8% between 2005 and 2010 (NISR, 2011). Beside, poultry, pigs and fish consumption has also been increasing. However, beef is still the most important meat in Rwanda (MINAGRI, 2012). A recent study has indicated that in response to population and increasing per capita consumption, change breed composition the national cattle herds' size will have to increase from the current estimate of approximately 1.1 million (FAO, 2015) to more than 2 million heads by 2020. However, due to expansion of arable agriculture, the availability of conventional grazing land for fodder is steadily getting exhausted and alternative feed resources are necessary. Despite their fibrous nature, cereal straws and agro-industrial by products are ubiquitous biomass that have been used and perceived to be cheap sources of the feed for ruminant livestock. In developing countries, urea treatment is perceived to be the most appropriated treatment method for quality improvement of fibrous

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Table 1. Price of items used in the straw based beef feedlot.

Item	Source	Unit	Price (RwF)
Rice straw	Cooperative	kg	100
Maize bran	Open market	kg	120
Cotton seed cake	Open market	kg	400
Urea	Open market	kg	450
Initial carcass price	Farm gate price	kg	800
Final carcass price	Abattoir	kg	1800

RwF, 1$= 750 RwF.

Table 2. Composition and final price of product used in the straw-based beef feedlot.

Treatment		Composition				Cost				FP
		RS	MB	dCSC	Urea	RS	MB	dCSC	Urea	
UTRS	0	0.96	0	0	0.04	0	0	0	18	18
Concentrate	0.5	0	0.66	0.34	0	0	40.2	66	0	106.2
Concentrate	1	0	0.66	0.34	0	0	80.4	132	0	212.4
Concentrate	2	0	0.66	0.34	0	0	160.8	264	0	424.8

UTRS=urea treated rice straw, RS=rice straw, MB=maize bran, dCSC = decorticated cottonseed cake, FP=final price

materials (Wanapat et al., 2013). Experience in India has revealed that adoption urea treated straw technology among dairy farm holdings was subjected to availability of fodder, cost effectiveness of inputs for straw treatment, price incentives of products and the economy scale associated with the unit of production (Chander, 2010) and as well as organizational capacity of extension service delivery (Walli, 2010). In Rwanda, Crop Intensification Program (CIP) and the cooperative paradigm for development provides the organizational premise for extensions service and the economy of scale for success in straw based feedlots. The existing land pressure and policy support for crop-livestock integration leaves cost-effectiveness as the major key information required to promote straw-based feedlots for crop-livestock integration. Therefore, the objective of this study was to determine effects of cattle genotypes and levels of concentrate supplements on cost effectiveness of feedlot beef production using urea-treated rice straw (UTRS).

MATERIALS AND METHODS

Location, animals and feeds

The study was carried out at Rwanda Agriculture Board, Songa Research Station in Southern Province of Rwanda (02° 25' 255''S, 029° 48' 004''E). The station is located in the mid-altitude zone (1471 m asl) with an average annual temperature of 25.5°C; an average annual rainfall of 1087 mm and relative humidity of 77%. Rice, maize and cassava are the major crops cultivated in the area. The animals were steers of three cattle genotypes viz: purebred Ankole (A×A), Ankole × Friesian (A×F) and Ankole × Sahiwal (A×S) steers. The feeds were UTRS (4%, w/w) and concentrates made from decorticated cottonseed cake (dCSC) (66%) and maize bran (MB) (34%).

Use of proxy indicators

Proxy indicators were used to determine enterprise profitability and likelihood of economic viability. The GM analysis was used to estimate enterprise profitability. Net Present Value (NPV) and Internal Rate of Return (IRR) were used to estimate the likelihood of economic viability. The cost of the feed was computed from the price of items (Table 1) and the composition of feed ingredients (Table 2).

Daily cost of feed per steer was the product of final price and daily intake. Total feed cost over 90 days of feeding was cumulative sum of daily feed cost per steer. Purchase cost of the steers was taken as the farm gate price of carcass at the beginning of the trial. Revenue at the beginning was the product of abattoir price and estimate of carcass weight. Carcass weight was the product of live weight and dressing percentage. The dressing percentage was adapted from similar study using the similar breeds (Asizua, 2010) because procurement protocol did not allow for slaughter of the steers (Table 3).

Total cost of production was the sum of cost of carcass at the beginning of the feeding trial and cumulative cost of feed per steer. GM was the difference between carcass value at 90 days and carcass value at the beginning of the feeding trial. What-if Analysis (Microsoft Excel, 2010) was used to estimate Breakeven Cost (BEC) at existing price; Breakeven Price (BEP) at existing cost; and competitive cost of production. Competitive cost was the highest cost, below which the price of beef could be reduced below the current price without incurring losses. The GM associated with these costs and prices were also recorded.

Data analysis

Data entry was done using Microsoft Excel and the analysis of data was done by Statistical Analysis Software (SAS) version 9.00.

Table 3. Dressing percent of steers feed different levels of concentrate supplements.

Level of supplement (g/day)	Dressing percentage
0	49
500	58
1000	60
2000	63

Adapted from Asizua (2010).

RESULTS

Weights and value of carcass

The initial weight (IWT) did not differ (p>0.05) by genotype. The final weight (FWT) at slaughter differed by genotypes (p<0.05) and levels of supplement (p<0.05). The interaction effect was not significant (p>0.05). The FWT were higher (p<0.05) in A×A and A×S than A×F steers. They were also higher in steers fed UTRS with 500 g/day (p<0.05), 1000 g/day (p<0.001) and 2000 g/day (p<0.001) of concentrate. The weights did not differ (p>0.05) among steers fed UTRS with concentrate (Table 5).

Carcass weight

Estimates of carcass weight (ECW) differed by genotype (p<0.05) and highly across dietary treatments (p<0.0001) without significant interaction effect (p>0.05). The ECW was higher (p<0.05) in A×A and A×S than in A×F steers. It was lower in steers fed UTRS without supplements than in those fed 500 g/day (p<0.001); 1000 g/day (p<0.0001) and 2000 g/day (p<0.0001) of concentrates. The weight did not differ between steers fed 2000 and 1000 g/day of concentrates and between steers fed 1000 and 500 g/day of concentrate (Table 5). The interaction effect was not significant (Table 5).

Initial value and final value of carcass

The initial value (INV) of the carcass differed (p<0.05) only by genotype of steers. It was higher (p<0.01) in A×A and tended also to be higher (p=0.0673) in A×S than in A×F steers (Table 5). Linear, quadratic and cubic trends were not significant. The final value of carcass (FNV) differed (p<0.05) by genotype of steers. The FNV were higher in A×S and A×A than A×F steers. Linear, quadratic and cubic trends were significant.

Feed and total costs

Feed cost differed by genotype (p<0.01) and levels of concentrate supplements (p<0.0001). The effect of supplement had a strong tendency to vary (p=0.0569) by genotype. The cost was higher in A×S than in A×A and A×F steers. All levels of concentrate supplement increased feed cost in all steers significantly (p<0.0001) with strong linear and curvilinear trends (Table 6).

Successive levels increased cost above the previous level quite significantly (p<0.0001). The cost did not differ (p>0.05) across genotypes when UTRS was fed without supplement or UTRS with 500 g/day concentrates. At 1000 g/day, the cost of feeding was higher (p<0.05) in A×S than in A×A steers and tended to exceed (p=0.0689) feed costs in A×F steers.

The tendency for significance of interaction effect was associated with difference in costs at 1000 and 2000 g levels of supplementation. Cost did not differ (p>0.05) across genotypes when steers were fed either UTRS without supplements, or UTRS with 500 g/day supplements. At 1000 g/day of concentrate allowance, cost of feed was higher (p<0.05) in A×S than in A×A and tended to be higher (p=0.689) than in A×F steers as well (Table 6).

Total cost differed by genotype (p<0.05) and levels of concentrates offered (p<0.0001). The effects of supplementation were not depended (p>0.05) on genotype. The prices were lower with steers fed UTRS with 1000 g/day (p<0.05) and UTRS with 500 g/day (p<0.001) of concentrate than steers fed UTRS without supplement; or UTRS with 2000 g/day of concentrate (Table 7). Investments in purchasing and fattening the steers on UTRS without supplements were lower when the steers were fattened on UTRS without supplements than when they were fattened on UTRS with 500 g/day concentrate (p<0.01) and 1000 or 2000 g/day concentrates (p<0.0001). The trends of these differences were highly linear and curvilinear (p<0.0001; Table 6). The highest and lowest TC were recorded when the steers were fattened on UTRS with 2000 g/day concentrates and UTRS without supplements respectively. The costs did not differ (p>0.05) in steers fed UTRS with 500 and 1000 g/day (Table 6).

Break-even price at experimental cost

What-if analysis revealed that the prices of beef would be cost effective at the experimental cost and did not differ (p>0.05) by genotype; but they differed (p<0.05) by dietary treatment. However, there was a tendency for the BEP to be higher (p=0.0871) with A×F than with A×A steers. Despite lack of interaction, the BEP was significantly lower with A×A steers fed UTRS with 500 g/day of concentrates than with A×A steers fed UTRS without supplement (Table 7). Otherwise, there were significant differences (P<0.05) across genotype at all levels of supplementation with concentrates.

Minimum cost at break-even price

Dietary treatments highly influenced (p<0.0001) the

Table 4. Weights (kg) and values (Rwanda Franc) of Ankole, Ankole×Friesian and Ankole×Sahiwal steers fed urea treated rice straw with varying levels of concentrate supplements.

Parameter	Genotypes				Supplement levels					Trends		
	A×A	A×F	A×S	SEM	0	500	1000	2000	SEM	Lin	Quad	Cub
IWT	164.8	163.7	145.8	8.30	150.9	160.6	158.4	162.5	23.5	ns	ns	ns
FWT	198.9^{a}	169.8^{b}	200.3^{a}	8.96	159.4^{b}	193.0^{a}	201.1^{a}	205.2^{a}	10.34	*	*	*
WTG	28.8	33.3	39.9	4.30	25.7	45.3	38.2	33.6	5.70	ns	ns	ns
ECW	115.2^{a}	98.5^{b}	116.2^{a}	5.18	78.1^{c}	111.9^{b}	120.7^{ab}	129.3^{a}	5.98	**	**	**
INV	141,534	115,303	132,379	6,401	126,911	132,543	133,858	125,641	7,391	ns	ns	ns
FNV	207,402^{a}	177,344^{b}	209,199^{a}	9,326	140,606^{c}	201,492^{b}	217,170^{ab}	232,659^{a}	10,769	*	*	*

^{abc}Means with different superscripts within a row are significantly different (p<0.05); *P<0.01; **p<0.001; ns-not significant (p>0.05); SEM-standard error mean; FWT=final weight; ECW= estimates of carcass weight; INV=initial value (Rwanda Francs); FNV= final value; WTG= weight gain; A×A=purebred Ankole; A×F=Ankole×Friesian crossbred; A×S=Ankole×Sahiwal crossbred; Lin=linear; Quad=quadratic; Cub=cubic.

Table 5. Interaction effects of genotype on levels of concentrate supplements on live and carcass weights of Ankole, Ankole×Friesian, and Ankole ×Sahiwal steers feed urea treated rice straw with varying levels (0, 500, 1000 and 2000g/day) of concentrates.

Parameter	A×A				A×F				A×S				P-Value		
	0	500	1000	2000	0	500	1000	2000	0	500	1000	2000	G	CI	G×CI
IWT	160.4	152.9	176.9	169.0	160.4	167.3	164.6	153.4	122.8	161.5	133.7	165.3	ns	ns	Ns
FWT	173	200	210	214	140	176	180	184	166	203	214	218	*	*	Ns
WTG	16.6	32.6	18.9	47	32.6	52.8	42.9	25.1	28.0	50.5	52.7	28.6	ns	ns	Ns
ECW	85	116	126	135	68	102	108	116	81	118	128	137	*	***	Ns
INV	138,586	135,490	147,458	144,602	109,582	123,862	123,114	104,652	132,566	138,278	131,002	127,670	*	ns	Ns
FNV	152,145	208,1539	226,530	242,393	123,260	183744	194,860	208,514	146,412	212,193	231,120	247,070	*	***	Ns

*p<0.01; ***p<0.0001; ns-not significant (p>0.05); FWT=final weight (kg); ECW=estimates of carcass weight; INV=initial value of carcass (RwF); FNV=final weight; WTG=weight gain; A×A=purebred Ankole; A×F=Ankole×Friesian crossbred; A×S=Ankole×Sahiwal crossbred; CI=concentrate inclusion; G= genotype.

minimum cost at BEP. Steers did not differ (p>0.05), but strongly tended to affect (P=0.0681) the minimum cost at BEP. This tendency was associated with higher (p<0.05) minimum cost associated with A×S than A×F steers and a very strong tendency for minimum cost associated with A×A steers to be higher (p=0.0604) than minimum cost associated with A×F steers (Table 7). The cost associated with steers fed UTRS without supplement was lower than the cost associated with steers fed 500 g/day (p<0.05), 1000 g/day (p<0.001) and 2000 g/day (p<0.0001). The cost associated with steers fed UTRS with 500 g/day of supplement was lower than costs associated with steers fed UTRS 2000 g/day (p<0.001); but it was not significantly lower (p>0.05) than cost associated with steers fed UTRS with 1000 g/day. The cost associated with UTRS supplemented with 2000 g/day was higher but significantly than cost associated with UTRS steers fed with 1000 g/day concentrates (p>0.05). Although, there was not significant interaction effect, Table 7 showed that all levels of supplementation in A×F and A×S steers was associated with significant increase of minimum cost above respective steers fed UTRS without supplement. In A×A steers, feeding UTRS with 500 g/day concentrate increased (p>0.05) minimum cost significantly.

Maximum cost at break-even price

Dietary treatments highly affected (p < 0.0001)

Table 6. Costs and prices associated with the production of beef using Ankole, Ankole×Sahiwal and Ankole×Friesian steers fed urea treated rice straw with varying levels of concentrate supplements.

Parameter	Genotypes				Supplement levels					Trends		
	A×A	A×F	A×S	SEM	0	500	1000	2000	SEM	Lin	Quad	Cub
FC	73,891^{b}	74,417^{b}	80,467^{a}	1,475	29,178^{d}	63,848^{c}	78,859^{b}	133,148^{a}	1,704	***	***	***
TC	215,425^{a}	189,720^{b}	212,846^{a}	7,572	156,089^{c}	196,391^{b}	212,717^{b}	258,789^{a}	8,743	***	***	***
BEP	1,869	2,019	1,913	60.0	2,058	1,783	1,858	2,033	70.0	ns	ns	ns
C_{min}	206,375^{a}	184,563^{a}	209,375^{a}	7,957	153,583^{c}	192,583^{b}	207,000^{b}	247,250^{a}	9,188	***	***	***
C_{max}	217,188^{a}	193,375^{a}	220,313a	8,435	160,500^{c}	203,167^{b}	217,917^{b}	259,583^{a}	9,740	***	***	***
BEC_{1800}	212,063^{a}	184,563^{a}	209,063^{a}	9,314	150,417^{c}	208,750^{b}	216,667^{ab}	231,750^{a}	12,419	**	**	**
$C\ t_{threshold}$	201,313^{a}	175,313^{a}	198,250	8,775	142,917^{b}	198,167^{a}	205,583^{a}	219,833^{a}	11,700	**	**	**

^{abcd}Means with different superscripts within a row are significantly different (*P<0.05*); ***P<0.001*; ****P*<0.0001; ns-not significant (P>0.05); FC= feed costs;TC=total cost; BEP=Breakeven price;C_{min}=Minimum cost at breakeven price;C_{max}=Maximum cost at breakeven price;BEC_{1800}=breakeven cost at RFW1800/kg of beef; $C_{threshold}$=cost at turning point for the next competitive price, A×A=purebred Ankole; A×F=Ankole×Friesian; A×S=Ankole×Sahiwal; Lin=linear; Quad=quadratic; Cub=cubic.

Table 7. Interaction effects of genotype by concentrate levels in Ankole, Ankole×Friesian and Ankole×Sahiwal steers feed urea treated rice straw with varying levels of concentrate supplement.

Parameter	A×A				A×F				A×S				P-Value		
	0	500	1000	2000	0	500	1000	2000	0	500	1000	2000	G	CI	G×CI
FC	32,995	61,369	74,940	126,259	26,013	63,810	76,907	130,940	28,526	66,365	84,732	142,245	**	***	ns
TC	171581	196859	222398	270861	135595	187672	200021	235592	161092	204643	215734	269915	*	***	ns
BEP	2,075	1,600	1,825	1,975	2,050	1,900	2,025	2,100	2,050	1,850	1,725	2,025	ns	*	ns
Min cost $_{BEP}$	168,250	189,750	217,000	250,500	133,000	180,500	194,000	230,750	159,500	207,500	210,000	260,500	ns	***	ns
Max cost $_{BEP}$	175,750	201,500	228,500	263,000	139,000	189,750	203,750	241,000	166,750	218,250	221,500	274,750	ns	***	ns
BEC1800	151,750	229,750	226,000	240,750	153,500	183,500	193,500	207,750	146,000	213,000	230,500	246,750	ns	***	ns
Pct	144,250	218,250	214,500	228,250	146,000	174,250	183,500	197,500	138,500	202,000	218,750	233,750	ns	***	ns

*p<0.01; ** p<0.001;***p<0.0001; ns-not significant (p>0.05); BEC= break-even cost; BEC1800 = break-even cost at RwF 1800/kg of beef; Max=Maximum; Min-=minimum; FC= feed cost; TC=total cost; BEP= break-even price; Pct=Competitive threshold price, A×A=purebred Ankole; A×F=Ankole×Friesian crossbred; A×S=Ankole×Sahiwal crossbred; Lin=linear; Quad=quadratic; Cub=cubic; CI=concentrate inclusion; G=genotype.

maximum tolerable cost of feedlotting at BEP. The price tended to differ (p=0.0597) across genotypes without a significant (p>0.05) interaction effect. The tendency in genotype effect was associated with a significantly higher maximum cost of production associated with A×S than A×F steers (p<0.05) and a tendency of the maximum cost in A×A to be higher than in A×F steers (p=0.0597). The cost associated with UTRS without supplements was lower than the cost associated with UTRS plus 500 g/day concentrate (p<0.01); UTRS with 1000 g/day concentrate (p<0.001) and UTRS with 2000 g/day (p<0.0001). The cost associated with 2000 g/day concentrate was higher than the cost associated with 1000g/ concentrate (p<0.01); and 500 g/day concentrate (p<0.001). There was no difference (p>0.05) between maximum cost at BEP associated with 500 and 1000 g/day dietary treatments.

Break-even cost at current price of beef (RwF 1800)

BEC at RwF 1800 kg^{-1} of beef were highly depended ($p<0.001$) on dietary treatment and not steers ($p>0.05$). However, there was a tendency for the cost to be high with A×A steers than A×F steers ($p=0.0572$). It also tended to be higher ($p=0.0885$) in A×S than in A×F steers. The costs were higher in steers fed UTRS with supplements than in those fed UTRS without supplements (Table 7). The cost did not differ ($p>0.05$) at the same level of concentrates across steers (Table 8).

Threshold cost at current price of beef (RwF 1800)

The threshold cost was the cost below which the farmer could reduce the price of beef that could be gain a competitive edge in the existing market. This cost was highly influenced ($p<0.001$) by the dietary level of concentrate supplements and steers and the interaction with dietary treatments did not have significant ($p>0.05$) effect. However, there were tendencies for threshold cost to differ between A×A and A×F ($p=0.0564$) and A×S and A×F ($p=0.0904$) steers. The threshold costs were lower in UTRS than in UTRS with 500 g/day concentrate ($p<0.01$), 1000/day concentrate ($p<0.001$) and 2000 g/day concentrate ($p<0.0001$). The threshold price did not differ ($p>0.05$) in diets with concentrate supplements (Table 8).

Gross margins at experimental cost

Levels of concentrate supplements was the only factor that significantly influenced ($p<0.0001$) margins that would be realized from carcass sales under the experimental conditions of the trial. GM did not differ ($p>0.05$) among steers and neither were the effects of levels of concentrates dependent on the steers. Mean GM were negative across all genotype of steers. However, the GM values were not significantly different ($p>0.05$) from zero except in A×F steers ($p<0.01$). Gross margin values were negative in steers fed on UTRS without supplements and in those fed on UTRS with 2000 g/day. At other levels (500 and 1000 g/day), GM values were positive but not significantly different ($p>0.05$) from zero (Table 9).

Gross margin at breakeven price

GM at BEP depended on dietary treatment ($p<0.05$) and not ($p>0.05$) on genotype of steers. At 0, 1000, and 2000 g/day supplement the GM at BEP did not differ ($p>0.05$) significantly (Table 10). Despite lack of significant interaction, the GM was higher ($p<0.05$) in A×A steers fed UTRS with 500 g/day concentrate than in A×S steers on the same dietary treatments (Table 10).

Gross margin at minimum cost at break-even price

Levels of concentrate supplementation highly affected ($p<0.001$) the GM that would be realized at minimum cost at BEP. This effect applied across all genotype of steers because the interaction effects were not different; and the GM did not differ ($p>0.05$) among genotypes. Nevertheless, the GM associated with A×S steers were higher ($p<0.05$) than the GM associated with A×F steers.

The UTRS without supplements had lower GM at minimum cost for the BEP than UTRS with 500 g/day concentrate ($p<0.05$); UTRS with 1000 g/day concentrate ($p>0.01$) and UTRS with 2000 g/day concentrate ($p<0.0001$). This GM did not differ ($p>0.05$) between UTRS with 500 g/day concentrate and UTRS with 1000 g/day concentrate; and between 1,000 and 2000 g/day concentrate. It tended to be higher ($p=0.0731$) in UTRS with 2,000 g/day concentrate than UTRS with 500 g/day concentrate.

Gross margin at maximum cost at break-even price

GM at maximum cost for BEP did not differ ($p>0.05$) by cattle genotype and dietary treatment levels. The GM was not significantly greater ($p>0.05$) than zero in A×A steers but it tended to be significantly greater ($p=0.0907$) than zero in A×F and it was significantly greater ($p<0.01$) than zero in A×S steers. Across dietary treatments the GM tended to be higher ($p=0.0963$) in UTRS plus 2,000 than 500 g/day concentrate feeding.

Break-even cost and margin at current abattoir price of beef

Levels of concentrate offer affected ($p<0.001$) the BEC at the prevailing abattoir price of beef. However, there was a strong tendency for the cost to be higher ($p=0.0885$) in A×S than in A×F steers. The BEC was lower in UTRS rations than in UTRS+500 g/day ($p<0.01$), UTRS+1000 g/day ($p<0.001$) and UTRS+2000 g/day ($p<0.0001$). The cost did not differ ($p>0.05$) among dietary treatments with concentrate supplements. The GM associated with the BEC at current price of beef was not affected ($p>0.05$) by cattle genotypes and dietary treatments. The GM for cost for competitive price adjustment were not dependent ($p>0.05$) on genotype of steers. However, they strongly tended to be higher in A×A ($p=0.0657$) and A×S steers ($p=0.0698$) than in A×F steers (Table 4). They differed highly significantly ($p<0.001$) with levels of concentrates. The GM in steers fed UTRS with 2,000 g/day ($p<0.0001$), 1,000 g/day ($p<0.001$) and 500 g/day ($p<0.01$) were higher than the GM in steers fed UTRS without supplement. But the GM did not differ ($p>0.05$) among steers fed UTRS with supplements (Table 10). They were highly influenced ($p<0.001$) by dietary treatment.

Table 8. Interaction effects of diet on Ankole, Ankole×Friesian and Ankole×Sahiwal steers fed UTRS with varying levels of concentrate supplements

Parameter	A×A				A×F				A×S				Trends	
	0	500	1000	2000	0	500	1000	2000	0	500	1000	2000	Lin	Quad
FC	32,995	61,369	74,940	126,259	26,013	63,810	76,907	130,940	28,526	66,365	84,732	142,245	**	***
BEP	2,075	1,600	1,825	1,975	2,050	1,900	2,025	2,100	2,050	1,850	1,725	2,025	ns	*
MinCBEP	168,250	189,750	217,000	250,500	133,000	180,500	194,000	230,750	159,500	207,500	210,000	260,500	ns	***
MaxCBEP	175,750	201,500	228,500	263,000	139,000	189,750	203,750	241,000	166,750	218,250	221,500	274,750	ns	***
BEC1800	151,750	229,750	226,000	240,750	153,500	183,500	193,500	207,750	146,000	213,000	230,500	246,750	ns	***
Pct	144,250	218,250	214,500	228,250	146,000	174,250	183,500	197,500	138,500	202,000	218,750	233,750	ns	***

*P<0.01; ** P<0.001;***P<0.0001; ns-not significant (P>0.05); FC=feed cost; BEP = break-even price; MinCBEP= minimum cost at BEP; MaxCBEP= maximum cost at BEP; BEC $_{\text{RwF1800/kg beef}}$ = break-even cost at RwF 1800/kg of beef;; BEP= break-even price; Pct = competitive threshold price; A×A=purebred Ankole; A×F=Ankole×Friesian crossbred; A×S=Ankole×Sahiwal crossbred; Lin=linear; Quad=quadratic.

Table 9. Gross margins of Ankole, Ankole×Friesian and Ankole×Sahiwal steers fed urea treated rice straw with varying levels of concentrate supplements.

Parameter	Genotypes				Supplement levels					Trends		
	A×A	A×F	A×S	SEM	0	500	1000	2000	SEM	Lin	Quad	Cub
GM_{exp}	-8,023^{a}	-12,375^{a}	-3,647^{a}	4,248	-15,484^{b}	5,101^{a}	4,453^{a}	-26,130^{b}	4,906	ns	*	*
GM_{BEP}	5465,5	4191,81	5357,38	694,6	4759,54	2987	5854,17	6418,87	802,04	ns	ns	ns
GM_{Cmin}	11,278	9,379	11,982	862	7,343	11,070	11,438	13,669	995	**	*	*
GM_{Cmax}	466	567	1,045	326	426	487	521	1,336	377	*	ns	ns
GM_{BEC}	530	499	443	81	479	482	503	500	81	ns	ns	ns
$GM_{threshold}$	11280^{a}	9749.44^{a}	11256^{a}	536.5	7978.83^{b}	11065^{a}	11587^{a}	12416^{a}	619.5	**	**	**

^{ab}Means with different superscripts within a row are significantly different (*P<0.05*); **P<0.01*; ***P*<0.001; ns-not significant (P>0.05); GM_{exp}=gross margin at experimental cost; GM_{cmin}= gross margin at minimum cost; GM_{CmaX}= gross margin at maximum cost; GM_{BEP}= gross margin at breakeven price; GM_{BEC}= gross margin at breakeven cost; $GM_{threshold}$= gross margin at threshold cost; Lin=linear; Quad=quadratic; Cub= Cubic.

DISCUSSION

In this experiment, animals were not slaughtered because of procurement policy in the organization. Hence results of carcass weight are used to show relative that need confirmation carcass characteristics of steers fed quality-enhanced rice straws. CWT were higher in steers that received concentrates than in the steers fed UTRS without supplement. However, the additional gains for higher levels of concentrate than 500 g/day were not significant (Table 9). Intuitively, this level of supplementation is small and affordable by farmers with access to credit. The WG observed were lower than reported in grazing cattle given supplement (Asizua et al., 2010; Mlote et al., 2013). The discrepancy can be attributed to lower quality of the UTRS, compared to the materials available in open range.

The assumption was that the steers would be purchased from the market at farm gate at estimated carcass values. Relative to the TC, the FC constituted 16 to 36% of the initial investments in purchasing stock and feeding. Asizua et al. (2010) reported similar values as relative FC for feedlotting in Uganda. But these values were twice as high as the cost of beef fattening by supplementing open grazed cattle in Tanzania (Mlote et al., 2013). The present results showed that feeding and not cattle genotype is the key element that determines the profitability of fattening beef cattle using UTRS. This suggestion is supported by the findings of El-Asheeri et al.

Table 10. Gross margin (Thousands of Francs) analysis of effect of genotype and dietary treatments of Ankole, Ankole×Friesian and Ankole×Sahiwal steers fed urea treated rice straw with varying levels of concentrate supplements.

Parameter	A×A				A×F				A×S				Trends		
	0	500	1000	2000	0	500	1000	2000	0	500	1000	2000	G	CI	G×CI
GM	-19.5	11.7	4.12	-28.47	-12.34	-3.93	-6.161	-27.08	-14.68	7.55	15.39	-22.85	ns	***	ns
GM_{BEP}	4.38	5.37	6.78	5.33	4.02	2.45	4.25	6.05	5.88	1.15	6.53	7.88	ns	*	ns
$GM_{MinCost}$	7.88	12.37	12.04	12.83	6.52	9.69	10.25	11.05	7.63	11.15	12.03	17.13	ns	**	ns
$GM_{CostMax}$	381	617	535	330	521	447	498	802	377	398	530	2,875	ns	ns	ns
GM_{BEC}	395	781	530	414	630	244	360	764	412	422	620	320	ns	ns	ns
$GM_{threshold}$	7.89	12.28	12.03	12.91	8.13	9.49	10.36	11.01	7.91	11.42	12.37	13.32	ns	**	ns

*P<0.01; **P<0.001; ***P<0.0001; ns= Not significant (P>0.05); GM=gross margin at experimental cost; BEP= break-even price; $GM_{mincost}$= gross margin at minimum cost; $GM_{CostmaX}$=gross margin at maximum cost; GM_{BEC}= gross margin at breakeven cost; $GM_{threshold}$= gross margin at threshold cost; CI= concentrate inclusion; G= genotype.

(2008), who found that benefit/cost ratio increased by 6% when 25% of concentrates feed mixture was replaced by corn silage. The ECW was lower in the steers fed UTRS without supplements than in those fed UTRS with supplements (Table 5). Asizua et al. (2009) reported similar results where feeding supplement affected slaughter weight (p <0.001), hot carcass weight and hot carcass percentage (p <0.05). At the current price of RwF 1800 kg^{-1} beef; it is economically feasible to breakeven by feeding 500 g/day supplement to UTRS (Table 6). Overall, the results from the study suggest that straw-based feedlot beef production was marginally acceptable. The economic feasibility is likely to increase if revenues from trimmings from carcass parts were included. Trimmings and offals are valuable components of carcass in East Africa that is steadily gaining commercial importance. These parts are recommended to be part of the confirmatory study in a public-private partnership framework.

Conclusion

Cattle genotype did not affect growth, expected carcass weight, and values of steers feed UTRS. Concentrate supplements significantly improve growth, and expected carcass weight and value. UTRS-based feedlots beef is marginally acceptable under current market prices with concentrate supplement at 500 g/day. Highly levels of supplements are acceptable with a policy incentive that increases abattoir to farmers. However, these results need confirmation with actual results from slaughtered cattle to determine carcass yields.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Production practices of local pig farmers in Ghana

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Local pig production is of economic, nutritional and socio-cultural importance to livelihoods in Ghana. Data was collected from 176 local pig farmers in four regions of Ghana using pretested structured questionnaire. Majority of the farmers interviewed were males over 30 years and kept crossbred pigs (64%) with income (95%) as their main motivation. In terms of housing of pigs, most farmers use sheds (39%), about a third had permanent structures (34%), whilst the rest (22%) use stalls with a few keeping their animals in their yards (2%) or having no housing facility (2%) at all. Growth rate of pigs was a relatively important trait (49%) for the farmers compared to aesthetic traits like coat colour or ear orientation. Majority of the farmers (90%) acquired their breeding stock from family, friends and the open market with only 10% acquiring breeding stock from government breeding stations. Local pig production in the study area was characterised as semi-intensive with significant opportunities for stakeholders to make interventions for improvement through provision of improved breeds, housing, feeding and veterinary care.

Key words: Food security, farmer education, pig production, sustainable breeding programmes.

INTRODUCTION

As human population growth increases worldwide, there is need for continuous food supply to ensure food security (FAO, 2006). For the past three consecutive years, there has been a rise in hunger worldwide. It has been reported that about 11% of the world's population is undernourished, amongst which 23.2% are in sub-Saharan Africa and 15.1% are within western Africa (FAO, 2018). Livestock serve as a key source of protein and nutritional well-being (Komatsi and Kitanishi, 2015) and local pig production becomes an attractive option on account of the ease of management, prolificacy of the species and the many small-scale farmers keeping the animals (Osei-Amponsah et al., 2017). Pig production has a high potential to increase productivity due to its fast growth rate, shorter generational interval, good feed conversion efficiency, and high litter sizes compared to cattle (Mbuthia et al., 2015). There is however the need for more information on pig production practices of local farmers in order to make appropriate recommendations for improvement to increase productivity (Adjei et al., 2015).

Characterization of pig production systems provides useful information for their improvement and conservation. There is paucity of information on the

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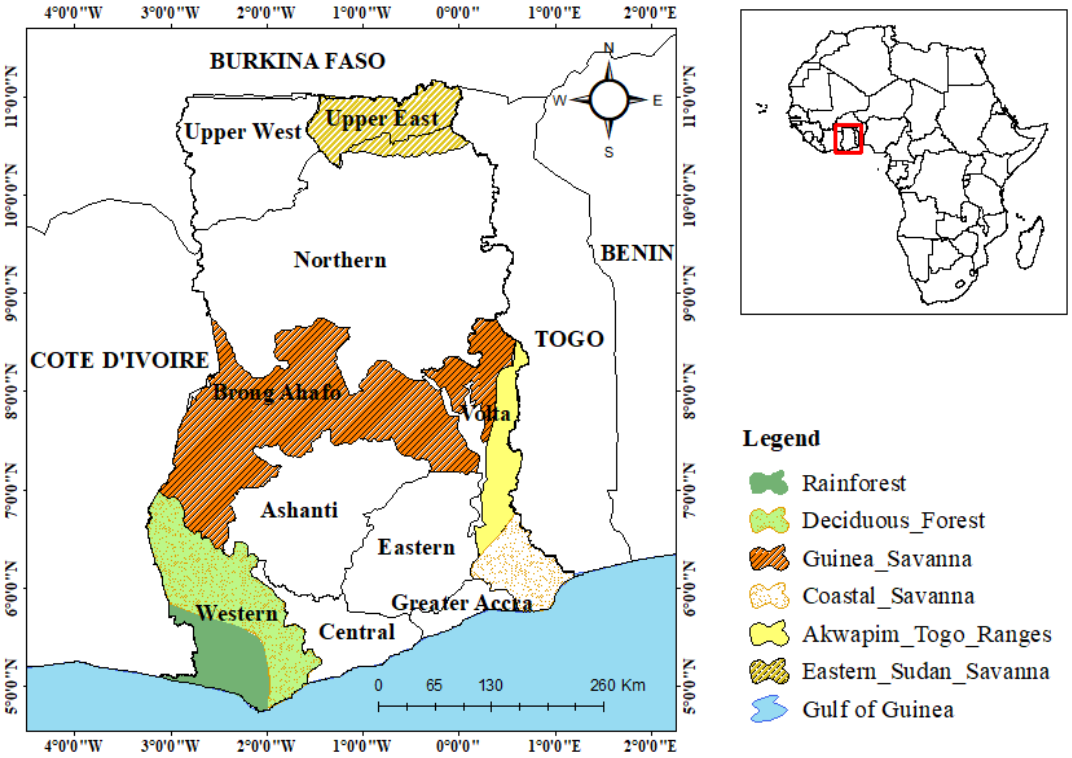

Figure 1. Map of Ghana, showing the location of farmers surveyed in this study.

on the production practices of local pig farmers which can be useful in the establishment of breeding programmes to enhance their production potentials (Adjei et al., 2015; Ayizanga et al., 2018). In this study, primary data were collected on production practices of local Ghanaian pig farmers to identify their limitations and challenges and make appropriate recommendations for improvement. The study should provide adequate information on pig production practices across all agro-ecological zones of Ghana and enhance the livelihoods of the millions of farmers including vulnerable women and children whose livelihoods to a large extent depend on pig production.

MATERIALS AND METHODS

Using purposive sampling, with assistance from District Directors and Extension officers of the Ministry of Food and Agriculture (MoFA, Ghana), pig farmers who raised local pigs were identified from selected districts of four regions of Ghana (Figure 1). These were the Upper east region (Sudan savanna ecological zone), the Brong-Ahafo region (Guinea savanna zone), Western region (Forest zone) and Volta region (Coastal savanna zone). A total number of 135 farmers were interviewed for the study using a pretested structured questionnaire. Following FAO guidelines (FAO, 2007), data was collected on the demographic attributes of the farmers (farmer's name, age, location, educational background) and pig production practices (breeds raised, trait preferences, housing systems, feeding, access to veterinary services and mortality rate recorded on farms). The data were analyzed using Statistical Package for Social Sciences (SPSS) version 20.0 (SPSS, 2011) and the Survey Package in R version 3.5.2 (R Core Team, 2018).

RESULTS

Demographics of Ghanaian local pig farmers

The results of the survey indicated a significant difference ($P < 0.05$) between gender, age and education background of pig farmer across the different regions (Table 1). Apart from the Western region which recorded the highest number of females (87%) engaged in pig farming, the three other regions recorded relatively high number of male farmers. Across all the regions studied, majority of the farmers interviewed were young adults between the ages of 20 and 50 years. While majority of farmers in the Brong-Ahafo, Upper East and Volta regions had no formal education, it was found out that farmers in the Western region were more likely to have at least primary education.

Pig production systems in the regions

Three breed types were identified namely, the local breed thus Ashanti Dwarf pigs (ADPs), Exotic breeds (Large

Table 1. The demographic attributes of local pig farmers.

Demographic attribute	Brong-Ahafo (%)	Upper East (%)	Volta region (%)	Western region (%)
Gender				
Male	29 (74)	16 (67)	12 (48)	6 (13)
Female	10 (26)	8 (33)	13 (52)	41 (87)
Chi square test *P*-value		3.445e-08**		
Age				
20-30	3 (8)	1 (4)	18 (72)	3 (6)
31-50	20 (51)	12 (50)	5 (20)	20 (43)
51+	16 (41)	11 (46)	2 (8)	24 (51)
Chi square test *P*-value		3.597e-12**		
Educational level				
None	22 (56)	15 (63)	10 (40)	12 (26)
Primary	5 (13)	4 (17)	7 (28)	25 (53)
Secondary	7 (18)	3 (13)	5 (20)	6 (13)
Tertiary	5 (13)	2 (8)	3 (12)	4 (8)
Chi square test *P*-value		0.01064**		

**Significant at P < 0.05

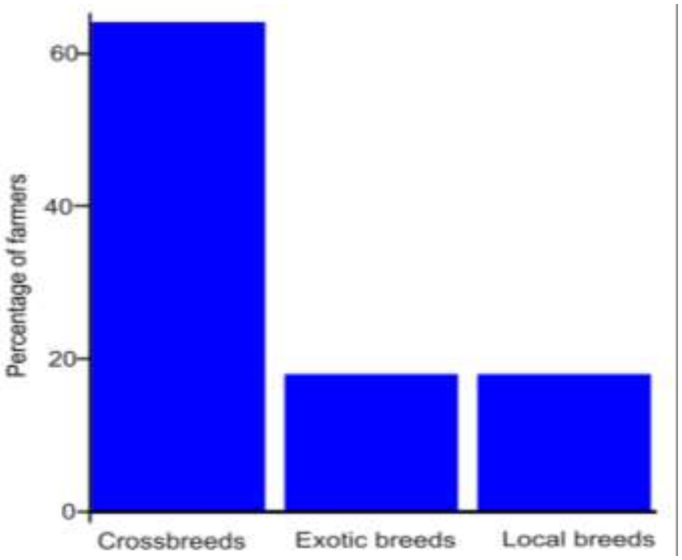

Figure 2. Breeds raised by the sampled farmers; crossbreds were the major breeds raised by farmers.

whites and Landraces) and crossbreeds (crosses between local pigs and exotics). From the study, it was discovered that, the majority of farmers were keeping crossbred pigs compared to either ADPs or exotics (Figure 2). It was also found out that, most of these farmers (95%) raise pigs to serve as a source of income and not to provide just meat for the household. In terms of trait preferences, majority of the pig farmers (49%) consider the growth rate of the pigs with about a third (30%) indicating body size and body length of the pig as important. However, these pig farmers consider less the coat or skin colour of the pigs (Figure 3). Almost all the pig farmers interviewed had some sort of housing facility. About a third of the pig farmers (35%) had permanent structures, only 2% of the farmers had no housing facility with others using sheds (39%), stalls/shade (22%) or yards (2%) (Figure 4). As shown in Figure 5, most of the pig farmers (66%) fed their pigs with kitchen left overs

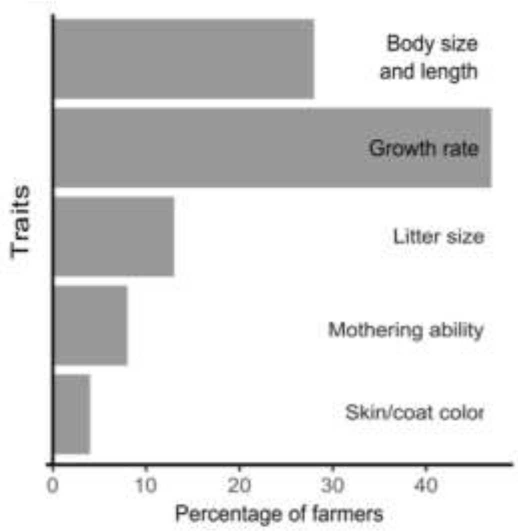

Figure 3. Trait preferences by farmers; growth rate is the most preferred trait by farmers sampled.

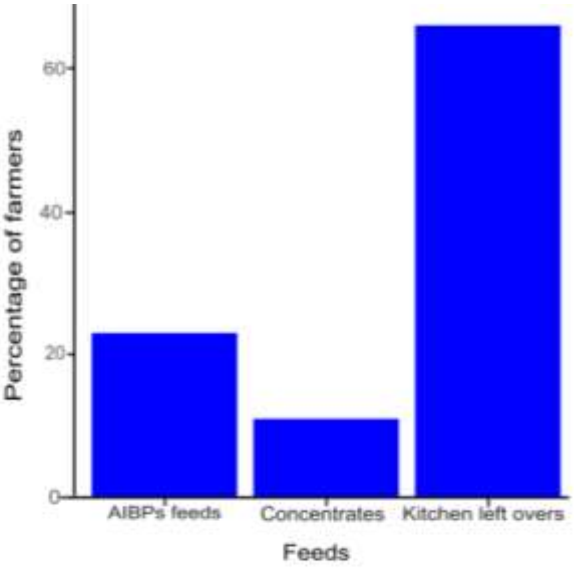

Figure 5. Feed types fed to pigs by sampled pig farmers; majority of the farmers sampled fed their pigs with kitchen left overs.

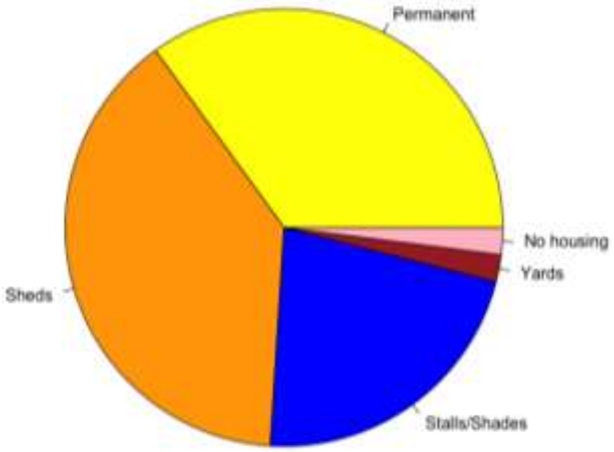

Figure 4. A pie chart showing housing systems used for pig production. The majority of farmers interviewed used sheds as housing facility.

(cooked cassava, fish, yam and soup) with a small fraction (11%) of farmers providing concentrates. However, some of the farmers (23%) also provide their pigs with feedstuff from agro-industrial by-products (AIBPs). According to majority (89%) of the pig farmers, feedstuffs are easily accessible but are costly. Most respondents (64%) acquired their breeding stock from family members, friends and the open market (26%) with only 10% of the respondents acquiring their breeding stocks from breeding stations (Table 2). Majority (65%) of the local pig farmers sampled had access to veterinary services with most of them (84%) recording no mortality on their farms.

DISCUSSION

In the Volta region, Upper east and Brong-Ahafo region men were mostly the owners of local pigs but were generally managed by the women with the men concentrating on managing their crop farms. However, in the Western region, the study revealed that local pigs were owned and managed by women who engage in mixed farming, this indicates the eminent role women play in livestock production. This is in agreement with FAO reports that, women play an important role in subsistence farming including livestock production and food processing (FAO, 2006, 2008). Across the regions, apart from the Western region, most of the farmers especially in the Brong-Ahafo and Upper East regions have not had formal education. Similarly, Aina (2007) reported that majority of African farmers have not had formal education and most of them cannot read or write in any language and this contributes to their non-adoption of improved farming practices. UNESCO (2018), also reported that, as at 2010 about 58% of the Ghanaian population under the age of fifteen have had no formal education but by 2017, 84.5% of Ghanaian children were enrolled in primary education indicating the continuous effort to improve education in Ghana. Interestingly, the Western region may have recorded the highest number of educated farmers because from the year 1984 to 2000, the basic school enrolment increased significantly by 87% in an effort to curtail teenage pregnancy and other social vices in that region (GSS, 2004). The level of education of farmers recorded in the Western region may have also contributed to the high number of women engaged in pig

Table 2. Sources of breeding stock.

Source	Frequency	Percentage
Family and friends	86	64
Breeding stations	15	11
Open market	34	26

farming in that region, as education has been identified by Kimbi et al. (2015) as one of the factors that influence farmer's adoption to change. Results of this study also revealed that, majority of the local pig farmers were young adults aged between 20 and 50 years. This is of great significance because young people can contribute immensely to agricultural development in rural communities; policy makers and agricultural development experts worldwide have expressed worry that young people have less interest in taking up farming in rural communities (FAO, 2014).

A previous study reported that pigs are raised as homestead animals to provide just food for the household (Ganaba et al., 2011), but this study revealed that, although some pig farmers still raise pigs to provide the household with food, most pig farmers currently raise pigs mainly as a source of income. The study also revealed that exotic breeds (mainly Large White, Landrace and Duroc), Ashanti Dwarf Pigs and crossbreeds are the pig breeds raised by local pig farmers in Ghana. However, the majority of farmers were engaged in crossbreeding. This result is in agreement with a report by Osei-Amponsah et al. (2017) that most farmers resort to indiscriminate crossing of the local breeds with exotic breeds in a quest to improve the productivity of local pig breeds. This however leads to inbreeding and consequently low production, reproduction, poor health and dilution of adaptive traits needed for sustainable local pig production. Unfortunately, this practice has been encouraged over the years as the Ministry of Food and Agriculture import Grand Parent exotic breeds mainly Large White and supply to farmers for breed improvement (MOFA, 2013). We believe that future interventions must be carefully planned to maintain the adaptive germplasm needed for local pig production.

In the designing of breeding programmes for breed improvement, it is important to consider farmer's trait preferences. In determining which economic traits are preferred by farmers, both this study and previous work (Ouma et al., 2007) found that trait preferences by farmers are heterogeneous. Most pig farmers prefer pig breeds with fast growth rates; some also take into consideration the animal's body size/length, litter sizes, and good mothering ability. However, only a small fraction of farmers considers the animal's coat/skin colour. This is important information to consider in developing a pig breed for local production in Ghana.

Unlike in commercial farming where permanent housing facilities are built to provide shelter for pigs, in smallholder pig farming systems, pigs are raised under sheds, yards, stalls or shades. In the regions studied, only few farmers had permanent housing structures while majority of the sampled local pig farmers made use of sheds, yards and stalls or shades for housing their pigs. This may be due to how cheap, how accessible materials are and how easy it is to construct sheds, yards and stalls in these areas than it is for constructing permanent housing facilities (Karnuah et al., 2018).

High cost and availability of feed is one challenge most farmers face in pig production. In this study most of the farmers reported feed stuffs were available but costly. Due to this, they resort to feeding their pigs with kitchen waste and AIBPs rather than more expensive concentrates. Although the pig farmers did not keep financial records, they said they do not earn as much as commercial pig farmers. The feedstuffs used by these local pig farmers may explain the low level of income made from these pigs by the farmers. This agrees with reports by Karnuah et al. (2018) that local feedstuffs and concentrates were available in Liberia but expensive for the local pig farmer and affects the level of income of most local pig farmers.

The proximity of the various farms to each other (Supplementary Figure 1) explains why the pig farmers get their breeding stocks from friends, family and as inheritance. Only few farmers buy their breeding stock from breeding stations which are then circulated again to family and friends by crossing with other pig breeds in their localities. Due to this, there is a high possibility of indiscriminate crossbreeding among pigs in the communities studied. Finally, with regards to litter size, disease resistance and mortality experienced on farm, although these pig farmers do not keep records on their farms, they concluded that although local pigs had smaller litter sizes, they were resistant to most endemic diseases. Most farmers said they have access to veterinary services but are not able to purchase commercial drugs. Nonetheless, they record low mortality on their farms. This result agrees with reports that, local pigs are hardy, disease resistant and is able to survive drought incidence in Ghana (Adjei et al., 2015; Osei-Amponsah et al., 2017; Ayizanga et al., 2018).

CONCLUSIONS AND RECOMMENDATIONS

Local pig production in Ghana can be characterized as a semi-intensive production system with farmers keeping mostly crossbreeds. Growth rate and body size of pigs are important traits farmers consider in the selection of their breeding stock.

This study revealed that for the adoption of improved technologies by farmers, education must be prioritized. The Ministry of Education, Ghana Education Service

(GES) together with other stakeholders must put in place adult education schemes for local pig farmers.

To ensure the sustainable growth of the local pig industry in Ghana, improved housing, feeding and regular training of farmers, and adoption of community-based breeding programmes are recommended.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

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SUPPLEMENTARY FIGURE

Supplementary Figure 1. Example images of housing conditions for pigs.

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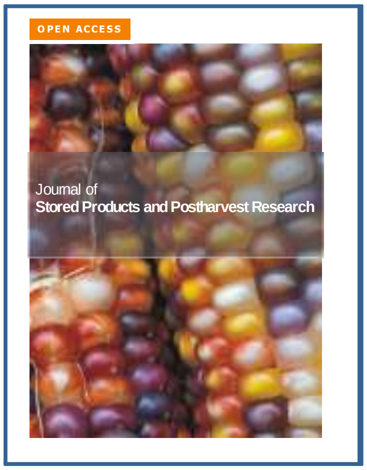

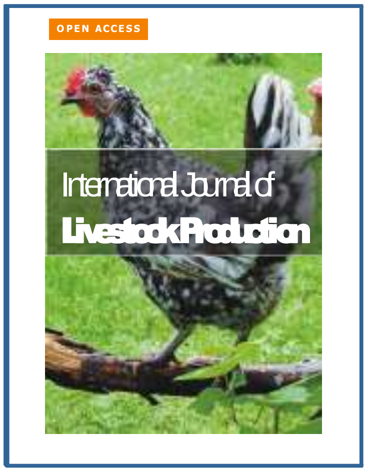

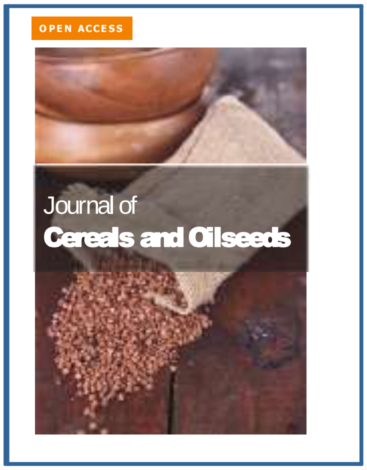

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