Performance of F1 Piglets of Sows Fed Fermented and Enzyme-Supplemented Cassava Peel Meal Based Diets

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Abstract

The performance of F_1 piglets fed fermented or enzyme-supplemented cassava peels was investigated. Peels from freshly harvested cassava were fermented for four days, sun-dried for 3-5 days, then milled. The cassava peel meal (CPM) replaced maize in grower and finisher diets in T_1 (control), T_2 (fermented CPM) and T_3 (fermented CPM + maxigrain^R enzyme) in a completely randomized design. The diets were served at 4% of live body weights daily to 27 Largewhite x Duroc weaner-gilts, aged 8 weeks and weighing 10.61±0.27 kg. The piglets suckled until mid-lactation, then shared finishing diets with the sows in addition. Data was analyzed with one-way ANOVA on SPSS. Average litter sizes, average birth weights, average weaning body weights and mortality rates had no significant ($p>0.05$) differences. Average daily body weight gains differed significantly ($p<0.05$) 155.24±0.09g (T_1) and 159.29±0.15g (T_3) compared to 146.67±0.11g (T_2). Fermented cassava peels with or without enzyme supplementation has no deleterious effect on the performance of F_1 piglets.

Keywords: Gilts, fermented cassava peels, maxigrain^R enzyme, F_1 piglets, performance
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1. Introduction

Selection for litter size has led to an increased within-litter variation in piglet birth weight. A critical birth weight of 950 g has been proposed, below which the development of myofibers and lipids may be modified. Birth weight is an important trait in pig production (Quiniou *et al.,* 2002). Low birth weight results from intrauterine growth retardation during gestation. Small piglets form a lower total number of skeletal muscle fibres during prenatal development compared with their larger littermates (Gondret *et al.,* 2006). Quiniou *et al.,* (2002) demonstrated that average piglet body weight may decrease and the percentage of piglets with low birth weight may increase with increasing litter size. These findings have been associated with the effect known as intrauterine crowding which, together with genetic and epigenetic factors, influences angiogenesis, growth, and vascularization of the placenta. Consequently, nutrient and oxygen supply to the fetuses and ultimately, their growth and development are affected (Town *et al.,* 2004; Wu *et al.,* 2004). Pere and Etienne (2000) reported that when litter size increases, the uterine blood flow increases, but to a lower extent than the number of fetuses. This results in reduced uterine blood flow per fetus, which then might affect fetal nutrient supply. The birth weight of piglet is 1% from its slaughter weight. The piglets with birth weight higher than 1.2 kg are considered viable and reach the maximum of its production efficiency (Herčik, 2003). Pre-weaning mortality is a major cause of wastage in pig production. Birth weight variation within litters affects piglet survival and weight gain. Parity and litter size are some of the factors affecting birth weight. Milligan *et al.,* (2002) indicated that parity influences birth weight and generally, sows in first parity have lower birth weight yields than sows in other parities. There is a negative correlation between litter size and birth weight, hence increase in litter size yields reduced birth weight (Damgaard *et al.,* 2003). In pig production, weaning number and weaning weight are important parameters. Birth weight and litter size affect weaned numbers and weight. In addition, with high birth weights there is a tendency for high weaning number [(Quiniou *et al.,* 2002; Gondret *et al.,* 2005). There is an inverse relationship between birth weight and piglet mortality and the pre-weaning mortality rate is high in piglets with low birth weight (Damgaard *et al.,* 2003; Mesa *et al.,* 2006). Marcatti (1986) indicated a high mortality rate of 60% for piglets born under 800 g. Whittemore and Green (2001) suggested that the growth of a pig from birth to maturity is best described by the Gompertz function, which infers that the pig has a predetermined growth path and that there are large, fast-growing animals and smaller, slower-growing animals. The function also means that a larger genotype or a pig with a greater propensity for growth will, at any age, be bigger and grow faster than a smaller genotype, and that pigs that are heavier at birth and (or) weaning will maintain this advantage as they grow older and attain mature body weight earlier (Williams, 2003). However, the Gompertz function fails to describe the post-weaning period during which pigs usually lose weight and then slowly recover; it sometimes takes 6 – 9 days for them to regain their maintenance energy requirement (Pluske *et al.,* 1995). Weight at birth, weaning and during the immediate post-weaning period are major determinants of the subsequent growth performance of pigs (Wolter & Ellis, 2001), although the manner in which pigs reach a heavier weight also appears crucial. Williams (2003) reviewed numerous studies showing that weights at birth and at one week of age are correlated with weaning weight, and that weight at weaning is correlated to subsequent performance. In addition, (Tokach *et al.,* 1992) and (Azain, 1993) reported that pigs growing well (225 – 340 g/d) in the first week after weaning reached market weight 10 – 28 days before pigs exhibiting poor gain (0 – 110 g/d) in the first week after weaning. However, details of birth weights were not provided. The effect of weight gain (and thus feed intake) in the first week after weaning and the effect of weaning weight are additive and account for approximately 80% of the variation in body weight on day 20 after weaning and 34% of variation in body weight at 118 days of age (Miller *et al.,* 1999; Ilsley *et al.,* 2003). Furthermore, (Lawlor *et al.,* 2002) commented that the type of diet fed after weaning can affect the significance of the relationship between birth weight and post-weaning performance. They recommended feeding a high-density diet after weaning to take advantage of this relationship. Pigs that are heavier at weaning seem to maintain their weaning weight advantage to slaughter weight (Mahan & Lepine, 1991; Dunshea *et al.,* 2003, but the manner in which a piglet attains that weight appears to have a marked influence on subsequent growth performance. Therefore, this experiment was predicated on assessing the performance and general wellbeing of F_1 generation piglets farrowed by gilts fed fermented CPM-based diets.

2. Materials and methods

2.1 Experimental site

The experiment was carried out at the piggery unit of the Teaching and Research Farm at the Federal College of Animal Health and Production Technology, Moor Plantation, Ibadan, Oyo State, Nigeria. Ibadan is geographically located at latitude 7° 22' 39'' N and longitude 3° 54' 21'' E and falls within the tropical rainforest wet and dry climate, with a lengthy wet season. It has mean total rainfall of 1420.06 mm, mean maximum and minimum temperatures of 26.46 °C and 21.42 °C respectively and relative humidity of 74.55%.

2.2 Source of ingredients and feed formulation

Fresh cassava peels for this experiment was sourced from Orile-Ilegun; an industrial layout in Ibadan, Oyo State, Nigeria. The maxigrain^R enzyme was sourced from the open market with the following constituents: Amylase, xylanase, Beta-glucanase, cellulase, pectinase, protease, phytase and lipase. Four processing methods were carried out on cassava peels to determine the process that would reduce hydrogen cyanide glycoside most, improve crude protein content and be more practicable by the rural farmers. Such processing method (fermentation) was used to treat the cassava peels for onward compounding of the experimental diets thus:

T_1 = Conventional maize-based diet (control).
T_2 = T_1 with the maize component (40%) replaced with fermented cassava peels.
T_3 = T_1 with the maize component (40%) replaced with fermented cassava peels supplemented with maxigrain^R enzyme.

The dietary composition of the experimental grower and finisher rations are presented in Tables 1 and 2.

2.3 Experimental animals, design, management and duration

A group of 27 Large white x Duroc female weaner pigs aged 8 weeks and weighing 10.61±0.27 kg each, with good body condition, conformation and at least six pairs of teats, were used for this experiment. Measurement and recording of their body weights were carried out using weighing balance and were allotted to the above treatments using completely randomized design. The piglets were allocated to three treatment groups, each replicated thrice. They were closely observed for deformity and other aberrations that could render them unfit for the experiment and replacements were made in such eventuality. Prophylactic administration against endoand ectoparasites were done using ivomec^R (ivermectin) subcutaneous injection at the dose of 1 ml/33 kg body weight. There was also intramuscular administration of long acting oxytetracycline injection at the dose rate of 1 ml/10 kg body weight, which was repeated after 72 hours to help eliminate possible pathogenic microbes that were still under incubation. Grower diet (Table 1) was offered daily at 4% of their body weight (Santiago & Tegbe, 1987; Onyimonyi, 2002). The grower diets were given for the first eleven weeks after which they were replaced with finisher diet (Table 2) till the end of the experiment. Clean drinking water sourced from a borehole in the farm was supplied *ad libitum*. After farrowing, the primiparous sows were maintained on finisher diet (Table 2). The sows received 2.5 kg of feed daily and additional 0.2 kg of feed for every piglet farrowed (Miller, 2001). The piglets ate from the sows' rations (finisher) at about the mid-lactation and continued till the piglets were weaned at 6 weeks of age.

2.4 Data collection

Birth weights were taken at birth using weighing balance, and recorded for analysis. Litter size at birth was also taken for each sow and treatment groups. Mean piglet body weight gain were measured till weaning, particularly mean piglet weights at mid-lactation and weaning, litter size at weaning and mortality rate were also recorded. The weights were taken fortnightly till weaning at 6 weeks of age.

2.5 Statistical analysis

All data were subjected to analysis of variance for completely randomized design. Significant differences between means were separated using Duncan's Multiple Range Test (Duncan, 1955).

3. Results and Discussion

3.1 Performance of F_1 piglets till weaning

Table 3 shows the performance of F_1 piglets farrowed by sows fed fermented and enzyme-supplemented cassava peel meal diets. There were no significant ($p>0.05$) differences among the treatments with respect to the average birth weight, weaning age and the average final body weights. There was however, significant ($p<0.05$) difference when T_1 and T_3 were compared to T_2 with respect to the total and daily body weight gains. There were no significant ($p>0.05$) differences between T_1 and T_3. The mid-lactation (21st day) body weights had no significant ($p>0.05$) difference among the treatment groups. The mortality rates were significantly different ($p<0.05$) across the treatment groups with T_2 having more cases than T_1 whereas T_3 recorded the least number of cases.

3.2 Litter sizes

The average litter sizes of 7.33±0.06 piglets (T_1), 6.00±0.03 piglets (T_2) and 6.33±0.08 piglets (T_3) are more than 5.3 piglets reported by Motaleb *et al.* (2014). The T_1 result was similar to 7.33±3.4 piglets/litter for Sinha *et al.* (2015). This range of 6 - 7.33 piglets per litter is also similar to 7.47 piglets/litter reported by (Orheurata, 2000) but slightly differed from 8.17 piglets/litter reported by (Omeke, 1990) and 7.67±0.33 - 8.67±0.33 piglets/litter observed by (Abonyi, 2011). Generally, the mean litter size in this study was lower than 12 piglets reported by Cole & Foxcroft, (1982) in domesticated sows and 12.2 piglets reported by (Halina *et al.,* 1993) as well as 12.00±0.24 reported by (Iheukwumere *et al.,* 2008). This variation could be due to feeding system (restricted), breed of pigs, parity and feed composition. The smaller mean litter size for treatments fed CPM-based diets (T_2 and T_3) than the control (T_1) was apparently due to lower metabolizable energy and crude protein levels in these diets. Numerically, the enzyme-supplemented CPM-based diet (T_3) showed marginal superiority over the CPM-based diet only (T_2) possibly due to effect of enzyme. Milligan *et al.,* (2002) and Damgaard *et al.* (2003) indicated that parity influences birth weight and generally, sows in first parity have lower birth weight and litter size than in subsequent parities.

3.3 Birth weights

The average birth weights of 1.12±0.04 kg (T_1), 1.02±0.06 kg (T_2) and 1.23±0.03 kg (T_3) were similar to 1.11 kg and 1.27 kg obtained by (Purabi *et al.,* 2013) for crossbred and Hampshire pigs respectively as well as 1.03±0.13 - 1.24±0.08 kg reported by (Abonyi, 2011) but differed from 1.44 kg obtained by (Purabi *et al.,* 2013) for Duroc. Similarly, the birth weights as recorded by (Sharma, *et al.,* 1990; Omeke, 1990; Nath, 1993; Singh, 1994) and (Abonyi, 2011) in half-breeds of indigenous and Large White x Yorkshire were also in good agreement with the present findings. However, (Johnson & Omtvedt, 1973) and (Stewart & Drewry, 1983) reported a heavier average birth weight of 1.406±0.065 kg in Duroc. In contrast, (Pluske *et al.,* 2005) reported birth weights of 1.83kg and 1.32 kg for heavy and light breeds of pigs respectively. In the same vein, (Hossain *et al.,* 2011) reported a contradicting birth weight of 1.72 kg, likewise (Dejan *et al.,* 2007) who got 1.71 kg for intermediate breed and 2.40 kg for heavy breed. The highest average birth weight showcased by pigs on enzyme-supplemented diet (T_3) over control (T_1) and CPM-based diet (T_2) could be due to effect of maxigrain^R enzyme on the utilization of feed ingredients (particularly fermented cassava peels) as well as the effect of fermentation on the CPM that helped to reduce the HCN content below detrimental level. Studies have reported improved performance when exogenous enzymes are used in chicken (Zyla *et al.,* 2000; Onyango *et al.,* 2005; Silverside *et al.,* 2006) and pigs (Young *et al.,* 1993; Yi *et al.,* 1996; Adeola et al., 1998; Matsui et al., 2000; Omogbenigun *et al.,* 2004; Jendza *et al.,* 2005; Cowieson & Adeola, 2005). The addition of digestibility-improving enzymes to feed can improve nutrient bio-availability and absorption, and thereby enhance the value of the feed as a source of energy, protein and other nutrients (Ullmann's, 2003; Schäfer *et al.,* 2007; Bedford & Gary, 2010). Enzymes are mostly used when the dietary ingredients contain relatively higher amount of fiber (Bedford, 2000) and to break down the phytate molecule that binds phosphorus and some other mineral elements in plant-based feedstuffs (McDonald *et al.,* 2001; Fuller, 2004).

3.4 Daily body weight gain

The average daily body weight gains of 155.24±0.09 g (T_1), 146.67±0.11 g (T_2) and 159.29±0.15 g (T_3) showed no significant difference ($p>0.05$) between T_1 and T_3 but with T_2 ($p<0.05$). The piglets on enzyme-supplemented CPM diets performed best possibly due to enzyme effect. This can be corroborated by the finding of Omogbenigun *et al.* (2004) who reported improvement in average daily gain of piglets receiving enzyme-supplemented diets. Olukosi *et al.,* (2007) also found improvement in broilers fed enzymes cocktail. The weight gains in this study were heavier than the 105.35 g daily weight gain obtained by (Akdag & Muglali, 2008) while some authors had reported mean values better than this present study (Shon *et al.,* 1994; Nessmith *et al.,* 1997; Angulo & Cubilo, 1998; Lauridsen & Danielsen, 2004; Straub *et al.,* 2005; Pluske *et al.,* 2005; Dejan *et al.,* 2007; Václavková *et al.,* 2012). The possible reasons for lower average daily gains could be environmental temperature, type of feed/ingredients, genetic make-up, breed and sex. Besides, type of feeding regimen (restricted) had effect. It can also be attributed to limiting nutrients (Kidd *et al.,* 2001; Café *et al.,* 2002) as portrayed by the lowest daily weight gain of T_2.

3.5 Weaning body weights

The average weaning body weights of 7.64±0.13 (T_1), 7.18±0.17 kg (T_2) and 7.92±0.15 kg (T_3) were similar to 7.67 kg and 7.32 kg reported for crossbreed (Hampshire x Duroc) (Dejan *et al.,* 2007; Purabi *et al.,* 2013) but heavier than 4.24 kg reported by (Akdag, 2003). The results were however less than 8.9 - 9.7 kg obtained in previous studies (Vesseur *et al.,* 1997; Milligan *et al.,* 2002; Hossain *et al.,* 2011) and much less than 8.45±0.11 - 9.84±0.35 kg observed by (Abonyi, 2011) and 11 - 14.20 kg obtained in other studies (Bruininx *et al.,* 2001; Mota *et al.,* 2002; Bates *et al.,* 2003; Straub *et al.,* 2005). The difference in weaning body weights could be attributed to the effect of the enzyme on the digestion and absorption of nutrients in respect of T_3 that showed superiority over T_2 and T_1. The litter size differential could also be a contributing factor to differences in the average final body (weaning) weights. The relatively similar weaning weights also suggested that all the experimental diets were good and that there was no detrimental effect of HCN from CPM possibly due to fermentation (T_2) and maxigrain^R enzyme-supplementation (T_3). Additionally, the control (T_1) performed best because of the nutritional advantage (metabolizable energy and crude protein) it had over others. Other factors that could have limited the growth potential of suckling piglets include teat position (Zschorlich & Ritter, 1984a; Zschorlich & Ritter, 1984b; Puppe *et al.,* 1993), milk composition and percentage milk protein (Noblet & Etienne, 1989) and establishment of lactation and successful nursing (Valros *et al.,* 2002). The non-significant difference ($p>0.05$) in the final body (weaning) weights among the treatment piglets could also align with the findings of some authors that there was no improvement in performance of pigs given exogenous feed enzymes. Thacker *et al.* (1991) and (Inborr *et al.,* 1993) observed no improvement in performance of pigs fed rye- or barley-based diets supplemented with xylanase. Officer (1995) reported no growth improvement as a result of enzyme supplementation in weanling pigs receiving wheat-SBM diet. Thacker *et al.* (1988) similarly reported no effect of an enzyme mixture that had β-glucanase, pentosanase, cellulase, amylase and pectinase on barley-based diets fed to 80 kg pigs. However, the numerical difference between pigs on maxigrain^R enzyme supplementation and other pigs could be attributed to effect of enzyme supplementation. Omogbenigun *et al.,* (2004) reported improvement in average daily gain of piglets that received enzyme supplemented diets. In addition, several studies have shown improvement of growth performance of pigs after the use of phytase (Nasi, 1990; Cromwell *et al.,* 1993; Adeola *et al.,* 1998). William (2003) also reviewed numerous studies showing that weights at birth and one week of age are correlated to subsequent performance. This assertion has been exonerated by this experiment when the initial weights were compared to the final (weaning) weights since (Rehfeldt & Kuhn, 2006) showed that piglets with lower body weights at birth grow slower.

3.6 Mortality rate

The mortality rates of 9.09% (T_1), 16.67% (T_2) and 5.26% (T_3) were lower than 34.24% obtained by (Akdag & Muglali, 2008) but similar to reports on different pig breeds by some authors (Holyoake *et al.,* 1995; Vesseur *et* *al.,* 1997; Leenhouwers *et al.,* 1999; Steverink et al., 1991; Roehe & Kalm, 2000; Valros *et al.,* 2002; Lauridsen & Danielsen, 2004). Similarly, the survival rates were 90.91% (T_1), 83.33% (T_2) and 94.74% (T_3). They were higher than 65.76% obtained by (Akdag & Muglali, 2008) but similar to the mortality rates of some others (Thomas *et al.,* 1983; Mota *et al.,* 2002). Many authors have reported lower survivability rates (Chabo *et al.,* 2000; Nandakumar *et al.,* 2004; Wabacha *et al.,* 2004; Dutta & Rahman, 2006; Kliebenstein *et al.,* 2007; Li *et al.,* 2011; Pedersen *et al.,* 2011). The above mortality rate could have been caused by sow lying on the piglets, weakness due to starvation and weight differential, diseases or low immunity due to lack of access to colostrum probably as a result of negative weight differential. Svendsen *et al.* (1986) and (Varley, 1995) had postulated that pre-weaning mortality could be caused by sow lying on the piglets, starvation and diseases.

4. Conclusion

Fermented cassava peels with or without enzyme supplementation has no deleterious effect on the performance of F_1 piglets.

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Table 1 Dietary composition of pig grower diets (g/kg)

Ingredients	**T_1**	**T_2**	**T_3**
Maize	400	-	-
CPM	-	400	400
PKC	200	295	295
BDG	140	100	100
GNC	125	110	110
BLM	50	50	50
Palm oil	40	40	40
Bone meal	20	20	20
Oyster shell	10	10	10
Methionine	2	2	2
Lysine	7.5	7.5	7.5
Premix vitamin*	4	4	4
Salt	1.5	1.5	1.5
Total	**1000**	**1000**	**1000**
Calculated nutrient values			
Crude protein (%)	20.82	20.47	20.47
ME (kcal/kg DM)	2871.50	2759.23	2759.23

*Provided the following per kilogramme of diet:
Vitamin A–8,000 IU, Vitamins D3 –3,000 IU, Vitamins E–8 IU, Vitamin K –2mg, Vitamin B1 – 1 mg, Vitamin B2 – 0.2 mg, Vitamin B12 – 5 mg, Nicotinamide – 10 mg, Selenium – 0.1 mg, Ca Pantothenate – 5 mg, Folic acid – 0.5 mg, Choline Chloride – 150 mg, Iron – 20 mg, Manganese – 80 mg, Copper – 8 mg, Zinc – 50 mg, Cobalt – 0.225mg, Iodine –2 mg Antioxidant – 0.1ppm

Table 2 Dietary composition of pig finisher diets (g/kg)

Ingredients	T1	T_2	T_3
Maize	400	-	-
Cassava peel meal	-	400	400
Palm kernel cake	225	235	235
Brewer's dried grain	100	100	100
Wheat offal	140	90	90
Soybean meal	-	40	40
Blood meal	50	50	50
Palm oil	40	40	40
Bone meal	20	20	20
Oyster shell	10	10	10
Methionine	2	2	2
Lysine	7.5	7.5	7.5
Vitamin premix*	4	4	4
Salt	1.5	1.5	1.5
Total	1000	1000	1000
Calculated nutrient values			
Crude protein (%)	17.02	17.36	17.36
ME (kcal/kg)	2822.88	2710.23	2710.23

*Provided the following per kilogramme of the diet:
Vitamin A – 8,000 IU, Vitamins D3 – 3,000 IU, Vitamins E – 8 IU, Vitamin K – 2mg, Vitamin B1 – 1 mg, Vitamin B2 – 0.2 mg, Vitamin B12 – 5 mg, Nicotinamide – 10 mg, Selenium – 0.1 mg, Ca Pantothenate – 5 mg, Folic acid – 0.5 mg, Choline Chloride – 150 mg, Iron – 20 mg, Manganese – 80 mg, Copper – 8 mg, Zinc – 50 mg, Cobalt – 0.225mg, Iodine – 2 mg Antioxidant – 0.1 ppm.

Table 3: The performance of F_1 piglets farrowed by sows fed fermented and enzyme-supplemented cassava peel meal based diets.

Variable	T1 (contr)	T2 (CPM only)	T3 (CPM + Enz)	±SEM
Av. birth weight (kg)	1.12 ±0.04	1.02±0.06	1.23±0.03	0.26
Weaning age (days)	42.0±0.00	42±0.00	42±0.00	0.00
Av. litter size	7.33±0.06	6.00±0.03	6.69±0.08	2.18
Total no of piglets	22.00±0.18	18.00±0.22	19.00±0.15	1.91
Total no of weaned piglets	20.00±0.13	15.00±0.16	18.00±0.12	3.66
Mortality rate (%)	9.09^{b}	16.67^{a}	5.26^{c}	8.67
Av. mid-lactation body weight (kg)	4.50 ±0.09	4.16 ±0.07	4.43 ±0.11	0.84
Av. weaning body weight (kg)	7.64±0.13	7.18±0.17	7.92±0.15	1.73
Av. total body weight gain (kg)	6.52 ± 0.21^{a}	6.16 ± 0.18^{b}	6.69 ± 0.23^{a}	1.15
Av . daily body weight gain (g)	155.24 ± 0.09^{a}	146.67 ± 0.11^{b}	159.29 ± 0.15^{a}	7.08

a,b,c: Means on the same row with different superscripts are statistically different ($p<0.05$).