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Composite leaf meal (CLM) diet: Its effects on the body temperature of growing pigs

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ABSTRACT

The effects of feeding composite leaf meal (CLM) based-diets on the body temperature of growing pigs was investigated. Thirty-six Large White pigs with average initial weight of 17.50kg were used. Six experimental diets: the control diet (D1) with 0% CLM and diets 2 (D2), 3 (D3), 4 (D4), 5(D5) and 6 (D6) with CLM included in the diet at 1%, 2%, 3%, 4% and 5% respectively were fed to the animals. Body temperature measurement revealed that the rectal temperatures varied directly with the ambient temperatures irrespective of age and the former could be estimated from the latter. The estimations for the average morning (6.00 a.m), afternoon (12.00 noon) and evening (6.00.p.m.) rectal temperatures were 12.60ºC + ambient morning temperature (MAT), 10.49ºC + afternoon ambient temperature (AfAT) and 10.89ºC + evening ambient temperature (EAT) respectively. The average rectal temperature (ART) was also estimated as average ambient temperature (AvAT) + 11.50°C. The effect of the diets showed a progressive increase in the ART with increase in the level of CLM. The rectal and scrotal temperatures ranged between 38.34±0.06 - 38.43±0.07ºC and 31.00±0.00 -33.00±0.00ºC among the treatments respectively. The absence of wide fluctuations in the rectal and scrotal temperature as a result of the inclusion of CLM showed that its utilization at these levels would not subject growing pigs to undue thermal stress.

Keywords: Ambient temperature; under-utilized plants; pigs; scrotum; thermogenesis.

INTRODUCTION

Research efforts in the developing countries in recent times have been directed on the need to address the ever increasing cost of animal feeds which has always constituted a perennial hinderance to the expansion of livestock industry. Many alternative feed ingredients sourced locally especially from agro-industrial by-products are credited with the potentials of solving this costly feed problems. The use of cassava tuber wastes (Aro *et al.,* 2013), cocoyam peels (Edache *et al.,* 2008) and citrus wastes (Oragaya *et al.,* 2012) in livestock feed have been reported. These ingredients have been used mainly to resolve the high cost of energy and protein ingredients in livestock nutrition. Another livestock feed ingredient that contributes a large proportion to the high cost of feed is the vitamin/mineral component of the feed otherwise called the vitamin/mineral premix. Though, this ingredient is normally incorporated into the diet at a relatively low level, such inclusion often comes with a very large chunk of the total financial outlay earmarked for the feed component of the livestock enterprise. The reason for this is that most of the vitamin/mineral premixes used in the developing countries especially in sub-Saharan Africa are imported and hence sold to the local livestock farmers at a cost that is usually not affordable and mostly unbearable to them.

The need to experiment with local and mostly under-utilised plant species that can furnish these vitamins and minerals in livestock diets is imminent. Such under-utilised plants include fluted pumpkins *(Telfaria occidentalis*), bitterleaf (*Vernonia amygdalina*), basil (*Ocinum gratissimum*), drumstick tree (*Moringa oleifera*), Siam weed (*Chromolaena odorata*) and cassava (*Manihot spp.*). Teguia *et al.* (1993) reported that bitter leaf could replace 300g/kg of maize without affecting feed intake, body weight and feed efficiency. Ajibade *et al.* (2006) reported on the rich iron content of fluted pumpkin and its use to combat anaemia in human population. Reports have also shown that the leaves of these plants contain appreciable content of vitamins, amino acids and minerals (Makkar and Becker, 1996; Kakengi *et al.,* 2003; Aregheore, 2004; Mensa *et al.,* 2008; Aro *et al.,* 2009; Ogbe *et al.,* 2011) that can adequately replace the conventional vitamin/mineral/amino acid premixes in livestock diets when used either singly or as leaf composites (Adegbenro *et al.,* 2011). The use of the leaf meal of these plants could therefore provide cheaper alternatives to the costly conventional vitamin/mineral premixes thereby helping to change the prospect of the livestock industry in the sub-Saharan Africa for the better. Apart from furnishing the essential vitamins, minerals and amino acids in the diets of farm animals, literautre is replete with the ethno-medicinal use of these plants (Chiang *et al.,* 2005; Egbunike and Nworgu, 2005; Aro *et al.,* 2009) and the physiological modulation and conditioning of several systems and organs of the body by the extracts, seed or leaf meals of these plants (Ijeh *et al.,* 2004; Duke, 2008; Olugbemi *et al.,* 2010).

Feeding or nutrition is known to have a very great influence on the environmental physiolgy of livestock (Louis *et al*., 1994). The energy density in various feed formulations has been adjusted to ameliorate the impact of thermal stress as dictated by environmental variables like humidity, solar radiation, draught and ambient temperature (Robinson, 1998). Some feed ingredients like pepper have been tried as alternative vitamin/mineral premixes are reputed to have thermogenic properties (http//www.health.com) that are capable of subjecting livestock to thermal stress when incorporated into their diets. Other feed ingredients like safflower seeds are known to induce thermogenesis because of their high content of linoleic acid (Encinias *et al.*, 2002). This feed-induced thermal stress could work synergistically with some other variables of the environment like the season, temperature and humidity to undermine the reproductive capacity of our livestock species.

Pigs are known for their low capacity for sweating when environmental temperature increases from 23 to 34ºC (Stone, 1981). Heat may adversely affect spermatogenesis, causing a mild to moderate testicular degeneration. Several studies have shown the adverse effects of elevated ambient temperatures, heat stress and/or hot weather on sperm production (Colenbrander and Kemp, 1990) and sperm morphology in boars (Stone, 1982; Larsson and Einarsson, 1984; Malmgren, 1989). Female pigs are also not immune to these environmental stressors. The reproductive efficiency of sows is known to be affected by the temperature (Prunier *et al.*, 1997; Tantasuparuk *et al*., 2000) and nutrition (Foxcroft, 1992; Neil *et al*., 1996). This study was therefore conducted to investigate the prospect of using a combination of leaf meals (composite leaf meal) from some under-utilised plant species as a replacement of dietary mineral/vitamin premix and their probable effects on the body temperature of growing pigs.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the piggery unit of Teaching and Research Farm, Department of Animal Production and Health, School of Agriculture and Agricultural Technology, Federal University of Technology, Akure - Nigeria located within Latitude 7º 18" North of Equator and Longitude 5º 10"East of Greenwish Meridian. The experiment was carried out for a period of six weeks (42 days) between March 30 and May 11, 2013. This is the period of the year tagged early rainy season in southern Nigeria.

Housing and Experimental Layout

A total of thirty-six weanling pigs of mixed sexes with an average initial liveweight of 17.50kg were used. The animals were randomly distributed into six treatment groups with six animals per group. Each treatment was replicated six times with one animal per replicate. Each animal was housed in a pen measuring 2m x 3m and provided with a fixed concrete feeder and drinker.

Preparation of the Experimental Diets

The test ingredient (Composite Leaf Meal) that was incorporated into the experimental diets with other feed ingredients was prepared using leaves (leaf composites) obtained from five different plant species. The leaf composites were; cassava leaf, (*Manihot esculentum*), bitter leaf (*Vernonia amygdalina*), basil (*Ocimum gratissimum*), drumstick tree (*Moringa oleifera)* and fluted gourd or fluted pumpkin (*Telfaria occidentialis*) in equal proportions (w/w). The leaves were air-dried, ground, mixed together and incorporated into the swine diets at 0%,1%, 2%, 3%, 4% and 5% for Diets 1, 2,3,4 and 5 respectively.. The animals were fed at 5% of their live weight throughout the duration of the experiment with unrestricted access to water supply. The composition (%) of the experimental diets is presented in Table 1.

Data Collection and Analysis

Data collected from the experimental study were on ambient temperature, rectal temperature and scrotal temperature. The ambient and rectal temperatures were taken thrice daily at 6.00 a.m., 12 noon and 6.00 p.m. on three consecutive days weekly while the scrotal temperature was taken in the last week of the experiment. Completely randomized design (CRD) was used in the analysis of the data which involved six treatment diets and six replicates per treatment resulting in thirty-six (36) number of observations.

Table 1: Composition (g/100g) of the experimental diets

Items	D1	D2	D3	D4	D5	D6
Basal ingredients	99.75	98.80	97.85	96.90	95.95	95.00
Conventional premix	0.25	0.20	0.15	0.10	0.05	0.00
Composite leaf meal (CLM)	0.00	1.00	2.00	3.00	4.00	5.00
Total	100.00	100.00	100.00	100.00	100.00	100.00

D1 = Diet with 100% conventional premix; D2 = Diet with 80% conventional premix; D3 = Diet with 60% conventional premix; D4 = Diet with 40% conventional premix; D5 = Diet with 20% conventional premix; D6 = Diet with 0% conventional premix. 1.00% of CLM replaced 0.05% of the conventional premix in the diets.Basal ingredients = Maize, soybean meal, palm kernel meal, groundnut meal, brewers' dried grains, wheat offal, vegetable oil, bone meal, limestone and table salt

Data collected were subjected to one-way analysis of variance using SPSS (2006) version 15 statistical package. Significant means were separated with Duncan's multiple range test at 0.05 level. The statistical model for CRD is: Yij = μ + Ti + ϵij
Where, Yij = observation, μ = overall mean, Ti = level of inclusion of CLM (i = 1–6), and εij = residual error (j = 1–6).

RESULTS

Table 2 compared the Average Ambient Temperature (AvAT) with the Average Rectal Temperature (ART) of the pigs fed dietary inclusion of CLM.

Table 2: Weekly average ambient temperature (AvAT) for the period versus average rectal temperature (ART)

Weeks	Average ambient temperature (°C)	Average rectal temperature (°C)
1	26.58±0.03a	37.78±0.06a
2	26.28±0.06a	37.58±0.03a
3	27.67±0.05a	38.30±0.05a
4	26.50±0.05a	38.10±0.04a
5	25.89±0.03a	37.93±0.30a
6	26.11±0.05a	38.38±0.04a
Mean	26.51±0.05a	38.01±0.09a

Values with the same alphabet within the columns are not statistically (P>0.05) different.
Mean ± standard error of the mean.

The AvAT ranged between 27.67°C in week 3 and 25.89°C in week 5. The difference between the maximum and minimum ambient temperature during the period of study was 1.78°C. The ART ranged between 37.58°C in week 2 and 38.38°C in week 6 with a difference of 0.80°C in between them. With a given ambient temperature, the rectal temperature can be easily estimated. For instance, in this trial, the rectal temperature equals AvAT + 11.50°C. Table 3 shows weekly records of ambient and rectal temperature (°C) of growing pigs taken in the mornings, afternoons and evenings. Week three of the experiment showed the highest morning ambient temperature (MAT) of 26.17°C, while week one showed the lowest MAT of 23.00°C. The highest morning rectal temperature (MRT) of 37.82°C was recorded in the sixth week of the experiment, while the lowest MRT of 36.96°C was observed in the first week. The average MAT for the entire period of 6 weeks was 24.92°C while the same average for rectal temperature was 37.52°C. The difference between the two averages was computed as 37.52°C-24.92°C which equals 12.60°C. The MRT could therefore be estimated from the MAT as 12.60°C + morning ambient temperature. The highest afternoon ambient temperature (AfAT) of 28.17°C was recorded in week three while the lowest temperature (26.17°C) was recorded in week six. The afternoon rectal temperature (AfRT) showed the highest value (38.50°C) in the third week of the experiment and the lowest (34.40°C) in the fifth week.
The mean afternoon ambient temperature (AfAT) for the entire period was 27.17°C, while the mean AfRT was 37.65°C. The difference between the two temperatures was 10.49°C. The AfRT could therefore be estimated from the AfAT by adding 10.49°C to any given afternoon ambient temperature (AfAT). The mean evening ambient temperature (EAT) for the 6 week period was 27.45°C while the corresponding value for the evening rectal temperature (ERT) was 38.34°C with a difference of 10.89°C between them. Hence, ERT could be estimated from EAT by adding the difference (10.89°C) to any value obtained for EAT. Table 4 shows the fluctuations of ambient temperature (°C) with rectal temperature (°C) across treatments taken in the mornings, afternoons and evenings. With morning ambient temperature (MAT) of 24.92°C, the morning rectal temperature (MRT) varied from 37.42°C in D2 to 37.94°C in D6. The observation was a gradual increase in rectal temperature from D4 (37.48°C) to D6 (37.94°C). Though all values were statistically similar to the control, an increased thermogenesis due to increase in the dietary level of CLM was observed from D4 to D6. The afternoon ambient temperature (AfAT) stood at 27.17°C for all the treatment diets while the afternoon rectal temperature (AfRT) ranged from 38.24°C in D4 to 38.39°C in D6. The AfRT decreased from 38.38°C in D1 to 38.24°C in D4 before showing a progressive increase from 38.32°C in D5 to 38.39°C in D6. Again D6 was observed as the most thermogenic diet. The average evening ambient temperature (EAT) stood at 29.00°C across treatments.

Table 3: Weekly records of ambient and rectal temperature (°C) of growing pigs taken in the mornings, afternoons and evenings

Weeks	Morning temperature		Afternoon temperature		Evening temperature	
	Ambient	Rectal	Ambient	Rectal	Ambient	Rectal
1	23.00±0.03	36.96±0.10	27.75±0.06	37.96±0.06	29.00±0.04	38.42±0.09
2	25.00±0.06	37.38±0.10	27.17±0.06	38.21±0.05	25.83±0.03	37.19±0.05
3	26.17±0.03	37.74±0.06	28.17±0.03	38.50±0.04	28.67±0.06	38.69±0.06
4	25.17±0.05	37.53±0.06	27.17±0.04	38.34±0.05	27.17±0.06	38.36±0.05
5	24.67±0.05	37.70±0.06	26.50±0.04	38.40±0.06	26.50±0.03	38.53±0.05
6	24.67±0.04	37.82±0.07	26.17±0.05	38.47±0.04	27.50±0.06	38.82±0.03
Mean	24.92±0.04	37.52±0.08	27.17±0.05	37.65±0.05	27.45±0.05	38.34±0.06

Mean values in the same column without superscripts are not statistically (P>0.05) different.
Mean ± standard error of the mean.

Table 4: Fluctuation of ambient temperature (ºC) with rectal temperature (ºC) across treatments taken in the mornings, afternoons and evenings

	Morning temperature		Afternoon temperature		Evening temperature	
Diets	Ambient	Rectal	Ambient	Rectal	Ambient	Rectal
D1	24.92±0.53	37.59±0.10	27.16±0.33	38.38±0.06	29.00±0.18	38.31±0.12
D2	24.92±0.53	37.42±0.10	27.16±0.33	38.38±0.05	29.00±0.18	38.32±0.08
D3	24.92±0.53	37.49±0.08	27.16±0.33	38.26±0.06	29.00±0.18	38.34±0.11
D4	24.92±0.53	37.48±0.10	27.16±0.33	38.24±0.08	29.00±0.18	38.33±0.11
D5	24.92±0.53	37.53±0.13	27.16±0.33	38.32±0.07	29.00±0.18	38.41±0.09
D6	24.92±0.53	37.94±0.10	27.16±0.33	38.39±0.05	29.00±0.18	38.31±0.12
Mean	24.92±0.53	37.58±0.10	27.16±0.33	38.33±0.07	29.00±0.18	38.34±0.10

D1 = Diet with 100% conventional premix + 0% CLM; D1 = Diet with 80% conventional premix + 20% CLM; D3 = Diet with 60% conventional premix + 40% CLM; D4 = Diet with 40% conventional premix + 60% CLM; D5 = Diet with 20% conventional premix + 80% CLM; D6 = Diet with 0% conventional premix + 100% CLM. Means in the same columns without superscripts are not statistically significant (P>0.05). Mean ± Standard error of the mean; CLM = Composite leaf meal which replaced 0-100% of the conventional premix in the diets respectively.

Table 5: Fluctuation of average rectal and scrotal temperature (ºC) with ambient temperature (ºC) across treatments

Diets	Average ambient temperature (AvAT)	Average rectal temperature (ART)	Average scrotal temperature (AST)
D1	26.11±0.10	38.37±0.08	32.75±0.25
D2	26.11±0.10	38.40±0.06	33.00±0.00
D3	26.11±0.10	38.34±0.06	33.00±0.00
D4	26.11±0.10	38.36±0.07	32.00±0.00
D5	26.11±0.10	38.39±0.08	31.00±0.00
D6	26.11±0.10	38.43±0.07	32.00±0.50

D1 = Diet with 100% conventional premix + 0% CLM; D1 = Diet with 80% conventional premix + 20% CLM; D3 = Diet with 60% conventional premix + 40% CLM; D4 = Diet with 40% conventional premix + 60% CLM; D5 = Diet with 20% conventional premix + 80% CLM; D6 = Diet with 0% conventional premix + 100% CLM. Means in the same columns without superscripts are not statistically significant (P>0.05). Mean ± Standard error of the mean; CLM = Compositeleaf meal which replaced 0-100% of the conventional premix in the diets respectively.

The evening rectal temperature (ERT) varied from 38.31°C in D1 and D6 to 38.41°C in D5. Variation in ERT with the dietary treatments did not follow a particular trend, however, D5 was observed as the most thermogenic diet while D1 and D6 were the least.

The fluctuations in rectal, scrotal and ambient temperature across the treatment diets are shown in Table 5. An average ambient temperature (AvAT) of 26.11°C prevailed at the time of data collection. The average rectal temperature (ART) and average scrotal temperature (AST) varied across treatment diets. The lowest ART (38.34°C) was recorded in D3 while the highest (38.43°C) was recorded in D6. The highest AST (33.00°C) was record in D2 and D3, while the lowest (31.00°C) was recorded in D5.

DISCUSSION

Ambient temperature versus rectal temperature of the growing pigs (Table 2) showed that the rectal temperature varied alongside the ambient temperature. In other words, the body temperature as determined by the rectal temperature depends on the ambient temperature. Pigs have a low capacity for increased sweating when temperature increases. These narrow fluctuations in ambient temperature (25.89°C-27.67°C) over the six weeks' period as shown in Table 2 coincided with an equally narrow fluctuation in the rectal temperature of 37.58°C-38.38°C, a temperature within the normal body temperature for pigs (Williams,2013). This implied that these pigs were still able to adjust physiologically over the period to stay within their thermo-neutral zone regardless of the CLM components of their different diets. A pig's normal body temperature varies between 38.7°C to 39.8°C (Williams, 2013). Heat may adversely affect spermatogenesis of the boarlings and this can cause a mild to moderate testicular degeneration. Heat stress and hot weather have an adverse effect on sperm production (Colenbrander and Kemp, 1990) and sperm morphology in boars (Larsson and Einarsson, 1984; Malmgren, 1989).

The variation in average ambient temperature recorded in this experiment vis-à-vis the rectal temperature (Table 3), either taken in the morning, afternoon or evening for the six weeks' duration of the study showed that reproductive indices are not likely to be adversely affected by incorporating CLM in the diets. The higher the ambient temperature which translates to a higher physiological temperature, the lower the physiological performance of the animal. The variation in ambient or air temperature (25.89°C-27.67°C) obtained in this study also corroborated the report of Stone (1982) who concluded that normal sperm output of Large White boars could be maintained at air temperatures as high as 29°C, hence the possibility of compromising the sperm producing capability of breeding boars fed these CLM-based diets is very remote.

The performance of the female stock is also dictated by environmental variables like the ambient temperature, humidity, and nutrition (Prunier *et al*., 1994; Neil *et al*., 1996; Peltoniemi *et al*., 1999). Variations in ambient temperature and photoperiod are believed to be the primary external factors influencing seasonal fertility in sows. Prunier *et al*. (1994) reported that high ambient temperatures may contribute to seasonal infertility by decreasing feed intake in sows. High ambient temperatures on the reproductive performance of sows, is characterized by a decreased farrowing rate, prolonged weaning–to–first–service interval, and in some cases, a decreased litter size (Tantasuparuk *et al*., 2000). High ambient temperatures may, under certain circumstances, have an indirect, adverse effect on fertility by reducing the voluntary feed intake of lactating sows, leading to an energy imbalance (Prunier *et al*., 1997). The use of CLM under this study is however unlikely to subject sows to the ill effects of high ambient temperature mentioned above because none of the CLM-based diets raised the body temperature of the pigs beyond their comfort zone. Rather, results for this experiment (Table 3) could be used as a simple estimation of body temperature (rectal temperature) from the ambient temperature. For instance, the morning rectal temperature (MRT), the afternoon rectal temperature (AfRT) and evening rectal temperature (ERT) for the six weeks' period could be estimated from their corresponding ambient temperatures as: morning ambient temperature(MAT) + 12.60ºC; afternoon ambient temperature (AfAT) + 10.49ºC and evening ambient temperature (EAT) + 10.89ºC respectively. This affords the animal husbandman the opportunity of determining the body temperature of his pigs at any period of the day without necessarily stressing them through manual handling.

Since there were no sharp/significant fluctuations in the rectal temperature taken either in the morning, afternoon or evening during the course of the experiment vis-à-vis the treatments applied (Table 4), the utilization of CLM in the diets did not pose any serious risk to the pigs as far as aggravation of thermal stress is concerned. However, the observation was a gradual increase in the morning rectal temperature (MRT) from D4 (37.48°C) to D6 (37.94°C), afternoon rectal temperature (ART) from 38.24°C in D4 to 38.39°C in D6 and evening rectal temperature (ERT) from 38.31°C in D1 and D6 to 38.41°C in D5. Table IV therefore showed that a gradual increase in thermogenesis of the diets was observed at dietary inclusion of CLM beyond 3% level (i.e. 60% replacement of the conventional premix). This implied that the inclusion of CLM at higher levels than used in this trial could result in significant increase in the thermogenesis of the diets as to provoke heat stress in the animals with consequent untoward physiological responses (Colenbrander and Kemp,1990; Prunier *et al*., 1997; Tummaruk *et al*., 2004).

The observation in Table 5, which showed fluctuations of rectal and scrotal temperature with ambient temperature taken in the mornings, afternoons and evenings across dietary treatments, was a persistently lower scrotal temperature relative to the rectal temperature. This is a highlight of the thermo-regulatory mechanism of the scrotum at maintaining a lower testicular temperature for optimal sperm production (Aro, 2014). This thermo-regulatory mechanism was quite efficient in curtailing the probable induced dietary thermogenesis provoked by increase in the level of CLM in the diets. This is because in spite of higher rectal temperature in D5 (38.39±0.08ºC) and D6 (38.43±0.07ºC, the scrotal temperatures were maintained at lower values in D5 (31.00±0.00ºC) and D6 (32.00±0.00ºC) than in D1 (32.75±0.25ºC).

CONCLUSION

Higher but statistically insignificant rectal temperatures were observed in the CLM-based diets beyond 3% level of incorporation than in the control diet. An implied thermogenesis of the CLM that could predispose growing pigs to thermal stress at higher concentration of the CLM in diets meant for swine should therefore be expected. Within the limit of this experiment, utilization of CLM up to 5% level is recommended because at this level, the pigs were still within their thermo-neutral zone where they can still make physiological adjustments to meet immediate environmental exigencies. Furthermore, the experiment showed that the scrotum has an in-built mechanism for lowering the testicular temperature below that of body (rectal) temperature even under the influence of dietary challenge. The thermoregulatory role of the scrotum at enhancing maximum spermatogenesis within the confines of testicular parenchyma is thus confirmed by this study. Also, from this experiment, estimation of rectal (body) temperature for a particular period of the day (morning, afternoon or evening) can be made once the ambient temperature for that period of the day is known. This will further eliminate stress factors that are normally imposed on animals through rough handling in a bid to take their body temperature through manual manipulations.

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