Physiological response of weaned pigs fed *Spondias mombin* supplemented diets in humid tropics

[1]Alaba, O., Ogunwumiju, B., [2]Odu, O. and Lawal, T. T

1. Animal Physiology and Bioclimatology Unit, Department of Animal Science, University of Ibadan, Ibadan, Nigeria.

2. Agricultural Biochemistry and Nutrition Unit, Department of Animal Science, University of Ibadan, Ibadan, Nigeria.

Corresponding author:femialaba@gmail.com; mobile: +2347054634435

Abstract

Heat stress is a situation in which the animal body has problems dissipating excess heat due to breakdown in maintaining homeostatic body core temperature which resulting to inadequate heat dissipation and discomfort. In this study, Spondias mombin leaf meal (SMLM) rich in ascorbic acid was supplemented in feed aimed at determining effect on selected physiological responses of growing pigs. Sixteen growing female pigs weighing 10.5 to14.0kg were randomly allotted to four treatment supplemented maize feed ingredient with 0, 2.5, 5 and 7.5% SMLM w/w in a completely randomized design with four animals and two replicates per treatment as shown in table1. Results confirmed diurnal variation in temperature-humidity index THI (morning and evening). This variation affects respiratory rate, animal thermal stability and heartbeat rate. There was positive and strong relationship in ameliorating temperature changes in housing environment as animals cope better in diet supplemented with SMLM than control. Respiratory rates were similar across all treatments both morning and evening measurements. However, from table 2, there was significant difference ($p<0.05$) between control and other treatments with T2 and T3 been similar. Highest values of heart rates were observed in T3 indicating some contribution to involuntary physiological actives in pigs which may be effect of some biocomponents of Spondias sp to cerebella actions in animal brain controlling such involuntary muscle activities. Supplementation of SMLM up to 5% maize in growing female pigs diet have potential to confer thermal stability on animals during high temperature periods notable in humid tropics.

Keywords: Heat stress, Spondias mombin, THI, ascorbic acid, thermal stability, physiological response

Réponse physiologique des porcs sevrés nourris avec des régimes complémentaires de Spondias mombin dans les régions tropicales humides

Résumé

Le stress thermique est une condition dans laquelle le corps de l'animal a des problèmes pour dissiper l'excès de chaleur en raison de la dégradation du maintien de la température interne du corps homéostatique, ce qui entraîne une dissipation thermique et une gêne insuffisantes. Dans cette étude, la farine de feuilles de Spondias mombin (SMLM) riche en acide ascorbique a été complétée dans des aliments destinés à déterminer l'effet sur certaines réponses physiologiques des porcs en croissance. Seize porcs femelles en croissance pesant de 10,5 à 14,0 kg ont été attribués au hasard à quatre ingrédients alimentaires de maïs supplémentés par traitement avec 0, 2,5, 5 et 7,5% de SMLM p / p dans une conception complètement randomisée avec quatre animaux et deux répétitions par traitement, comme *indiqué dans le tableau 1. Les résultats ont confirmé la variation diurne de l'indice température-humidité THI (matin et soir). Cette variation affecte la fréquence respiratoire, la stabilité thermique de l'animal et la fréquence cardiaque. Il y avait une relation positive et forte dans l'amélioration des changements de température dans l'environnement de logement, car les animaux réagissent mieux avec un régime alimentaire complété avec du SMLM que le témoin. Les fréquences respiratoires étaient similaires pour tous les traitements, les mesures du matin et du soir. Cependant, à partir du tableau 2, il y avait une différence significative (p <0,05) entre le contrôle et les autres traitements avec T2 et T3 étaient similaires. Les valeurs les plus élevées de fréquence cardiaque ont été observées dans T3 indiquant une certaine contribution aux actifs physiologiques involontaires chez les porcs qui peuvent être l'effet de certains biocomposants de Spondias sp sur les actions cérébrales dans le cerveau animal contrôlant ces activités musculaires involontaires. La supplémentation en SMLM jusqu'à 5% de maïs dans le régime alimentaire des porcs femelles en croissance peut conférer une stabilité thermique aux animaux pendant les périodes de températures élevées notables dans les régions tropicales humides.*

Mots clés: Stress thermique, Spondias mombin, THI, acide ascorbique, stabilité thermique, réponse physiologique

Introduction

Optimal production in swine is largely affected by housing, environment as well as climatic conditions like ambient temperature, relative humidity, wind speed and solar radiation which varies according to seasonal changes may confer stresses in various forms to livestock. In the swine industry, economic losses associated with heat stress are mainly explained by reduced and inconsistent growth, decreased feed efficiency, decreased carcass quality (increased lipid deposition and decreased protein accretion), poor sow performance, increased mortality (especially in sows and market hogs) and morbidity, and decreased facility efficiency (Baumgard and Rhoads, 2013; Ross *et al*., 2015). Heat stress is a situation in which the animal body has problems dissipating excess heat due to breakdown in maintaining homeostatic body core temperature which results to inadequate heat dissipation leading a range of discomfort to symptoms of heat rash, heat syncope, heat cramps, heat exhaustion and heat stroke. Indices like Black Globe-Humidity Index, temperature humidity index (THI) is used to measure heat stress. Scientists Buffington *et al.,* (1981), Marai (2000), Ogunjimi (2008) have worked on various animals to come up with characteristic equations that best describe effect of humidity and ambient temperature on farm animals.

Several researchers have shown that high environmental temperature adversely affects swine growth and feed intake. In recent times there seems to be global climatic fluctuation in the tropics with already high ambient temperature. However, Nigeria is close to the equator and characterized by high ambient temperature between 27- 44 °C, which might be detrimental to the performance of animals (Iyeghe-Erakpotobor *et al*., 2012). Maintenance of a homeostatic body core temperature is a critical brain function accomplished by a central neural network. This orchestrates a complex behavioral and autonomic repertoire in response to environmental temperature challenges or declining energy homeostasis and in support of immune responses and many behavioral states. Swine exhibit a strong thermostatic regulatory mechanism (Nienaber *et al*, 1994), with feed intake reduction as a control variable and body temperature as a feedback, this ultimately affect production. Under heat stress conditions, the decline in the rate of heat production is much more rapid than the decline in body temperature. Thus, heat storage within the body (elevated body temperature) appears to be a feedback mechanism to effectively delay additional eating activity (Eigenberg *et al.*, 1995). Normally, adjusting voluntary feed intake is one of the main adaptations employed to modify metabolic heat production in response to ambient temperature changes. Therefore, when ambient temperature increases, euthermia is maintained mainly by increasing heat loss and reducing heat production (Collin *et al*., 2001). Strategies to reduce heat production include decreasing feed intake and its associated thermic effect of feeding (Quiniou *et al*., 2002), along with decreased physical activity and reducing basal metabolic rate (Collin *et al*., 2001). Ogunjimi *et al*. (2008) reported that the relationship of environmental temperature, relative humidity, energy intake and heat production in growing animal is fundamental factor that must be considered in designing and managing of an efficient livestock production. In recorded history, medicinal plants have been in use for the treatment of man and animal diseases (Osai, 1998; Ibewike *et al.*, 1997). A plant becomes a medicinal plant only when its biological activity has been ethnobotanically reported or scientifically established (Elujoba, 1997). *Spondias mombin* is a fructiferous tree having habitat in Nigeria, Brazil and several other tropical forests in the world. This plant is readily common around us in South West of Nigeria (Iyeye in Yoruba) and is commonly used in folk medicine. Various cultures frequently maintain within their collection of traditional medicine substances valued as drugs for treating diseases (Elizabetshy, 1992). The entire dependence of man on plants and plant products directly for his basic needs as food, clothing and shelter and indirectly for their beneficial influence on the climate and maintenance of his immediate and remote environment make plants vital to his survival and the basis of his continued existence. Very rich in vitamins C and B-complex. Njoku and Akumefula (2007) reported ascorbic acid content is about 19.35mg/100g. Preliminary researches reported the plant to have a wide range of antibacterial, antiviral and antifungal properties (Castner *et al*., 1998). It was reported to have abortifacient and uterine muscle contraction effects (Nworu *et al.*, 2008). On the other hand, Kramer *et al.* (2006) recommended its use for pregnant woman but only after five months of pregnancy. They noted that the observed cytotoxic effects of the plant may have some benefits in protecting the foetus from pathogens. Furthermore, they claimed that its high level of cytotoxicity, is indicative of analgesic properties. Thus they concluded that the use of the plant to ease pain during childbirth supports this evidence. Raji *et al*., (2006) showed that the aqueous leaf extract of the plant has a dose-dependent anti-fertility action, but with full recovery achieved within four weeks after cessation of treatment with the extract. This experiment is designed to investigate effect of *S. mombin* supplemented diet to reduce heat stress and enhance thermal stability in replacement gilts raised in hot humid season.

Materials and methods

Experimental location

The study was carried out at the Teaching and Research Farm (TRF) of the University of Ibadan, Ibadan located between latitudes 60°10" and 90°10" north of the equator and longitudes 30° and 60° of the Greenwich during hot dry season (February to March, 2020). A total of sixteen (16) female weaned pigs with average weight of 10.5 to

14.3kg were allotted to four treatments in a completely randomized design with two replicates per treatment which lasted for four weeks. The experimental pen was thoroughly cleaned, washed and disinfected prior to the arrival of the animals. Water was served *ad libitum*. The animals randomly assigned into their four (4) experimental units with diets containing 0%, 2.5%, 5% and 7.5% *S. mombin* replacement of maize in each treatment. Composition of diets as shown in Table 1, clean drinking water was sourced from farm borehole was provided *ad libitum* for experimental animals throughout the period of experiment.

Physiological data collection and measurement

The rectal temperature (RT) of pigs was taken with a clinical thermometer, while respiratory rate (RR) and heart beat rate (HR) were taken as the number of breaths per minute. Parameters were monitored twice daily (7:30am in the morning and 4pm in the evening) while weekly average was calculated for each animal per pen.

Table1: Ingredient and Nutrient Composition of Diets Fed to growing pigs Supplemented with *Spondias mombin* leaf meal (SMLM) Electrolytes and Ascorbic Acid

Feed ingredients (%)	T1	T2	T3	T4
Maize	45	42.5	40	37.5
SMLM	-	2.5	5.0	7.5
Soya bean meal	20	20	20	20
Corn bran	3	3	3	3
Palm kernel cake	25	25	25	25
Fish meal	2	2	2	2
Dicalcium phosphate	2.5	2.5	2.5	2.5
Oyster shell	1.5	1.5	1.5	1.5
Broiler starter premix	0.25	0.25	0.25	0.25
Lysine	0.3	0.3	0.3	0.3
Methionine	0.2	0.2	0.2	0.2
Calculated nutreint levels				
Crude protein (CP)	17.0	17.46	18.0	18.51
Metabolizable energy (ME)	2603.84	2591.7	2580.4	2569.1
Crude fiber (CF)	6.0	7.0	7.4	7.7
Calorie: protein	153:1	148:1	143:1	138:1

Thermoregulation

Equations of THI according to Ogunjimi *et al*., (2008) are;

THI= t-[(0.31-0.31RH/100)]-(t-14.4)

Where: t °C = ambient temperature and RH = relative humidity %.

From the thermo comfort level of an animal environment according to LPHSI (1990), the THI values were classified as follows: <27.8 = absence of heat stress; 27.8 to 28.9 = moderate heat stress; 29.0 to 30.0 = severe heat stress; > 30.0 = very severe heat stress.

Statistical analyses

Physiological data obtained were analyzed using one way analysis of variance (ANOVA) procedure of SAS (2011) program. Means were compared using the Duncan multiple range test (DMRT) option of the same software. Also relationship between THI and average physiological measurements for each treatment were assessed.

Results

The results of effects of *Spondias mombin* leaf meal on some physiological parameters both in the morning and evening are presented in Tables 2 and 3. Relative humidity values range of 53 to 90% and ambient temperature values of 24.4 to 33.7 with calculated THI ranging between 22.94 to 33.10 were obtained in the piggery house during the experimental period. Animals in treatments 2 and 3, were similar in values of rectal temperature which significantly differ (P<0.05) from T1 and T4 both during morning and evening observations. Respiratory rates values of pigs across treatments were similar for both morning and evening assessments, though higher in T2 and T3 (evening). Mean values for morning heart rates in T1 significantly differ from other treatments which almost follow the same pattern for evening measurement except for mean value of T3 which does not differ (P>0.05) from T1. However, highest values of heart rates was observed in T3 indicating some contribution to involuntary physiological actives in pigs which may be effect of some biocomponents of Spondias sp to cerebella actions in animal brain controlling such involuntary muscle activities

Table 2: Effect of *Spondias mombin* Leaf meal on some physiological parameters in the morning

Parameter	T1	T2	T3	T4	SEM
Rectal temperature	38.40^{ab}	38.32^{b}	38.20^{b}	38.62^{a}	0.055
Respiratory rate	46.09	41.18	42.0	42.46	0.822
Heart rate	92.18^{b}	102.18^{a}	99.36^{a}	101.86^{a}	1.443

a, b: means on the same row with different superscripts are significantly different(p<0.05)T1-Control, T2- 2.5% suplimented SMLM, T3- 5% suplimented SMLM, T4- 7.5% suplimented SMLM, SEM-Standard error of mean.

Table 3: Effect of *Spondias mombin* Leaf meal on some physiological parameters in the evening

Parameter	T1	T2	T3	T4	SEM
Rectal temperature	39.50^{c}	39.95^{ab}	39.64^{bc}	40.20^{a}	0.0923
Respiratory rate	42.00	44.770	43.687	42.187	0.7749
Heart rate	101.81^{b}	105.51^{ab}	101.81^{b}	108.58^{a}	1.500

a, b: means on the same row with different superscripts are significantly different(p<0.05)T1-Control, T2- 2.5% suplimented SMLM, T3- 5% suplimented SMLM, T4- 7.5% suplimented SMLM, SEM-Standard error of mean.

Discussion

Rectal temperature

In the present study, results show the average daily temperature values indicated a range above the thermo neutral zone for weaned pigs (24-30) pushing weaners into warm zone of environmental temperature beyond which hyperthermia sets in. However, from Table 1, it is observed that SMLM supplemented diet in T2 and T3 does not significantly differ (P<0.05) from control in rectal temperature assessed in morning period. Higher RT vale in T4 maybe as a result of heat increment conferred by extra heat produced through digestion and metabolism of SMLM in fed. These observations put together confirms the positive relationship between THI and RT as shown in Table 3. At evening time, ambient temperature tend to be higher but the same trend as observed in the morning period played out. Although, pigs generally reduce feed intake and spend more time cooling off which have made breeders to develop various housing methods like highpressure fogging systems, rain-makers system and desiccant system demonstrated by Gates *et al.,* (2001).

Respiratory rate

Means obtained for both morning and evening breathing rate do not differ across treatments. Although, variation in values may emanate from handling which cause some level of fright to animals. Table 3 shows inverse relationship between changes in THI and breathing rate except in T3. Scientific research works have been done to correlate diet with breathing. As one of the numerous body activities, breathing require fuel which is provided in feed intake. Except in disease condition, temperature variation/changes may not have so much effect of respiration. This is evident in Tables 1 and 2. Zander (1990) reported a negative influence of malnutrition on respiration for a short time. Respiratory muscles demand for animals for more oxygen when the is a pulmonary muscle infection and evident in increased breathing (Berthon and Wood, 2015).

Heart rate

Sameh *et al.*, (2017) reported the antioxidative and cytoprotective effect of *Spondias sp*, having potential to reduce oxidative stress in cardiac muscles. In addition, bioactive components like methyl gallate and gallic acid, have inhibitory effect on cells that causes cardiac cells degenerative disease. Although, diets with SMLM supplementation significantly differ from control, results from this study shows that heart beats and rates of pigs are within range of heart beat which has a strong relationship with THI. This may indicate effects of secondary metabolites bioactive component of SMLM with portion of animal brain concerned with regulation of the heart and its functionality, that is its medulla.

Conclusion

The study showed diurnal variation in temperature humidity index (THI) and housing environment of growing pigs with the highest THI in the evening period for each day, which has a marginal pulsation on the physiological performance of animals. Also, optimal relative humidity and temperature alongside with 5% supplementation *Spondias mombim* leaf meal help maintain thermal stability and physiological adaptation to environment during temperature conditions that can cause heat stress, therefore enhancing productivity of replacement gilts reared in high humid period of the year.

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