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Behavioural response of growing pigs reared in hot humid environment to feed withdrawal periods and ascorbic acid supplementation

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Additional keywords

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SUMMARY

This study was carried out with the aim of investigating the behavioural response of growing pigs to feed withdrawal periods and ascorbic acid supplementation during the hot periods of the day. Fifty four (54), 8 weeks old mixed breed pigs with average initial body weight of 5.5±0.2 kg were arranged in a 3x3 factorial layout. Factor A consists of 3 levels of feed withdrawal periods (0, 2 and 4 hours) and factor B consists of 3 levels of ascorbic acid supplementation (0, 1500 and 2500 mg/kg feed). The experimental pigs were grouped on weight equalization into 9 treatment groups of 3 replicates with 2 pigs per replicate. The behavioural activities of the pigs were monitored with the aid of closed-circuit digital video cameras mounted above the pen house. Eight hours recordings of the pigs' behaviours for 4 consecutive days per week for 3 weeks duration were obtained. Data collections were based on the number of pigs found exhibiting a particular behavioural activity within 1 hour of direct observation. Data obtained were subjected to analysis using two-way Analysis of Variance. The behavioural activities of rooting (3.69 times/frequency), walking (5.57 times/frequency) and drinking (1.67 times/frequency) increased significantly (P<0.05) with increase in level of feed withdrawal periods. Pigs on ascorbic acid supplementation at 0 mg/kg feed exhibited the highest (P<0.05) general behavioural activities (sitting, rooting, drinking and recumbency) than their counterparts on ascorbic acid supplementation. Eating behaviour of pigs increased significantly with increasing level of ascorbic acid supplementation. Interaction between feed withdrawal periods and ascorbic acid supplementation influenced most of the behavioural characteristics of growing pigs. Pigs on 4 hours feed withdrawal period and ascorbic acid supplementation at 1500 mg/kg feed had higher docile behaviours; hence, 4 hours feed withdrawal period and ascorbic acid supplementation at 1500 mg/kg feed can be adopted as management tool to improve the behaviours of growing pigs.

Respuesta comportamental de cerdos en crecimiento criados en ambiente cálido húmedo para alimentar los periodos de restricción y la suplementación de ácido ascórbico

Palabras clave adicionales

Comportamiento.
Restricción de alimentación.
Clima caliente.
Cerdos y suplementos.

SUMMARY

Este estudio se llevó a cabo con el objetivo de investigar la respuesta conductual de los cerdos en crecimiento a periodos de restricción y de suplementación con ácido ascórbico durante los períodos calurosos del día. Cincuenta y cuatro (54), cerdos de 8 semanas de edad de raza mixta con un peso corporal inicial medio de 5,5 x 0,2 kg se dispusieron en un diseño factorial de 3x3. El factor A consta de 3 niveles de períodos de restricción de piensos (0, 2 y 4 horas) y el factor B consta de 3 niveles de suplementos de ácido ascórbico (0, 1500 y 2500 mg/kg de alimentación). Los cerdos del experimento se agruparon en ecualización de peso en 9 grupos de tratamiento de 3 réplicas con 2 cerdos por réplica. Las actividades de comportamiento de los cerdos fueron monitoreadas con la ayuda de cámaras digitales de video de circuito cerrado montadas sobre el refugio del corral. Se obtuvieron ocho horas de grabaciones de los comportamientos de los cerdos durante 4 días consecutivos a la semana durante 3 semanas de duración. Las colecciones de datos se basaron en el número de cerdos encontrados que mostraban una actividad de comportamiento particular 1 hora después tras la observación directa. Los datos obtenidos fueron sometidos a análisis bidireccionales de la varianza. Las actividades conductuales de hozar (3,69 veces/frecuencia), caminar (5,57 veces/frecuencia) y beber (1,67 veces/frecuencia) aumentaron significativamente (P<0,05) con un aumento en el nivel de los períodos de piensos de restricción. Los cerdos alimentados con suplementos de ácido ascórbico a 0 mg/kg de pienso exhibieron las actividades de comportamiento general más altas (P<0,05) (sentado, hozada, bebida y recumbencia) que sus homólogos alimentados con suplementación con ácido ascórbico. El comportamiento alimenticio de los cerdos aumentó significativamente con el aumento del nivel de suplementos de ácido ascórbico. La interacción entre los períodos de abstinencia de piensos y la suplementación con ácido ascórbico influyó en la mayoría de las características conductuales de los cerdos en crecimiento. Los cerdos con 4 horas de período de abstinencia de piensos y la suplementación con ácido ascórbico a 1500 mg/kg de pienso tuvieron comportamientos dóciles más altos; por lo tanto, 4 horas período de abstinencia de alimento y la suplementación con ácido ascórbico a 1500 mg/kg de pienso se pueden adoptar como herramienta de gestión para mejorar los comportamientos de los cerdos en crecimiento.

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INTRODUCTION

Heat stress is a major source of production loss in domestic livestock reared in tropical environment. Pigs are homoeothermic in nature that is they tend to maintain a relatively constant body temperature in spite of variation in their environment. A portion of metabolizable energy meant for production purpose can be directed into maintenance of the thermal balance in pigs when their microenvironment via off its thermoneutral zone (Njoku *et al*., 2015a, p.18). When the environmental temperature of the pigs is high, they eat less and therefore experience reduced efficiency in converting feed to muscles whilst in cool environment they tend to take in more feed in order to sustain their normal body temperature and better convert feed to flesh. To ameliorate the negative effects of extreme weather conditions in farm animals some management techniques that lead to the modification of domestic animal microenvironments have been adopted in livestock industry.

Various environmental intervention methods (use of insulators, fan and evaporative coolers) have been adopted as a means of modifying the microenvironment within the pig house. These intervention techniques are based on the principles of physics and pig physiology. However, due to high costs of installing and running these systems, it is not economically feasible for most pig farmers to modify the pen to any significant extent. Hence, the importance of reducing the heat load on pig through nutritional strategies cannot be overemphasised, even if this meant having to pay more for the feed.

Feed restriction is one of the management tools used in modulating the growth rate of fast growing domestic animals. It has been reported to improve feed efficiency, reduce feed cost and mortality rate in fast growing domestic farm animals leading to production of more economical high quality animal protein (Etalem *et al*., 2011, p. 33; Njoku *et al*., 2013, p. 387). It can also be used to prevent feed wastages; accumulation of excess body fat, as well as metabolic disorders such ascotes syndrome (Mahmood *et al*., 2007, pp. 138-140). However, severe feed restriction for longer duration has been criticized because it infringes the welfare of domestic animals; reduce the final weight, resulting to stunted growth and eventual death due to starvation (Mench, 2002, p. 23; Njoku *et al*., 2017, p. 175. Mild feed restriction or short duration of restriction can be utilized to achieve the beneficial effects of feed restriction without compromising the welfare of the animal. Denial of feed during hot hours of the day may be helpful to reduce the metabolic heat production thereby assisting the animal to maintain its thermo-balance, thus improving the welfare and productivity of the farm animals raised under hot humid condition.

Ascorbic acid is a natural occurring antioxidant that is currently used worldwide to attenuate the adverse effect of environmental stress (Kafri & Cherry, 1984, p. 125) and stress-induced tissue damage (Minka & Ayo, 2010, p. 135). Due to its reducing properties and function as an electron donor, it plays an important metabolic role. The biosynthesis of ascorbic acid in mammals takes place in the liver and kidney (Sabah Elkheir, Mohammed Ahmed & Abdel Gadir, 2008, p. 2). Under heat stress condition, the requirement of ascorbic acid may exceed the animal synthesizing ability, hence, it has been recommended as supplement in livestock production. Adenkola and Anugwa (2007, p. 16) stated that ascorbic acid (AA) supplementation improved weight gain and better feed utilization in piglets.

Despite the abundant information on the beneficial effects of feed restriction in terms of compensatory growth and carcass quality, only a handful of information exist in literature pertaining to the behavioural changes in pigs subjected to mild feed restriction especially those raised in hot humid environment in Africa. To this effect, this study was carried out to determine the behavioural response of growing pigs to feed withdrawal periods and ascorbic acid supplementation.

MATERIALS AND METHODS

The experiment was carried out at the Piggery Unit of the Directorate of University Farms, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. Fifty four mixed breed weaned pigs with body weight of 5.5 kg were gotten from the established drift in the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Nigeria. The pigs were grouped based on weight equalization into 9 treatment groups with 3 replicates of 2 pigs per replicate. Two pigs serving as a replicate were housed together in a naturally ventilated pen with floor dimension of 4 m by 3 m, equipped with concrete feeding and drinking troughs. Routine management practices were done on daily basis, with fresh water supplied *ad libitum* throughout the 90 days experimental period. Pigs on treatment one were fed *ad libitum* throughout the period, while those on treatment two and three were offered daily ration at 07:00 hrs. Feeders were withdrawn at 12:00 hrs and later returned at14:00 and 16:00 hrs of same day respectively for the two treatments. The rations of pigs on treatment 1 to 3 did not contain ascorbic acid. Pigs on treatment 4 were fed *ad libitum* with ration that contained ascorbic acid at the rate of 1500 mg/kg feed. The feeders of pigs on treatment 5 that contained ascorbic acid at 1500 mg/kg feed were withdrawn from 12:00 noon to 14:00 hours daily. Treatment 6 consists of pigs whose kilogram of feed contained 2500 mg ascorbic acid was withdrawn from 12.00 noon to 16.00 hours daily. Pigs on treatment 7 were fed *ad-libitum* while those in treatments 8 and 9 were subjected to two hours (12:00 - 14:00 hours) and four hours (12:00 – 16:00 hours) daily feed withdrawal periods respectively. The diets offered to pigs on treatments 7, 8 and 9 contained ascorbic acid at the rate of 2500 mg/kg feed. The concentrate diet given contained 18% crude protein, 4.30% ether extract, and 8.59% crude fibre and 2474.39 KJ/kg metabolizable energy as indicated in **Table I**.

The frequency of behavioural activities of the pigs which include standing, lying (sterna or lateral), sleeping, wallowing, eating, drinking, snout rubbing, threat of attack (fight), attempts to escape, mounting one another, huddling, and rooting the floor were ob-

Table I. Percentage composition of the experimental diet (Composición percentual de la dieta experimental).

Ingredients	Percentage
Maize	50
GNC	11.5
PKC	20.6
Wheat Offal	15
Bone Meal	2.6
Salt	0.05
Lysine	0.05
Methionine	0.05
*Pig premix	0.05
Total	100
Determined Analysis	
Crude protein	18
Metabolizable energy	2474.39
Fat	4.3
Fibre	8.59
Calcium	0.79

*Contained the following per kg diet vit A 10000000 IU; Vit D3 2500000 IU; Vit E 40000 IU ; Vit K3 4000 mg, Vit B1 750 mg, Vit B2 2000 mg, Vit B6 2000 mg, Vit B12 10 mcg, Niacin 13000 mg, Pantothenic Acid 5000 mg, Folic Acid 1000 mg, Biotin 10 mcg, Choline Chloride 50000 mg, Manganese 50000 mg, Zinc 100000 mg, Iron 80000 mg, Copper 50000 mg, Iodine 1000 mg, Selenium 200 mg, Cobalt 500 mg, Antioxidant 120000 mg.

Table II. Effect of feed withdrawal periods on behavioural characteristics of growing pigs (Efecto de lo periodos de restricción alimentaria sobre las caracteristicas comportamentales de cerdos en crecimiento).

Parameters/ (Times/frequency)	Feed 0 Hour	Withdrawal 2 Hours	Periods 4 Hours	S E M
Standing	4.51	4.31	4.76	0.29
Sitting	0.44	0.42	0.47	0.07
Sleeping	0.26[a]	0.24[a]	0.13[b]	0.03
Fighting	0.53	0.62	1.01	0.19
Lying down	0.80	0.71	0.72	0.09
Huddling	0.17	0.24	0.23	0.06
Wallowing	0.58[a]	0.38[ab]	0.25[b]	0.07
Walking	4.35[b]	4.63[ab]	5.57[a]	0.32
Rooting	2.40[b]	2.68[b]	3.69[a]	0.24
Eating	2.12	1.92	1.99	0.14
Drinking	1.08[b]	1.32[ab]	1.67[a]	0.10
Recumbency	1.67	1.36	1.41	0.13
*PINT	1.22	1.11	1.61	0.34
Snout rubbing	3.22	3.17	2.17	0.54
Jumping	0.56	0.22	0.89	0.27
Running	1.11	1.00	1.11	0.41

[a,b] in the same row not sharing common superscript are significantly different (P< 0.05)

*PINT means Persistent Inguinal Nose Thrusting

served with the aid of a CCTV digital camera mounted 3 metres above the pen to capture the behaviours as described by Knowles *et al.* (1999, pp. 577-578). Eight hours recordings of the pigs' behaviours for 4 consecutive days in a week for 3 weeks duration were obtained. The number of pigs exhibiting a particular activity within 1 hour of direct observation were counted and noted.

Standing behaviour is a posture in which the animal adopts an upright position with all legs supporting the body.

Lying behaviour means resting in a horizontal position on the floor of the pen. It include lateral (on the side with all legs extended), inclined (lying not completely on the side, but with legs partly extended) or sternal (upright on the chest), and recumbency; which involved contact of the body with the ground in a total resting position.

Sitting behaviour is defined as when the hindquarter of the body is in contact with the ground and the front legs supporting the body.

Feeding behaviour is defined as when the pig is standing with its head down, the head could be either in trough or in front of the trough when pigs is eating spilled food.

Drinking behaviour involves pigs pressing their nose against the drinking trough.

Walking behaviour is any actions in which the pig moves at least 2 steps from the previous position.

Rooting behaviour also known as oral-nasal-facial behaviour; it includes pushing and sniffing movements with snout at floor level, beyond the trough.

Belly-nosing is when pig performed rooting snout movements toward the belly-nosed of pen mates.

Huddling behaviour occurs when the pigs gathered together at a point most especially when in distress or fear.

Agonistic behaviour is defined as physical fights between two pigs. It is subdivided into 2 categories; aggression and displacement. The superior pig of a physical encounter will be counted for aggressive behaviour. In addition, fighting pigs which are not obviously inferior or superior, which evaded the aggressor without defending or which will be pushed away by a superior pig counted for displacement.

Data collected were arranged in a 3×3 factorial experimental layout and then subjected to two-way analysis of variance using SAS (2000) package. Significantly ($p<0.05$) different means among variables were separated using New Duncan's Multiple Range Test as contained in the same statistical package.

RESULTS

Effect of Feed Withdrawal Periods on Behavioural Characteristics of Growing Pigs

Effect of feed withdrawal periods on behavioural characteristics of growing pigs is presented in **Table**

II. Significant (P< 0.05) differences were noted for sleeping, wallowing, walking, rooting and drinking behaviours during feed withdrawal periods. Sleeping behaviour decrease significantly (P<0.05) with increase in level of feed withdrawal periods, 4 hours withdrawal period had the lowest mean value of 0.13 times/frequency when compared to the values 0.24 times/frequency and 0.26 times/frequency obtained for pigs on 4 hours and 0 hour feed withdrawal periods respectively. Wallowing behaviour of pigs decreased significantly (0.58, 0.38 and 0.25 times/frequency) with increasing level of feed withdrawal periods. Walking behaviour during withdrawal periods was significantly (P<0.05) higher in pigs on 4 hours feed withdrawal period 5.57 times/frequency than the values (4.63 and 4.35 times/frequency) recorded for those on for 2 hours and 0 hour feed withdrawal periods respectively. Rooting behaviour of growing pigs increased significantly (P<0.05) with increasing level of feed withdrawal periods. Pigs on 4 hours feed withdrawal period had the highest mean value of 3.69 times/frequency compared to 2.68 times/frequency and 2.40 times/frequency observed in 2 hours and 0 hour feed withdrawal periods respectively. Significant (P< 0.05) differences were noted in drinking behaviour of pigs, which increased (P<0.05) with increase in level of feed withdrawal periods, pigs restricted for 4 hours had an average mean value of 1.67 times/frequency, compared to those on 2 hours and 0 hour feed withdrawal periods (1.08 and1.32 times/frequency) respectively.

Effect of ascorbic acid supplementation on behavioural characteristics of growing pigs

Effect of ascorbic acid supplementation on behavioural characteristics of growing pigs is presented in **Table III** sitting, rooting, eating, drinking and recumbency behaviours were significant (P<0.05) influenced by ascorbic acid supplementation. Pigs on 0mg/kg ascorbic acid supplementation had higher mean value of 0.60 times/frequency of sitting behaviour, compared to pigs subjected to ascorbic acid supplementation at the rate of 1500 mg/kg which had a mean value of 0.44 times/frequency and 0.30 times/frequency observed for pigs on ascorbic acid supplementation of 2500mg/kg. Rooting behaviour of growing pigs decreased significantly (P< 0.05) with increasing level of ascorbic acid supplementation. Drinking behaviour of growing pigs in 1500 mg/kg ascorbic acid had a higher mean value of 1.95 times/frequency compared to those whose ration was supplemented with 2500 mg/kg ascorbic acid which had a mean value of 0.88 times/frequency Recumbency behaviour of pigs subjected to 1500 mg/kg of ascorbic acid had a higher mean value of 1.92 times/frequency compared to those fed without ascorbic acid 1.48 times/frequency and those supplemented with 2500 mg/kg ascorbic acid which had a mean value of 1.05times, respectively. Eating behaviour of pigs significantly (P< 0.05) increased with increasing levels of ascorbic acid supplementation. Pigs on diet containing 2500 mg/kg ascorbic acid supplementation recorded the highest mean value of 2.28 times/frequency, followed by the mean value of 2.00 times/frequency documented for pigs fed diet containing 1500 mg/kg ascorbic acid supplementation while those on control diet recorded the least mean value of 1.75 times/frequency.

Interaction between feed withdrawal and ascorbic acid supplementation on behavioural characteristics of growing pigs

Interaction between feed withdrawal periods and ascorbic acid supplementation on behavioural cha-

Table III. Effect of ascorbic acid supplementation on behavioural characteristics of growing pigs (Efecto de la suplementación con ácido ascórbico sobre las caracteristicas comportamentales de cerdos en crecimiento).

	Ascorbic acid supplementation (mg/kg)			
Parameters (Times/frequency)	0	1500	2500	SEM
Standing	4.38	4.89	4.32	0.29
Sitting	0.60^{a}	0.44^{ab}	0.30^{b}	0.07
Sleeping	0.23	0.19	0.21	0.03
Fighting	0.58	1.00	0.59	0.19
Lying	0.70	0.70	0.82	0.09
Huddling	0.17	0.20	0.26	0.04
Wallowing	0.37	0.42	0.42	0.07
Walking	4.91	5.34	4.30	0.32
Rooting	3.54^{a}	2.88^{ab}	2.53^{b}	0.24
Eating	1.75^{b}	2.00^{ab}	2.28^{a}	0.14
Drinking	1.95^{a}	1.24^{b}	0.88^{c}	0.10
Recumbency	1.92^{a}	1.48^{ab}	1.05^{b}	0.13
*PINT	1.33	1.06	1.56	0.34
Snout rubbing	3.33	2.33	2.89	0.54
Jumping	0.89	0.33	0.44	0.27
Running	1.61	0.61	1.00	0.41

$^{a, b, c}$ in the same row not sharing common superscript are significantly different (P< 0.05).
*PINT: Persistent Inguinal Nose Thrusting.

racteristics of growing pigs is shown in **Table IV**; The interaction between ascorbic acid supplementation and feed withdrawal periods showed significant (P<0.05) differences among sitting, sleeping, huddling, wallowing, walking, rooting, drinking and recumbency. The highest mean value (0.83 times/frequeny) of sitting behaviour was recorded for pigs on 2 hours feed withdrawal period whose ration was supplemented with 2500 mg/kg ascorbic acid supplementation while the least mean value of 0.17 times/frequency was obtained for pigs on 4 hours feed withdrawal periods and 2500 mg/kg ascorbic acid supplementation. Pigs on four hours withdrawal periods and 2500 mg/kg ascorbic acid supplementation had highest (P<0.05) mean value of 0.38 times/frequency for sleeping behaviour while the least mean value of 0.08 times/frequency was documented in pigs subjected to 4 hours withdrawal and 0 mg/kg ascorbic acid supplementation. The highest (P<0.05) huddling behaviour was observed in pigs subjected to 4 hours feed withdrawal period and 1500 mg/kg ascorbic acid supplementation. The highest mean value for wallowing behaviour was seen in pigs subjected to 2 hours feed withdrawal period and 1500 mg/kg ascorbic acid supplementation while the least mean value was seen in pigs subjected to 0 mg/kg ascorbic acid supplementation and 0 hour feed withdrawal period. Walking behaviour was highest in pigs on 4 hours feed withdrawal and 0 mg/kg ascorbic acid supplementation while the least was noted in pigs whose ration was withdrew for 2 hours and 2500 mg/kg ascorbic acid supplementation. The rooting behaviour of pigs on 4 hours feed withdrawal periods and 0 mg/kg ascorbic acid supplementation had the highest mean value of 5.56 times/frequency while the least mean value 2.10 times/frequency was seen in 2 hours feed withdrawal periods and 2500mg/kg ascorbic acid supplementation. Drinking behaviour highest value (2.21 times/frequency) was observed in pigs on 4 hours feed withdrawal period and1500mg/kg ascorbic acid supplementation while the least value (0.79 times/frequeny) was noted for those on 4 hours feed withdrawal period and 2500 mg/kg ascorbic acid supplementation. The recumbency behaviour ranged significantly (P<0.05) from 0.54 times/frequency (pigs on 4 hours feed withdrawal period and ascorbic acid supplementation at 2500 mg/kg feed) to 2.38 times/frequency (pigs on 0 hour feed withdrawal period and ascorbic acid supplementation at 1500mg/kg feed).

DISCUSSION

Feed withdrawal periods were observed to have caused different changes in behavioural activities of growing pigs in the present study. The significant decrease in sleeping behaviour could be attributed to high feeding motivation in the pigs whose feeders have been withdrawn. This must have affected their feed intake leading to decrease in sleeping behaviour since they have to engage in activities relating to scavenging. This scavenging tendency in the pigs on limited feed offered must have resulted to the development of stereotypic behaviour which is strongly related to the persistence of a high feeding motivation in the post-feeding period (Lawrence, Appleby & Macleod, 1988, p. 131). Bergeron et al. (2006, pp.34-35) enthused that the development of stereotypic behaviour in pigs is related to a combination of a lack of sufficient amount of food which promote satiety and frustration of fo-

Table IV. Interaction between feed withdrawal and ascorbic acid supplementation on behavioural characteristics of growing pigs (Interacción entre la restricción alimentaria y la suplementación con ácido ascórbico sobre las carácteristicas comportamentales de cerdos en crecimiento).

Withdrawal period (hours)	0			2			4			
Ascorbic acid (mg/kg)	0	1500	2500	0	1500	2500	0	1500	2500	SEM
Standing	4.65	3.65	4.83	4.94	4.96	4.77	3.96	4.31	4.69	0.50
Sitting	0.69^{abc}	0.23^{bc}	0.42^{abc}	0.19^{c}	0.77^{ab}	0.83^{a}	0.46^{abc}	0.27^{bc}	0.17^{c}	0.12
Sleeping	0.29^{abc}	0.10^{c}	0.29^{abc}	0.33^{ab}	0.13^{bc}	0.10^{c}	0.08^{c}	0.17^{abc}	0.38^{a}	0.05
Fighting	0.96	0.27	0.36	0.50	1.35	0.00	0.27	1.38	1.40	0.33
Lying down	0.65	0.90	0.85	0.75	0.63	0.75	0.71	0.58	0.85	0.16
Huddling	0.15^{ab}	0.04^{b}	0.31^{ab}	0.23^{ab}	0.21^{ab}	0.27^{ab}	0.13^{ab}	0.35^{a}	0.21^{ab}	0.06
Wallowing	0.5^{ab}	0.17^{b}	0.46^{ab}	0.38^{ab}	0.77^{a}	0.58^{ab}	0.23^{b}	0.31^{ab}	0.21^{b}	0.12
Walking	3.98^{b}	5.54^{ab}	4.38^{ab}	4.10^{b}	5.08^{ab}	3.88^{b}	6.65^{a}	5.42^{ab}	4.65^{ab}	0.55
Rooting	2.54^{b}	3.54^{b}	2.50^{b}	2.52^{b}	2.58^{b}	2.10^{b}	5.56^{a}	2.52^{b}	2.98^{b}	0.41
Eating	2.19	2.19	1.98	1.79	2.42	1.56	2.02	2.23	1.71	0.23
Drinking	1.02^{bc}	2.08^{a}	0.85^{bc}	0.71^{c}	1.56^{ab}	0.98^{bc}	2.00^{a}	2.21^{a}	0.79^{bc}	0.18
Recumbency	1.54^{ab}	2.38^{a}	1.10^{b}	1.46^{ab}	1.13^{b}	1.50^{ab}	1.44^{ab}	2.25^{a}	0.54^{b}	0.23
* PINT	1.67	0.67	1.33	1.00	2.00	0.33	1.33	0.50	3.00	0.59
Snoutrubbing	4.50	1.83	3.33	4.50	3.33	1.67	1.00	1.83	3.67	0.93
Jumping	1.17	0.33	0.17	0.00	0.50	0.17	1.50	0.17	1.00	0.47
Running	2.83	-0.00	0.50	1.67	0.67	0.67	0.33	1.17	1.83	0.70

[a, b,c] Means With different superscript within the same row are significantly different at p<0.05 significant different level. PINT: Persistent Inguinal Nose Thrusting

raging behaviour in restrictively fed pigs. The reduction in wallowing behaviour with increasing level of feed withdrawal period of pigs could be linked to the amount of metabolic heat production which has been reported to reduce with decrease in meal size (Njoku *et al*., 2012, p. 96; 2013, p. 387). Lower metabolic heat production must have increased heat tolerance of pigs resulting to minimal wallowing activity in order to maintain body homeostasis level. Walking and rooting behaviours were influenced by feed withdrawal periods, the positive influence in walking and rooting behaviours could be attributed to high locomotion activities which can be associated with increasing foraging behaviour (Stolba & Wood-Gush, 1989, p. 424). Feed withdrawal periods reduced the amount of time pigs spent at the feeder, and increased the proportion of time pigs engaged in pen-directed foraging behaviour. Day, Kyriazakis and Lawrence (1995, pp. 203-204) reported that pigs on 20% of *ad libitum* feed offered increased the time spent in rooting substrate. Also, Lawrence and Terlouw (1993, p. 2816) enthused that any condition that limit the performance of normal feeding behaviour in pigs will result to alternative stimuli. In this present study, drinking behaviour increased with increase in level of feed withdrawal periods, Excessive drinking has been considered as a form of stereotypic behaviour and food restriction has been reported to increase its incidence (Njoku *et al*., 2015b, p. 125). Terlouw, Lawrence and Illius (1991, p. 493) found that high-fed pigs, performed significant amounts of drinking activity immediately after the meal. However, in the longer term following the meal, high-fed pigs ceased to drink and increased lying behaviour while low-fed pigs persisted in drinking. This sustained drinking activity in pigs on feed withdrawal period is likely to reflect metabolic requirement in order to compensate for low abdominal fill. This is in consonance with the findings of Silanikove and Brosh (1989, p. 509) that reported 6-fold increase in water intake of pigs whose total daily ration was halved or completely withheld for a period.

It has been reported that pigs reared in a hot humid environment of the tropics are subjected to extended periods of high ambient temperature and humidity resulting to thermal stress (Njoku *et al*., 2015a, p. 16). The reduction in frequencies of sitting and recumbency behaviours in pigs with increasing level of ascorbic acid supplementation demonstrated that ascorbic acid has a reduced effect on oxidative stress and facilitated the physiological mechanism of thermoregulation. Sitting and recumbency position can serve as physiological mechanisms of dissipating heat through conduction and convection means of thermoregulatory in pigs. Tauler *et al*. (2003, pp. 662-663) and Minka and Ayo (2010, p. 135) assent to the fact that ascorbic acid decreases heat load through reduction in heat production or increasing heat loss by enhancing thermal exchange between the pig body and its environment. The mechanism of action of ascorbic acid in reducing thermal stress could be through the detoxification of reactive oxygen species known to be in large quantity in the body during stressful situations (Tauler *et al*., 2003, p. 658; Minka & Ayo, 2012, p. 339). Long-term stress has been reported to result in pathophysiological changes on the animals such as loss of appetite and body mass, a compromised immune system and dehydration (Knowles *et al*., 1999, p. 575). Ayo, Minka and Mamman (2006, p. 127) enthused that stress conditions in livestock is likely to manifest as disturbance of fluid, electrolyte and acid-base balance of the body of the animal. From this present study, the pigs on zero supplementation of ascorbic acid had highest drinking behaviour which is an indication that these pigs are under thermal and nutritional stress leading to high rate of dehydration through diuresis. In bid to maintain homeostasis, the pigs must have changed their drinking behaviour in order to counteract the adverse effect of dehydration. Parker (2004, p. 16) reported that the replacement of water from the GIT of Merino sheep may have been responsible for maintenance of body water in the presence of a cortisol-induced diuresis. While Guyton and Hall (2002, p. 235) stated that body water is regulated by intake of fluids, which is controlled by factors influencing thirst and renal excretion of water. Balz (2003, p. 1) reported that administration of dietary ascorbic acid plays vital role in the synthesis of neurotransmitters, norepinephrine and 5-hydroxytryptamine which are involved in the control of brain function and mood. Hence, the result of this present study support earlier findings that ascorbic acid supplementation increases body resistance to environmental stress by altering the hormones or factors responsible for a shift in the homeostatic mechanism during stressful condition (Tauler *et al*., 2003, , pp. 662-663; Ayo, Minka & Mamman, 2006, p. 127). The intense rooting behaviour exhibited by pigs on ascorbic acid free ration could be linked to frustration, hunger and metabolic stress caused by feed withdrawal period and other environmental conditions leading to the manifestation of aberrant behaviours relating to foraging. The fact that decreasing rooting behaviour with increasing ascorbic acid supplementation was observed from this present study testified to the fact that ascorbic acid assisted in the reduction of frustration associated with hunger. It has been established that ascorbic acid is a vitaminergetic neurotransmitter that plays a role in inhibiting cortisol secretion, a chief hormones of stress involved in the elicitation of fear and frustration in the limbic region (Karanth *et al*., 2000, p. 1891; Balz, 2003, p. 1). The improved feed intake in the pigs subjected to feed withdrawal periods and fed diets containing different levels of ascorbic acid attest to the fact that ascorbic acid supplementation aid in the suppression of stress at tissue and plasma levels. This present study supported the observations of Ali *et al*. (2008, p. 409) and Tuleun, Adenkola and Afele (2011, p. 1268) that the addition of antioxidants like ascorbic acid in the diets of livestock help in the detoxification of reactive oxygen species known to be abundance in the body during stressful conditions, leading to improved feed consumption rate. Kutlu and Forbes (1993, pp. 108-109) reported that poultry birds under stress will choose a feed supplemented with ascorbic acid if the feed is identifiable through the use of colour and reverts to normal feeding habit when the stressor has been removed.

CONCLUSION:

Feed withdrawal periods increased sleeping, wallowing, walking, rooting and drinking behaviours of pigs whereas the positive observations in sitting,

rooting, eating, drinking and recumbency behaviours point to the fact that ascorbic acid can be used to mitigate the negative effects of climatic and nutritional stress. Hence, they can be used as management tool to induce acceptable behaviours in pigs.

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