Journal of Cell and Animal Biology Vol. 4(3), pp. 051-057, March 2010
Available online at http://www.academicjournals.org/JCAB
ISSN 1996-0867 © 2010 Academic Journals

Full Length Research Paper

Rectal temperature responses of pigs transported by road and administered with ascorbic acid during the hot-dry season

O. O. Asala[1]*, J. O. Ayo[2], P. I. Rekwot[3], N. S. Minka[4] and A. Y. Adenkola[5]

[1]National Veterinary Research Institute, P. M. B. 01, Vom, Plateau State, Nigeria.
[2]Department of Veterinary Physiology and Pharmacology, Ahmadu Bello University, Zaria, Kaduna State, Nigeria.
[3]National Animal Production Research Institute, Shika, Zaria, Kaduna State, Nigeria.
[4]College of Agriculture and Animal Science, Ahmadu Bello University, Kaduna State, Nigeria.
[5]Department of Physiology and Pharmacology, College of Veterinary Medicine, University of Agriculture, Makurdi, Benue State, Nigeria.

Accepted 27 January, 2010

Experiments were performed in order to determine the rectal temperature (RT) responses of pigs to eight-hour road transportation and the effect of administration of ascorbic acid (AA) on the responses in transported pigs during the hot-dry season. Twenty three experimental pigs were given AA orally and individually at 100 mg/kg prior to the transportation, while thirteen control pigs were administered with 20 ml of drinking water. The RTs of the pigs were measured by inserting a clinical thermometer (Hartman Company, England) into the rectum via the anus. The ambient temperature (AT) and relative humidity (RH) were measured concurrently with the RT. The AT and RH values ranged between 23.5 - 39.0°C and 43 - 97% respectively. The values were outside the thermo-neutral zone for the pig, indicating that the season was thermally stressful. The AT values, which fluctuated with the hour of the day and increased with the hour of the journey, were significantly ($P < 0.001$) and positively correlated with RT values in both experimental ($r = 0.941$) and control pigs ($r = 0.942$). The overall mean RT value of 39.8 ± 0.1°C recorded in the experimental pigs after 8 h road transportation did not differ ($P > 0.05$) with the corresponding value of 39.4 ± 0.3°C in control pigs, demonstrating that AA did not induce hypothermia in experimental pigs. In conclusion, transportation of pigs by road for 8 h in the zone induces hyperthermia and administration of AA in the experimental pigs did not induce hypothermia. Optimum duration of road transportation of pigs is 6 h. This duration should be considered in the development of guidelines and welfare for pigs, transported by road during the hot-dry season.

Key words: Transportation stress, rectal temperature, ambient temperature, hot-dry season, ascorbic acid, pigs.

INTRODUCTION

It has been established that meteorological factors of high ambient temperature (AT) and high relative humidity (RH), characteristic of the hot-dry season, cause heat stress which exerts adverse effects on livestock production (Bianca, 1976; Ayo et al., 1998a and b; Renaudeau et al., 2007). During the hot-dry season transportation of pigs is unavoidable, inspite of the unfavourable meteorological conditions prevailing during the season. Of all the seasons prevailing in the Northern Guinea Savannah zone of Nigeria, the hot-dry season has been described as thermally stressful to livestock (Igono et al., 1982; Ayo et al., 1996, 1998a). Efforts have been employed previously to ameliorate the adverse effects of road transportation stress in pigs these include the administration of hypnotics, sedatives (Lopez-Olevera et al., 2006) and tranquilizers (Nyberg et al., 1988). Administration of these drugs in transported pigs

*Corresponding author. E-mail: ofcasala@yahoo.com. Tel: +2348065690278.

during the pre-slaughter period results in drug residues in the meat of such animals, especially in pigs that may be slaughtered compulsorily during the journey period as a result of stress (Peeters et al., 2006). An increasing body of evidence has shown that free radicals are generated in poultry subjected to heat stress (Sahota and Gillani, 1995; Altan et al., 2003; Sahin et al., 2004), resulting in depletion of the antioxidant, vitamin C (ascorbic acid, AA) in tissues. Tauler et al. (2003) and Williams et al. (2008) showed that antioxidants in the body decrease or are overwhelmed due to exercise stress. Road transportation stress in the body is ameliorated by administration of AA in goats (Minka and Ayo, 2007a and b) and pullets (Ayo et al., 2006; Minka and Ayo, 2008). AA is a potent antioxidant vitamin that is readily available, relatively inexpensive and with virtually no toxic or residual effects (Padayatty et al., 2003; Tauler et al., 2003; Sahin et al., 2004; Peeters et al., 2006), and it is readily metabolized in the body (Chervyakov et al., 1977). An important index in the evaluation of stress in domestic animals is rectal temperature (RT) (Bianca, 1976; Ayo et al., 1998a; Sinkalu et al., 2008; Adenkola et al., 2009). It is readily measured and shows the extent of thermal equilibrium in animals (Bianca, 1976).

The aim of the present study was to investigate fluctuation in RT responses in pigs transported by road during the hot-dry season, and the influence of AA administration on the fluctuation.

MATERIALS AND METHODS

The experiment was conducted at the animal research pen of the Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria (11° 10′ N, 07° 38′ E), located in the Northern Guinea Savannah zone of Nigeria. Transportation of the pigs was carried out during the hot-dry season in May, 2007 from Zaria (11° 10′ N, 07° 38′ E), to Pambegua (10° 4' N, 08° 16' E) and from Pambegua back to Zaria, covering a total distance of 400 km. The zone is characterized by three major seasons, namely: The hot-dry, rainy and harmattan seasons. Of the three seasons, the harmattan has been described as the most thermally stressful to livestock (Ayo and Oladele, 1996; Igono et al., 1982). This period marks the peak of the hot-dry season, just before the onset of the rainy season in the zone.

Animals and management

Twenty three (23), apparently, healthy adult local pigs comprising non-castrated males, non-pregnant and non-cycling females of about one-year-old and weighing between 40 - 50 kg served as subjects. The pigs were purchased from Samaru, Zaria four weeks before commencement of the experiment. They were housed in the animal pen of the Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria. The pen was made of concrete floor, cements block wall and roof, and consisted of two chambers. The pigs moved freely within the pen. They were managed intensively and fed a standard compounded feed, consisting of a mixture of maize bran and rice husk. Water was given ad libitum. The pigs were pre-conditioned for two weeks before commencement of the experiment, and they were dewormed using piperazine hydrochloride (Everchem, China) at a dose of 110 mg/kg orally. They were also treated against ectoparasites using Ivermectin^{R} (Merial, France) at a dose of 0.05 mg/kg subcutaneously.

Experimental design

After the two-week period of pre-conditioning, each pig was identified by a numbered neck collar. A week to the day of commencement of transportation, pigs were assigned experimental (Group I) and control (Group II) groups consisting of 13 and 10 pigs respectively. Neck collars already numbered (1- 23) were put in a bag and picked 'blindly' one at a time without replacement. Each collar picked was placed on the neck of individual pig caught at random. Animals with collar numbers 1 - 13 were classified as experimental (Group I) while those with collar numbers 14 - 23 were classified as control (Group II). On the day of transportation, 30 min before transportation, pigs in group I, which served as experimental animals were administered orally with 100 mg/kg body weight of AA (ARCHY Pharmaceuticals, Nigeria; NAFDAC no: 04-5270, Batch no:VCW 7024) dissolved in 20 ml of water. The 10 pigs in group II which served as control were administered with 20 ml of distilled water each orally. Feed and water were withdrawn 12 h before and throughout the journey period, which lasted eight hours. All the pigs were transported on asphalt roads at an average speed of 50 km/h. After the completion of the journey, the pigs were unloaded at the same spot from where they were loaded previously. Feed and water were then provided ad libitum.

Vehicle design and loading

A standard Bedford van (made in England) and popularly used in the Northern Guinea Savannah zone of Nigeria for transportation of pigs was used for the journey. The body of the vehicle was made of aluminium, and the floor of steel. The inner compartment of the vehicle measured 5.5 x 1.5 m. The side walls of the body of the vehicle to a height of 1.1 m were made of aluminium and above which had windows for ventilation. The vehicle had at its rear end a twin door with a rear wind screen. The upper side walls and roof are also covered with aluminium. The floor of the vehicle was covered with dry straw and covered with a thick rubber mat for secure footing. Transportation procedures were carried out according to the guidelines governing animal transport welfare by road as described by (Knowles et al., 1998). Briefly, pigs were loaded individually by two persons in a relatively calm condition. One person easily caught a pig at a time and carried it to the other person, who already was in the vehicle. The pigs were stocked at a rate of 0.3 m^2/pig.

Measurement of meteorological parameters

Meteorological parameters of ambient temperature (AT) and relative humidity (RH) were recorded using the wet and dry-bulb thermometer (Ellab Inc, U.S.A.).

The dry bulb temperature (DBT) and RH were recorded at the experimental site at 06:00, 13:00 and 18:00 h every other day for 5 days before the commencement of the journey. The parameters were also measured just before transportation and during the journey at 30 minutes, 2, 4, 6 h and finally at 8 h, when the journey was completed. Post-transportation, DBT and RH were recorded at 3 h after unloading and on days 1, 2 and 3.

Measurement of rectal temperature

Two weeks before commencement of the journey, the RT was determined every other day, during the measurement of the

Table 1. Meteorological Data from the study period before and after transportation.

	Ambient temperature (°C)		Relative humidity (%)	
Time, h	**Before**	**After**	**Before**	**After**
06:00	23.5 ± 0.4	22.0 ± 0.5	73.0 ± 8.0	80.3 ± 4.9
13:00	37.0 ± 1.0	29.6 ± 0.3	55.8± 6.0	56.6 ± 1.6
18:00	35.6 ± 1.0	28.0 ± 3.0	71.2 ± 6.0	61.5 ± 11.5
Overall Mean ± SEM	32.0 ± 4.2	26.5± 2.3	66.7 ± 5.4	66.1 ± 7.2

Table 2. Ambient temperature and relative humidity inside the vehicle during the journey period.

Hour of journey, h	Dry-bulb temperature (°C)	Relative humidity (%)
0.5	30.5	68.0
2	33.0	57.0
4	37.0	53.0
6	36.5	40.0
8	39.0	71
Mean ± SEM	34.0±1.7	59.3±4.7

meteorological parameters, at 06:00, 13:00 and 18:00 h for a total of 5 days. On the experimental day, the RT was measured just before loading the pigs into the vehicle. Thereafter as the vehicle kicked off, the RT was determined at 30 min, 2, 4, 6 and 8 h of the journey. On arrival, the RT was also measured after 3 h with the meteorological parameters after unloading and, subsequently, at 06:00, 13:00 and 18:00 h for 3 days consecutively post-transportation.

All measurements were carried out in a relatively calm condition, and each pig was restrained lightly and properly for the measurements. The RT was recorded as an indicator of the body temperature using a digital clinical thermometer (The Hartman's Company, PLC, England). The thermometer was inserted 5 cm deep into the rectum of each pig via the anus (Zaytsev et al., 1971) until an alarm sound was heard, indicating the end of the reading.

Statistical analysis

All data are expressed as mean ± SEM. Data were analysed using Student's *t*-test and Pearson's correlation analysis. Values of $P < 0.05$ were considered significant.

RESULTS

Meteorological data

The meteorological data are shown in Tables 1 and 2. The AT and RH recorded at the experimental site during the study period ranged between the maximum value of 39.0°C to the minimum value of 23.5°C, with a range of 16.5°C. The RH at the experimental site before transportation ranged between 43 - 97%. The dry bulb temperature (DBT) was highest at 13:00 h with mean value of 37 ± 1.0°C (Table 1). During the journey period, the DBT inside the vehicle rose gradually from 30.5°C, 30 min into the journey and attained a peak value of 39.0°C at the 8 h of the journey with a mean of 34.0 ± 1.7°C, while the RH ranged between 40 - 71% with a mean value of 59.3 ± 4.7%. Thus, the AT and RH had wide range values of 8.5°C and 29%, respectively during the journey period (Table 2). The AT ranged post-transportation between 21 - 31°C, while RH maximum and minimum values were 89 and 50% respectively (Table 1).

Rectal temperature of pigs before the journey

The RT of the experimental pigs measured for five days pre-transportation was lowest at 06:00 h and highest at 18:00 h, with the values of 36.8 ± 0.1 and 39.0 ± 0.1°C, respectively. The RT of the control pigs was also lowest at 06:00 h and highest at 18:00 h, with the values of 36.8 ± 0.1 and 38.9 ± 0.1°C, respectively. There was no significant difference ($P > 0.05$) between mean RT values of the experimental and control pigs pre-transportation, but the values were significantly different ($P < 0.05$) within the experimental and control groups between 06:00 h and 13:00 h, and between 06: 00 h and 18: 00 h (Table 3).

The hour of the day, maximum and minimum AT values were positively correlated with RT values, both in experimental and control pigs before transportation. However, the RH was negatively correlated with RT in all the pigs before and after transportation.

Table 3. Rectal temperature (°C) of experimental (13) and control (n = 10) pigs before and post transportation.

	Pre-transportation		Post-transportation	
Time, h	**Experimental**	**Control**	**Experimental**	**Control**
06:00	36.8 ± 0.1	36.8 ± 0.1	36.4 ± 8.0	36.4 ± 0.1
13:00	38.8 ± 0.1	38.7 ± 0.1	37.9 ± 0.2	37.6 ± 0.2
18:00	39.0 ± 0.1	38.9 ±0.1	38.3 ± 0.4	38.1 ± 0.4
Overall Mean ± SEM	38.2 ± 0.7	38.1± 0.6^{NS}	37.5 ± 0.6	37.3 ± 0.5^{NS}

^{NS} = non significant (P > 0.05) difference.

Table 4. Rectal temperature (°C) of experimental (n=13) and control (n=10) pigs during 8 h road transportation.

	Mean±SEM		Maximum		Minimum	
Hour of the journey	**Experimental**	**Control**	**Experimental**	**Control**	**Experimental**	**Control**
0.5	39.1 ± 0.3	38.7 ± 0.1	41.0	39.6	38.4	38.2
2	39.1 ± 0.1	38.8 ± 0.1	39.8	39.5	38.6	38.3
4	39.5 ± 0.1	39.3 ± 0.1	39.8	40.0	39.0	38.9
6	40.3 ± 0.1	39.9 ± 0.1	40.7	40.6	40.0	39.3
8	40.9 ± 0.1	40.5 ± 0.1	41.2	41.4	40.5	40.1
Overall Mean±SEM	39.8 ± 0.1	39.4 ± 0.3 ^{NS}	40.5 ± 0.2	40.2 ± 0.3 ^{NS}	39.3 ± 0.4	38.9 ± 0.3 ^{NS}

NS = non significant (P > 0.05) difference.

Rectal temperature of the pigs during the 8 h road transportation

During the journey period, the mean RT value fluctuated between 39.1 ± 0.3 and 40.9 ± 0.1°C in experimental pigs with an overall value of 39.8 ± 0.3°C, while in the control pigs the values fluctuated between 38.7 ± 0.1 and 40.5 ± 0.1°C. The overall mean value of 39.4 ± 0.3°C recorded in the control pigs were not significantly different (P > 0.05) from that of the experimental pigs. Although the mean maximum and minimum RT values in the experimental pigs (40.5 ± 0.2 and 39.3 ± 0.4°C, respectively) were slightly higher than the corresponding values obtained in the control pigs (40.2 ± 0.3 and 38.9 ± 0.3°C, respectively), they were not significantly different (P > 0.05) (Table 4).

The RT values rose with duration of the journey both in experimental and control pigs. In the experimental pigs, the values rose (P < 0.001) from 39.1 ± 0.3°C after 30 min to 40.9 ± 0.1°C at the 8th h of the journey. The RT value in the control pigs rose (P < 0.001) from 38.7 ± 0.1 - 39.4 ± 0.3°C at the 8th hour of the journey. The DBT increased significantly (P < 0.001) and was positively correlated with the RT values.

Fluctuations in rectal temperature of pigs post-transportation

The mean overall RT value three hours after the journey in the experimental pigs was 38.5 ± 0.2°C. The value was not higher (P > 0.05) than that of 38.1 ± 0.2°C recorded in control pigs. There was no significant difference between the mean values of RT in both experimental and control pigs recorded for three days post-transportation (Table 3).

DISCUSSION

Meteorological data pre-transportation

The meteorological data obtained in the present study indicated that the DBT, which ranged between 23.5 - 39.0°C, was predominantly outside the thermoneutral zone of 12 - 25°C established for the pig in the temperate regions (Bianca, 1976; Bazhov and Komlatsky, 1989). Thus, the DBT recorded pre-transportation of the pigs was not optimum for their normal thermoregulation. Similarly, the RH, which fluctuated between 43 - 97%, was outside the upper limit of the established normal RH values of 45 - 75% for the pig (Agricultural Research Council, 2006), indicating that the RH which the pigs were subjected to was also not conducive. The DBT and RH values recorded from the study period were characterized by high values, established to induce heat stress in pigs (Bazhov and Komlatsky, 1989; Ayo et al., 1998b; Vecerek et al., 2006). Thus, the conditions prevailing during the hot-dry season in the Northern Guinea Savannah zone of Nigeria are not optimum for the rearing of pigs. The meteorological conditions showed that transportation of pigs during the hot-dry

season was thermally stressful and that such transported pigs are inevitably subjected to concurrent actions of both heat and transport stresses. Measures aimed at alleviating these stresses were, therefore, taken into consideration in the present study through the administration of an antioxidant, AA demonstrated by Ayo et al. (2005, 2006) in pullets and Minka and Ayo (2007a,b) in goats to alleviate transportation stress.

Meteorological data during and post-transportation

The results of the DBT and RH obtained at the experimental site before and after the transportation of the pigs were not significantly different. This finding indicated that the DBT and RH values from the study period at the experimental site were similar, and that they exerted similar effects before and after the journey on the responses of the pigs to the transportation stress. There were considerable changes in the DBT values during the journey period, which rose from 30.5^{o}C at the first hour of the journey to a peak value of 39.0^{o}C at the 8th hour of the journey when the transportation was completed. The DBT values were outside the established thermoneutral zone for the pig (14 - 25^{o}C) (Bazhov and Komlatsky, 1989). This finding indicated that the AT prevailing during the transportation was also unfavourable to the pigs. Similarly, there was a wide fluctuation in the RH values during the journey. The high fluctuation (40 - 71%) with a range of 31% was outside the normal range values of RH for the pigs (45 - 75%) (A.R.C., 2006). During the journey, the high overall AT and RH values obtained have been shown to be thermally stressful to the pig (Bianca, 1976; Bazhov and Komlatsky, 1989). The AT and RH values obtained in the present study were not significantly different from the corresponding values of 31.8 ± 2.6% and 65.2 ± 6.4 %, respectively obtained during the transportation of goats in the hot-dry season in the Northern Guinea Savannah zone of Nigeria (Minka and Ayo, 2007a). The mean maximum AT value of 34.0 ± 1.7°C obtained in the present study was not significantly different from that of 34.1 ± 1.5°C recorded during the six-hour road transportation in pullets in the hot-dry season (Minka and Ayo, 2008). The RH value of 59.3 ± 4.7% obtained in the present study differed from that of 44.5 ± 1.4% obtained by Minka and Ayo (2008) during road transportation of pullets. The difference in the results on the RH value may be due to many factors including meteorological conditions, differences in species of animals used and the duration of the journey. This finding suggests that species variation may play some role in modulating the microclimatic conditions inside the vehicle during road transportation. The results further confirmed that the hot-dry season was thermally stressful to livestock during transportation by road in Northern Nigeria. Thus, for pigs to be transported successfully during the season and perform optimally, efficient thermoregulatory (homeostatic) mechanisms must be switched on.

Rectal temperature of pigs five days pre-transportation

The RT values in both experimental and control pigs showed diurnal fluctuations, and this finding is in agreement with those of Ayo et al. (1998a, 1998b), Piccione and Caola (2002) and Sinkalu et al. (2008). According to Piccione and Caola (2002), such fluctuations are driven by a biologic clock in the mammalian brain. The overall mean and maximum RT values obtained in experimental and control pigs before the transportation fell within the established normal range of 38 - 40°C (Zaytsev et al., 1971). However, the overall mean minimum values of 36.6 ± 0.8°C and 36.8 ± 0.7°C obtained in the control and experimental pigs, respectively were completely below the normal range of RT, established for pigs in temperate regions of the world. The RT in the pigs fluctuated between 36.6 and 39.8°C, with a range value of 3.2°C. According to Zaystev et al. (1971), such a wide range in RT values (above 1.0 - 1.8°C) impairs body functions and may result in heat stroke. Thus, the responses of the pigs demonstrated that the meteorological conditions prevailing during the hot-dry season in the zone are not conducive both for rearing and road transportation of pigs. However, the animals, by switching on the homeostatic mechanisms, maintained their RT values within the normal range of RT values in the pig. Furthermore, additional stress factors acting upon the pigs may completely impair their body functions and aggravate the incidence of road transportation-induced diseases. Thus, the relatively low RT values of about 37.0°C, obtained in experimental and control pigs, may be a component of the adaptive and compensatory responses of the transported animals to the thermally stressful hot-dry season in the zone.

Rectal temperature of pigs during eight hours of road transportation

The mean RT values obtained during the journey period rose ($P < 0.001$) with the hour of the journey in the experimental ($r = 0.968$) and control pigs ($r = 0.987$), and attained the peak at the 8 h when the journey was completed. The results clearly indicated that the journey time plays a crucial role in the RT values of transported pigs. The results showed that for normal thermoregulatory mechanisms to be maintained in the pig, the journey duration should be limited to six hours. This is because the mean RT values were maintained within the normal range in the pigs till the 6th hour. Thereafter, thermoregulatory mechanisms of the transported pigs were inadequate to maintain the RT values within the

normal range. The results further showed that transportation of pigs within the zone is recommended to be conducted within 6 h. If the need arises for the animal to be transported above this duration, measures aimed at enhancing the relative maintenance of the RT values within the normal physiologic range must be ensured. It is worth noting that in the present study the RT values in both experimental and control pigs were not significantly ($P > 0.05$) different, indicating that AA did not exert a hypothermic effect on transported pigs during the hot-dry season. This finding contradicts the results of studies conducted by Ayo et al. (2005) in pullets, Ayo et al. (2006) and Minka and Ayo (2007a) in goats, and Minka and Ayo (2008) in pullets, who showed that AA exerted a hypothermic effect in livestock transported by road during the hot-dry season. The differences in the results may be due to species variation, and the fact the doses given to the animal species varied. This observation requires further investigation. Furthermore, the study showed the need to increase the dose of AA in order to establish its anti-stress effect on transported pigs during the hot-dry season. This again requires further investigation.

Rectal temperature of pigs post-transportation

The overall mean and the mean maximum RT obtained three days after the journey were within the normal range of RT values. The result agreed with the findings of Minka and Ayo (2007a, b) that RT values of transported animals were restored to the normal values shortly post-transportation. The results also showed that transportation of pigs by road for 8 h induced a transient stress, and that the rising of the RT above the normal value was short-lived. The overall mean and mean maximum RT values obtained three days post-transportation in both experimental and control pigs showed that the values were significantly reduced following road transportation. The transportation depressed the thermal responses in the pigs after the journey and even below the initial (pre-transportation) values. This finding agreed with that of Ayo et al. (1998b) that road transportation in pigs induces an alarm response in the animals during the journey, which is later replaced by a stage of resistance. The stage of resistance observed in the present study was characterized by strong adaptation of the pigs, not only to the transportation stress, but also the heat stress characteristic of the hot-dry season in the Northern Guinea Savannah zone of Nigeria.

Conclusion

In conclusion, transportation of pigs by road for eight hours in the zone induces hyperthermia and administration of ascorbic acid at 100 mg/kg in the experimental pigs did not exert any significant ameliorative effect. Journey time and meteorological factors (AT and RH) play significant role in rectal temperature responses of pigs transported by road. Optimum duration of road transportation of pigs is six hours. This duration should be considered in the development of guidelines and welfare for pigs, transported by road during the hot-dry season.

REFERENCES

Adenkola AY, Ayo JO, Sackey AKB (2009). Ascorbic acid-induced modulation of rectal temperature fluctuations in pigs during the harmattan season. J. Therm. Biol. 32: 152-154.

Altan O, Altan A, Cabuk M Bayraktar H (2000). Effects of heat stress on some blood parameters in broilers. Turk. J. Vet. Anim. Sci. 24: 145-148.

Altan O, Pabuccuoglu A, Konyaliogu S, Bayraktar H (2003). Effects of heat stress on oxidative stress, lipid peroxidation and some stress parameters in broilers. Br. Poult. Sci. 44: 545-550.

Agricultural Research Council (2006). Ventilation control in intensive pig production units. http://www.arc.agric.za/home.asp?PID=1&ToolID=2&ItemID=1916 06/10/2008.

Ayo JO, Minka NS, Fayomi A (2005). Effects of ascorbic acid on rectal temperature of pullets transported by road during the hot-dry season in Northern Nigeria. Trop. J. Anim. Sci. 8: 43-48.

Ayo JO, Minka NS, Mamman M (2006). Excitability scores of goats administered ascorbic acid and transported during the hot-dry conditions. J. Vet. Sci. 7: 127-131.

Ayo JO, Oladele SB, Fayomi A (1996). Effects of heat stress on livestock production. A review: Nig. Vet. J. 1(Spec. Ed): 49-57.

Ayo JO, Oladele SB, Ngam S, Afolayan SB, Fayomi A (1998a). Diurnal variation of rectal temperature of Red Sokoto goats during the harmatttam season. Res. Vet. Sci. 66: 7-9.

Ayo JO, Oladele SB, Fayomi A (1998b). Stress and its adverse effects on modern swine production. Pig News Inf. 19: 51N-56N.

Bazhov GM, Komlatsky VI (1989). Biotechnology of Intensive Swine Production. Rossagropromizdat, Moscow p. 269 (in Russian).

Bianca WK (1976). The significance of meteorology in animal production. Intern. J. Biometeorol. 20: 139 -156.

Chervyakov DK, Yevdokimov PD, Vishker AS (1977). Drugs in Veterinary Medicine. Kolos Publishing House, Moscow pp. 496 (in Russian).

Igono MO, Molokwu ECI, Aliu, YO (1982). Body temperature responses of Savannah Brown goat to harmattan and hot-dry season. Int. J. Biometeorol. 26: 225-230.

Knowles TG, Brown SN, Edward JE, Warris PD (1998). Ambient temperature below which pigs should not be continuously showered in the lairage. Vet. Rec. 143: 575-578.

Minka NS, Ayo JO (2007a). Physiological responses of transported goats treated with ascorbic acid during the hot-dry season. Anim. Sci. J. 78: 164-172.

Minka NS, Ayo JO (2007b). Effects of six-hour road transportation on rectal temperature, respiration and heart rate of ostriches (*Struthio camelius*) chicks. Vet. Arhiv. 77: 39-46.

Minka NS, Ayo JO (2008). Haematology and behaviour of pullets transported by road and administered with ascorbic acid during the hot-dry season. Res. Vet. Sci. 85: 389-393.

Nyberg L, Lundstrom K, Edfors-Lilja I, Rundgren M (1998). Effects of transport stress on concentrations of cortisol, corticosteroid-binding globulin and glucocorticoid receptors in pigs with different halothane genotypes. J. Anim. Sci. 66: 1201-1211.

Lopez-Olvera JR, Marco I, Montane J, Lavin S (2006). Transport stress in southern chamois (*Rupicapra pyrenaica*) and its modulation by acepromazine. Vet. J. 172: 347-355.

Padayatty SJ, Katz A, Wang Y, Eck P, Kwon O, Lee J, Chen S, Dutta A, Dutta SK, Levine M (2003). Vitamin C as antioxidant: Evaluation of its role in disease prevention: A review. J. Am. Coll. Nut. 22: 18-35.

Peeters E, Driessen B, Geers R (2006). Influence of supplemental

magnesium, tryptophan, vitamin C, vitamin E and herbs on stress response and pork quality. J. Anim. Sci. 84: 1827-1838.
Piccione G, Caola C (2002). Biological rhythm in livestock. J. Vet. Sci. 3: 145-157.
Renaudeau D, Huc E, Noblet J (2007). Acclimation to high ambient temperature in large white Caribbean Creole growing pigs. J. Anim. Sci. 85: 779-790.
Sinkalu VO, Ayo JO, Adelaiye AB, Hambolu JO (2008). Effects of vitamin E on diurnal variation in rectal temperature of Black Harco pullets during the hot-dry season, J. Therm. Biol. 33: 32-36.
Sahota AW, Gillani AH (1995). Effect of ascorbic acid supplementation on performance and cost of production in layers maintained under high ambient temperature. Pak. Vet. J. 15: 155-158.
Sahin N, Onderci M, Sahin K, Gursu MF, Smith MO (2004). Ascorbic acid and melatonin reduced heat-induced performance inhibition and oxidative stress in Japanese quails. Bri. Poul. Sci. 45: 116-122.
Tauler P, Aguilo A, Gimeno I, Fuentespina E, Tur JA, Pons A (2003). Influences of vitamin C diet supplementation on endogenous antioxidant defences during exhaustive exercise. Eur. J. Phys. 446: 658-664.
Vecerek V, Malena M, Malena Jr, M, Voslarova E, Chloupek P (2006). The impact of transport distance and season on losses of fattened pigs during transport to the slaughter house in Czech Republic in the period from 1997 to 2004. Vet. Med. 51: 21-28.
Williams CA, Gordon ME, Betros CL, Mc Keever KH (2008). Apoptosis and antioxidant status are influenced by age and exercise training in horses. J. Anim. Sci. 86: 576-583.
Zaytsev VI, Sinev AV, Ionov PS, Vasilyev AV, Sharabrin IG (1971). Clinical Diagnosis of Internal Diseases of Farm Animals. Kolos Publishing House, Moscow p. 336 (in Russian).