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Khartoum. Values of some hematological parameters of 14 Black Neck Ostrich 7 male and 7 female age from 3-4 year, and 70–75 kg in weight were examined to determine the mean values obtained for White Blood cells Count (WBC), Erythrocytes Count (RBC), Hemoglobin Concentration Rates (Hb), Packed Cell Volume (PCV), Mean Corpuscular Volume (MCV/cl) and Erythrocytes Sedimentation Rate (ESR). The result of this study show that there are no significant different in all blood values between samples collected from male and female at p (P<0.05), expect in Red Blood Cells (RBC) there is significant different at (P<0.05). The main target of this study is to comparison between hematological values of Black Neck Ostrich in both male and female.

Key words: *Hematological, Ostrich, Parameters, Captivity, Birds*

Feedlot performance and carcass characteristics of Sudan Baggara bulls fed varying levels of pelleted sorghum straw

Original Research, B78

Babiker AA, Babiker IA, Abdelhadi OMA, Elemam MB and Salih AM.

***Online J. Anim. Feed Res.*, 2(5): 422-426, 2012.**

ABSTRACT: *Thirty six entire Sudan Baggara bulls of an average weight 201.53±6.85 kg and 2.5 year age were divided into four groups of nine animals each. These bulls were fed varying levels of pelleted sorghum straw (roughage portion) with a concentrate molasses based mash diet to examine the effect of nutrition on their feedlot performance and carcass characteristics. Results showed that, feeding of varying levels sorghum straw did not affect dry matter intake (DMI), average daily gain (ADG) and feed conversion ratio (FCR). Carcass characteristics and meat quality attributes were not affected by the treatments, but showed variable results.*

Key words: *Bulls, Pelleting, Molasses, Feedlot, Carcass Characteristics*

Prediction of live body weight from linear body measurements of west African long-legged and west African dwarf sheep in northern Ghana

Original Research, B79

Birteeb P.T. and Ozoje M.O.

***Online J. Anim. Feed Res.*, 2(5): 427*434, 2012.**

ABSTRACT: *The knowledge of live weight of animals is so important in the livestock production and marketing practices that this study was undertaken to develop models for predicting the weight of sheep at market ages. Data comprising of the weight and linear body measurements were collected on the West African Long-Legged (WALL) and the West African Dwarf (WAD) sheep from Pong-Tamale and subjected to regression analyses. The results revealed that heart girth was the best predictor of liveweight, with prediction accuracies of 92.36% for two years old WALL sheep and 81.20% for one year old WAD sheep, while wither height was the second most important trait in liveweight prediction, in simple linear models. The quadratic models of the single-trait models also had heart girth as the best predictor of liveweight, recording 92.92% accuracy for one year old WALL sheep. Only two traits were mostly required for weight estimation in the multiple-trait models, and the best model was obtained from two years old WALL where heart girth and body length accounted for about 95.53% in prediction accuracy. The multiple-trait quadratic models were generally better in liveweight prediction compared to the respective linear models. Clearly, weight estimation was more accurate among the WALL than the WAD sheep, and also among the younger sheep regardless of the breed. The variations in the models suggest that breed and age of sheep had influence on the type of models required to predict their live body weight.*

Key words: *Estimation, Linear models, Livestock, Live weight, Multiple regression, Quadratic model*

Factors affecting milk production traits of Saanen goat raised under Sudan - Semi Arid conditions

Original Research, B80

Ishag IA., Abdalla SA. and Ahmed M-K.A.

***Online J. Anim. Feed Res.*, 2(5): 435-438, 2012.**

ABSTRACT: *The aim of this study is to investigate the genetic and environmental factors affecting milk production characteristics of Saanen goats raised under Sudan conditions. It also aims at estimating heritabilities, phenotypic, genetic and environmental correlations among milk production traits. Means for total milk yield, lactation length and daily milk were 340.78±11.35 kg, 203.99±7.66 days and 1.50±0.05 kg, respectively. The season, year of calving and parity number had significant influence on total milk yield and daily milk yield. The lactation length was significantly (P<0.05) affected by season, year of kidding and origin of birth, and was insignificantly (P>0.05) influenced by parity number. The origin of birth insignificantly affected total milk yield and daily milk yield. The study concludes that the Saanen breed can effectively raise milk production in the state.*

Key words: *Milk yield, Lactation length, Heritability, Daily milk yield, Goats.*

Carcass characteristics of desert sheep under range conditions in north Kordofan state, Sudan

Original Research, B81

Tibin MAM, Bushara I, Eemam MB, Tibin IM and Jadalla JB.

***Online J. Anim. Feed Res.*, 2(5): 439-444, 2012.**

ABSTRACT: *This experiment was conducted to study the performance, carcass characteristics and meat quality attributes of desert sheep raised under range conditions around El Nuhood. Thirty desert sheep (15 males and 15 females) of almost the same age (about 8 months) were used in a 16 weeks study period. The sheep were randomly allocated to three groups (treatments) of ten animals (5 males and 5 females). The three groups were allowed to graze on natural range grasses at night only and were kept under shade during the day from 7:00 am to 6:00 pm. The first group was allowed water every 2-3 days and was considered as control. The second group was allowed access to water daily. The third group was allowed daily access to water and received concentrates supplement. At the end of the experimental period, eighteen animals (nine males and nine females) were randomly taken, weighed and slaughtered to study the carcass characteristics. The results included that were significant (P<0.05) differences among the treatment groups with regard to the warm carcass, cold carcass and empty body weight. There were significant (P<0.05) differences between females and males of the three treatments in slaughter weight, warm carcass weight and cold carcass weight. Males obtained higher weights than females. The dressing percentage on the basis of warm carcass and cold*

carcass was significantly (P<0.05) different in the three treatments. The gut fill expressed as a percentage of empty body weight was significantly (P<0.05) different among the three treatments. These results concluded that management strategy which involves shorter watering intervals and feed supplementation will probably reflect positively on the performance, carcass characteristic of Hamari sheep under range conditions.

Key words: *Dessert sheep, Performance, Carcass characteristic, Concentrate ration, Sudan*

Effect of feeding duration on performance and carcass characteristics of growing pigs

Original Research, B82

Njoku CP, Aina ABJ, Sogunle OM, Idowu OMO and Osofowora A

***Online J. Anim. Feed Res.*, 2(5): 445-449, 2012.**

ABSTRACT: *A total of 36 Large White weaner male pigs of 8 weeks old were allotted to two groups (ad libitum feeding for 3 months and 80% ad libitum feeding for 5 months) in a Randomized Completely Design, to evaluate the effect of feeding duration on performance and carcass characteristics of growing pigs Each group consists of 18 pigs with initial average weight of 9.67±0.26 and was further replicated into 3 with 6 pigs per replicate. Data were collected on weekly basis and carcass characteristics were done at the end of 3rd and 5th months of feeding. Feed duration had significant (P<0.05) influence on final body weight, daily weight gain, Daily feed intake, water consumption and daily cost of feeding with higher values (54.17 kg, 349.42 g, 1.63 kg, 5.05 litres and ₦74.72), respectively recorded for pigs fed 80% ad libitum for 5 months. Higher values of bled weight (46. 78 kg) and carcass weight (35.44 kg) were noted for pigs fed 80% ad libitum for 5 months. Pigs fed 80% ad libitum for 5 months had higher value in head (12.42%), ham (14.40%), shoulder (13.92%) and feet (2.73%) weights compared to values documented for pigs fed ad libitum for 3 months. Better values for back fat thickness (0.43 cm) and fat-free index (49.69) were obtained among the pigs fed ad libitum for 3 months. Feeding duration greatly influenced performance and carcass parameters and should be used in improving the quality of carcass.*

Key words: *Feeding Duration, Ad Libitum, Pig, Performance, Carcass Characteristics*

Influence of the probiotic, RE 3 on nutritional performance, hematological, immune status and carcass characteristics of rabbit reared under tropical conditions

Original Research, B83

Wallace P.A., Osei D.Y., Aseidu P., Amoah, K.O. Asafu-Adjaye A.

***Online J. Anim. Feed Res.*, 2(5): 450-456, 2012.**

ABSTRACT: *Thirty-six heterogenous population of California White, New Zealand White and Chinchilla weaner cross-bred rabbits of mean weight of 550 g were randomly assigned to four treatments of nine animals per treatment. The study was structured in such a way that there were two controls i. e. To- (treatment group without any additive in the basal diet) and To+ (treatment group treated with coccidiostat prior to commencement of feeding trial and fed the basal diet). The test treatment groups consisted of T_1 (supplemented with 1.0 ml RE 3 per kg feed) and T_2 (supplemented with 1.5 ml RE 3 per kg feed). The feeding trial lasted for a period of four months after which nutritional indices, hematological, immune function as well as carcass characteristics of the rabbits were assessed. The results of the lymphoid organ and indices showed that all the rabbits had similar immune response regardless of treatment. That was to imply that the immune function and status of all the rabbits seemed to be at the same level regardless of the presence or absence of RE 3. Furthermore, RE 3 neither influenced the growth nor the feed intake while feed conversion efficiency of rabbits fed 1.0 ml RE 3 per kg feed (T_1) demonstrated significant (P<0.05) improvement. Rabbits fed treatment T_1 also showed higher significant (P<0.05) serum levels of white blood cells and lymphocytes compared to those fed the other treatments. Also, RE 3 as a probiotic did not influence live weight, full stomach, full gastrointestinal and carcass length. It, however, caused significant (P<0.05) changes in the warm and chilled dress weights relative to all the others fed the other treatments.*

Key words: *Rabbit, Probiotic, Immune status, Hematology, Carcass, Nutritional profile, Tropical conditions*

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NUTRITIVE VALUE FOR SOME IMPORTANT RANGE SPECIES NORTHERN KORDOFAN, SUDAN

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ORIGINAL ARTICLE

ABSTRACT: *This study was conducted in North Kordofan State in the year 2009. The objectives were to identify the nutritive value, for the rangelands prevailing in the region .To achieve the objectives field and laboratory works were done. The field work was for sample collection while the lab work include proximate chemical analysis according to (A.O.A.C, 1990), was done for some range plants and trees to identify the nutritional and mineral content. Data were analyzed using SPSS software. The results showed that CP (crude protein), CF (crude fiber), ash, E.E (Ether Extract) and NFS (Nitrogen Free Extract) were in the range from 6-10, 35-45, 7-10, 1.1-2.1 and 36.7-46.7% respectively. The chemical analysis for selected browse trees were CP5.1%, CF 31-33%, EE 0.4-0.9%, ash 7-8.1% and NFE 53-56.9%. Mineral contents ranged from 0.0144-0.075 ppm for P, 0.002-0.063 ppm for K and 1-2.9 ppm for Iodine. Based on the findings it can be concluded that rangelands of North Kordofan is not poor in the term of nutritive value but it suffers of mineral deficiency. The study recommends that water and dams should be made with optimum distribution to access the non-reachable rangeland because of water deficiency, also supplementary feeding is needed in the term of concentrates and minerals.*

Key words: *Rangelands, Crude Protein, Crude Fiber, Ash, Ether Extract and Nitrogen Free Extract*

INTRODUCTION

Pastoral and agro-pastoral systems are the mainstay of the economy of North Kordofan State. Livestock and its products are the primary source of income for over 60% of the population. Animal raised are mainly sheep, goats and camels in the northern part of the state. Sheep, goats and some cattle in the southern parts. The major food grown are millet and sorghum, major cash crop include sesame, roselle and ground nut (RPA, 2005). The quality of forage depends largely upon its protein content and total digestible nutrients because it affects the digestibility of feed. Elnazeir (2008), stated that the important range species include plants, such as *Aristida mutablis, Cenchrus biflorus, Fimbristylis dicotomo, Zalea pentandra, Zornia glochidiata* and *Eragrostis tremula. and tress such as Acacia senegal(Hashab) Acacia tortilis(seyal) Balanites aegyptiaca and Maerua crassifolia (Sarah).* This work is undertaken as a result of previous study that recommends going forewords in term identifying nutritive value for rangelands of north Kordofan. There for understanding the nutritive value for some selected rangelands of north Kordofan is very important when planning for supplementary additives such as concentrates and minerals.

MATERIALS AND METHODS

Study Area

This study was conducted in North Kordofan State, which lies between latitudes 11°20' to 16°36' N, and longitudes 27° 13' to 32° 24'E. The State area amount to almost 25 million hectares, out of this area 14.5 million hectares are rangeland (Ministry of Agriculture, 2005). The State had a total population of 2.9 million, (5th population and houses census, 2009).

Field Work

The field work was carried out during the rainy season 2009. The samples were taken from two sites. The first site was south of Errahad town and the second site was north-east of Damukia about 60 km North West of Elobeid town. The proximate chemical analysis and mineral content was undertaken at range-livestock research laboratory, El-Obeid Agricultural Research Station. Selected samples were analyzed for CF, CP and minerals (P, K, I, Na, Mn) according to (AOAC, 1990).

Data Collection

Tools used for obtaining samples for proximate analysis are: Pair of scissors; Paper bags; Digital electric balance; Oven; Recording sheet.

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The selected grasses (Palatable and dominant species) species were clipped at 2.5 cm above ground level, using a pair of scissors. The harvested plants species were placed in paper bags and then oven dried at 70º C for 48 hours. Samples were then analyzed for Crud Fiber, Crude Protein, Ether Extract, Dry matter, Nitrogen Free Extract , and minerals (P, K, I, Na, Mn) according to (AOAC, 1990).

Statistical Analysis

SPSS software was used for statistical analysis.

RESULTS

Chemical analysis of selected range vegetation

The nutritive value for grasses species is illustrated in Table 1. The grasses include *Cenchrus biflorus* (Huskneet), *Fimbristylis dichtomo* (Um fissiat), *Eragrostis tremula* (Banu) and *Aristida sp* (Gaw), and the legumes *Zornia glochidiata* (lisseg), *Zalea pentandra* (Rab'a), *Crotalaria pycnosthya* (tagtag),. *Zornia glochidiata* (lisseg), *Cenchrus biflorus* (Huskneet) and *Fimbristylis dichtomo* (fissiat) had the highest crude fiber content (41%, 40%and 38%, respectively) while *Eragorstis tremula* (Banu) and *Zalea pentandra* (Rab'a) *Crotalaria pycnosthya* (tagtaga) recorded the highest crude protein content (11%). *Fimbristylis dichtomo* (fissiat), *Cenchrus biflorus* (Huskneet), *Eragrostis tremula* (Banu) and *Aristida sp* (Gaw) had the lowest crude protein content (6.2, 6.7, 6.8 and 6.6%, respectively).

The nutritive value for dominant trees is illustrated in Table 2. *Acacia senegal* (Hashab) had the highest crude protein (7%) and CF (31%) while *Ziziphus spina-christi* (sidir) contained the lowest CP and CF content with the other two trees recording intermediate contents.

Phosphorus content is shown in Table 3. *Fimbristylis dichtomo* (fissiat) was 0.0149 ppm while *Zalea pentandra* (Rab'a), *Aristida* sp (Gaw) and *Eragorstis tremula* (Banu) were 0.097ppm, 0.08ppm and 0.075ppm, respectively. Table 3 also showed that the potassium content was 0.063 ppm for *Eragorstis tremula (Banu)* while *Fimbristylis dichtomo* (fissiat), Aristida sp. (Gaw) and *Zalea pentandra* (Rab'a) were 0.055, 0.045 and 0.020 ppm, respectively. For Iodine content *Zalea pentandra* (Rab'a) and Aristida sp (Gaw), showed high content of 2.9 and 2.8 ppm, respectively, while *Fimbristylis dichtomo* (fissiat) and *Eragorstis tremula (Banu)* were 1.95 and 1.88 ppm, respectively.

Table 1 - The nutritive value for some important dominant grasses species

Dominant plant Species	CP%	CF%	DM%	ASH%	E.E%	NFE%
Aristida sp(Gaw)	6.2	38.8	93	7	1.2	46.7
Eragrositis tremula (Banu)	6.8	37	94.2	7.8	2.2	46.2
Cenchrus biflorus (Huskneet)	6	40	93.7	13	1.5	38.8
Zalea pentandra (Rab'a)	11	37	84	13	2.3	36.7
Zornia glochidiata (lisseg)	9	41	81	11	1.2	37.7
Crotalariat pycnosthya (gtaga)	10	35	80	11	2.2	37.8
Fimbristylis dichtomo (fisyat)	6.2	39	94	10	1.1	43.7
S.E	1.0	1.2	1.0	2	0.5	0.5

CP=Crude Protein, CF= Crude Fiber, DM=Dry Matter, E.E=Ether Extract, NFE=Nitrogen Free Extract

Table 2 - Nutritive value for some important dominant trees

	Dominant plant Species					
Dominant plant Species	**CP%**	**CF%**	**DM%**	**ASH%**	**E.E%**	**NFE%**
Acacia tortillas (Seyal)	5.7	30.5	94.5	7	0.4	56.9
Leptadenya pyrotechnica	5.1	33	94	8.1	0.54	53.3
Balanites aegyptiaca (higleeg)	5.2	31	93.5	7.6	0.8	55.4
Acacia Senegal (Hashab)	7	31	93.7	8	0.7	53.3
Ziziphus-spainna-christi (sidir)	5	31	93.4	7.5	0.9	55.6
SE	1	1.4	1.1	2.5	0.5	0.3

CP=Crude Protein, CF= Crude Fiber, DM=Dry Matter, E.E=Ether Extract, NFE=Nitrogen Free Extract

Table 3 - Chemical Analysis for mineral Content

	Mineral Content		
Species	**P (ppm)**	**K (ppm)**	**I (ppm)**
Zalea pentandra (Rab'a)	0.097	0.02	2.9
Aristida sp (Gaw)	0.08	0.05	2.8
Eragrositis tremula (Banu)	0.075	0.06	1.88
Cenchrus biflorus (Huskneet)	0.066	-	-
Zornia glochidiata (lisseg)	0.03	-	-
Fimbristylis dichtomo (fisyat)	0.15	0.06	1.95
SE	1	0.9	1.3

P=Phosphorus, K= Potassium, I = Iodine, ppm= part per million

DISCUSSIONS

The nutritive Value for some selected plants.

The study found that *Cenchrus biflorus*, Zornia *glochidiata* (lisseg), and *Fimbristylis dichtomo* (fissiat) had high crude fiber content while *Eragrostis termula, Zalea pentandra* (Rab'a) and *Crotalariat pycnosthya* (tagtag) had crude fiber content of 37, 37 and 35%, respectively. *Zalea pentandra* (Rab'a) had high crude protein content of 11% while *Fimbristylis dichtomo* (fisyat), *Cenchrus biflorus* (Huskneet), *Eragoristis tremula* (Banu) and *Aristida* sp. (Gaw) had crude protein content of 6.2, 6.7, 6.8 and 6.6%, respectively. This means that the Crude Protein of these grasses is sufficient for maintenance (Buter and Baily, 1973). A critical value of about 3.6% crude protein in feed is required (NRC, 1981), below which the apparent crude protein digestibility declines. It was obvious from the analysis that these species were not poor in nutritive value although they grow in the semiarid areas. However, the most critical time for livestock in the area is the dry season (Feb-June) when the nutritive value of range grasses decline sharply and reach CP levels of below 2% (El-Hag and El Wakeel, 1998).

For trees Acacia senegal (Hashab) had crude protein and crude fiber contents of 7% and 31%, respectively, while *Ziziphus spina-christi* (sidir) had respective values of 5 and 31%. Other trees in the two studied zones had values lying between these means. Trees and shrubs are estimated to contribute 20-30% of livestock feed sources in greater Kordofan (Darag and Suliman, 1988).

Mineral content for the dominant plants

Range plants in the area had lower mineral contents. This necessitates provision of supplementary mineral sources for livestock grazing these rangelands. K deficiency affecting the normal growth, also Tetanus symptoms will be observed. These deficiencies might be one of the major causes of the lower animal productivity in these areas. Iodine deficiency would lead to Endemic-goiter, reproductive failure, death and hairless of embryos. Also, toxic symptoms can be observed for calves of 100 kg wt when an iodine concentration of 500 mg/kg was offered Wilson (1980).

CONCLUSION AND RECOMMENDATION

Based on the findings it can be concluded that rangelands of North Kordofan is not poor in the term of nutritive value such as protein and fibre but it suffer of mineral deficiency.

Water and dams should be made with optimum distribution to access the non-reachable rangeland because of water deficiency. Supplementary feeding is needed in the term of concentrates and minerals.

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THE EFFECT OF DIETARY BENZOIC ACID SUPPLEMENTATION ON GROWTH PERFORMANCE AND INTESTINAL WALL MORPHOLOGY OF BROILERS

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ORIGINAL ARTICLE

ABSTRACT: *The research was conducted to determine the influence of benzoic acid on growth performance and intestinal wall morphology of broiler birds. The research was carried out using 120 day-old broilers divided into five (5) groups, each having 24 broiler birds, and eight (8) birds per replicate. The levels of inclusion of the benzoic acid was based on control 0%, Treatment 1 = 0.6%, Treatment 2 = 1.2%, Treatment 3 = 1.8% and Treatment 4 = 2.4%. After six weeks, 2 animals from each replicate were killed. The carcasses weights, the pH of the digester and organ proportions were determined. Result showed that the body weight gain of birds in Treatment 1 and Treatment 2 were the highest (T_1=1.44kg, T_2=1.76kg), but T_2 had the best growth performance which was significantly different (P<0.05) in the final body weight of other birds in other treatments. The different segment of the gastro-intestinal tract had different pH concentration which differed significantly (P<0.05) between the control and the treatments. Benzoic acid supplementation improved (P< 0.05) duodenal and jejuna villous height. This study showed that feeding benzoic acid at 1.2% inclusion level in broiler feed improved weight gain and also suppressed some microbes, which compete with the host animal for nutrient, thereby improving the growth performance and gut health of broiler birds.*

Key words: *Organic Acid Supplementation, Performance, Intestinal Wall Morphology And Broiler Chickens.*

INTRODUCTION

During the last 50 years, the uses of antibiotics as growth promoters in farm animals have been questioned. Although it is clear that antibiotics merit for growth performance and health in poultry. But antibiotics have been prohibited due to the development of resistant strains of pathogenic microorganisms and possible transmission of these resistant strains from the poultry birds to human consumers (Neu, 1992). The adjustment following the withdrawal of the use of sub-therapeutic antibiotics in poultry production has been difficult and many replacement solutions have been proposed by the feed additive industry. This led to the discovery of organic acid as an important approach, that have the potential to improve performance in poultry production (Patterson and Burkhold, 2003; Ricke, 2003). Organic acids and their salts have been widely used as feed components for poultry and many animal species to inhibit some pathogenic bacteria in their gastro-intestinal tract (Charveorach et al., 2004).

Benzoic acid plays an important role in lowering numbers of pathogenic bacteria like *Campylobecter jujuni,* which competes with the host animal for nutrient (Friedman et al., 2003). It contributes to some certain amount of energy to the host bird (Jamroz et al., 2003). Besides bacteriostatic feature, benzoic acid helps in reducing ammonia, thereby stimulates growth in pigs and broiler birds (Mroz et al., 2000; Buhler et al., 2006). It also helps to increase gastric proteolysis and improve digestibility of protein and amino acid in young broiler birds, thereby improving the feed efficiency and growth performance of broiler birds (Kirchgessner and Roth, 1988). Benzoic acid is an energy source of the epithelia cells of the large intestine (Roedigor, 1980) and terminal ileum (Chapman et al., 1995). It thereby improves the length of the ileal microvillus and depth of the caecal crypts on intestinal mucosal (Gaifa and Bokeri, 1990) which help in efficient feed absorption and assimilation in the broiler birds.

The effect of dietary benzoic acid supplementation as a good substitute of antibiotics growth promoters on growth performance and intestinal wall morphology was investigated.

MATERIALS AND METHODS

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A total of 120 day-old “Anak 2000” broiler chicks were used in the experiment. Chicks were housed in a warmed fumigated brooder house and fed on a starter diet for 4 weeks and finisher diet from 4 to 9 weeks. The chicks were individually weighed and allocated to 15 cages of 8 chicks, each, so that average initial body weight of birds of each cage did not vary significantly (P>0.05).

Birds were randomly allotted to five treatment groups, each with three replicates of eight birds. Control (c) birds were given a standard basal diet; Treatment 1 (T_1) was a diet with 0.6% of benzoic acid; Treatment 2 (T_2) a diet with 1.2% of benzoic acid; Treatment 3 (T_3) was a diet with 1.8% of benzoic acid and Treatment 4 (T_4) a diet with 2.4% of benzoic acid.

After thorough mixing of ingredients, the organic acid, which were in powder form were mixed at the stated concentrations. The starter and finisher diets were formulated to meet the nutrient requirements of the birds. Ingredient and chemical composition of the basal diets are presented in Table 1.

Table 1 - Ingredients and chemical composition of broiler starter and finisher diets

Ingredients	Starter phase (%)	Finisher phase (%)
Crude protein	21.00	18.00
Fats/oil	6.00	6.00
Crude fibre	5.00	5.00
Calcium	1.00	1.00
Phosphorus	0.45	0.40
Methionine	1.00	0.35
Salt	0.30	0.35
Metabolic energy	2800kcal/kg	2900kcal/kg

The experiment was designed using complete randomized design (CRD) and analyzed using analysis of variance (ANOVA) as described by Steel and Torrie (1980). The replicates were use as experimental units for studying the effect of benzoic acid on broiler growth performance and gut health. Levels of significance were calculated as per the standard method described by Duncan (1995) wherever any effect was found significant.

Housing and Management

Broiler chicks were housed in pens which were cleaned properly; the floor was covered with fresh saw dust. The day old chicks were weighed to determine their day old weight. The brooding temperature was maintained close to their requirement by heating device. The birds were vaccinated against new castle diseases and infections bursal disease on day 1, 14 and 21. The experiment lasted for 6 weeks. Mortality was recorded as it occurred. Body weight gain, feed conservation ratios and feed intake were obtained by calculation.

Measurement of pH in Different Parts of the Gut

To determine the pH, 10g of gut content from crop, proventriculus gizzard, duodenum, jejunum and ileum were collected aseptically in 90ml sterilized physiological saline (1:dilution) Al-Natour and Alshawabkeh, 2005) and pH was determined.

Morphological Evaluations

Intestinal samples from duodenum, jejunum and ileum were used to measure villus height and the depth of the crypts. Paraffin sections were made from formalin-fixed tissues samples and then were stained with loefflers’ haematoxyline and eosin and mounted on Distrene plasticizer xylene. Heights of intestinal villous were measured by ocular micrometer under 10 objective of microscope. The reading was taken from ocular micrometer and the actual villous height and depth of the crypt were obtained by conversion factor derived from stage micrometer (Lillie, 1965). The measurements were expressed as micrometers (μm).

Bacterial Count in Intestinal Contents

Two birds from each replicate were sacrifice at 9 weeks of age. Intestines, including duodenum, jejunum and ileum were removed and legated at both sides. Then tissues chymes were placed in 50ml tubes sterile saline (0.9g sodium chloride in 100ml distilled water) and then kept at 4^0C until used for intestinal sampling. Serial dilutions of collected samples from different parts of intestinal contents were made up to the fifth dilution with sterile saline (0.9g sodium chloride in 100ml distilled water) and different bacterial loads of the gut contents were enumerated by the pour method (Quinn et al., 1992).

Table 2 showed that no mortality was observed in T_2 during the course of the experiment, but T_3 and T_4 had mortality rate of 5.00% and 10.53% respectively. This result is in agreement with Polonen et al, (2000) who reported that overload of benzoic acid in animal diet might be toxic to animals. The initial and final body weight followed the same pattern in Table 2 as well as average body weight gain of broiler. There was an increased body weight gain in T_1 and T_2 which is in agreement with Patterson and Bunkhold, (2003) which reported that inclusion of organic acid helps improve growth in broilers. The ability of benzoic acid to improve growth in broiler birds might be because of its role in lowering the number of pathogenic bacteria like *Campylobacter Jejuni* and *Eschericha coli* that compete with the host animal for nutrients (Friedman et al., 2003). There was no significant difference in the weight gain; with T_3 and T_4 having the lowest weight gain of 1.41kg and 1.30kg respectively, which was probably

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due to the toxicity of the level of benzoic acid in their feed. Treatment 2 had 1.76kg weight gain which was probably the highest weight gain when compared with T_1 and the control group. Although T_4 had the lowest feed conversion ratio of 1.45, this does not justify it to be the best result because T_4 had poor feed intake (2.56g). This is in contrast to Akinmutimi (2004), who stated that the lower, the feed conversion ratio the better the result.

Table 3 showed the pH concentration of digesta collected from different segment of the gastro intestinal tract of broiler birds. It was observed that the caecum had the highest pH across the treatments. This is in agreement with Thompson and Hinton (1997) who observed that most organic acid used in feed and drinking water are absorbed at the upper gastro intestinal segment of poultry birds i.e. crop, proventriculus and gizzard; and only little portion of the organic acids get to the lower digestive tract i.e. caeca (Hummel et al., 1993). The crop of the broiler birds contains microbes that ferment food materials ingested by the animal, thereby causing an increase in the pH of the crop. This was observed with the control group having the highest pH of 7.13, but the actions of benzoic acid on microbes in the crop resulted to lower pH in all the treatment groups (T_1-T_4). The gizzard and ileum recorded the lowest pH level among the segments of gastro-intestinal tract, which was statistically significant ($P < 0.05$) in the GIT of the birds.

The supplementation of feed with benzoic acid resulted in significant lower count of microbes throughout the gastro-intestinal tract. There was a significant difference ($P<0.05$) in the microbial load counts among the various levels of treatments. It was observed that the lowest microbial load was recoded in T_4 (12.01×10^6), while the control group had the highest population of microbes (41.01×10^7). The lowest bacterial load in T_4 was due to the level of inclusion of benzoic acid, but this did not reflect well in the performance of the broiler birds.

Table 2 - Effects of Benzoic acid on growth performance in broilers

Treatment group	Mortality rate	Initial body wt(kg)	Final body wt(kg)	Total wt gain (kg)	Average wt gain (kg)	Total feed intake (kg)	Feed conversion ratio
Control	$0.83 \pm .00^b$	$0.40 \pm .00^a$	$2.05 \pm .00^{bc}$	$1.63 \pm .02^a$	$1.22 \pm .00$	$4.89 \pm .00^C$	$2.38 \pm .00^b$
T_1	$1.67 \pm .00^C$	$0.47 \pm .03^{ab}$	$2.12 \pm .05^c$	$1.66 \pm .07^a$	$1.31 \pm .02$	$4.77 \pm .03^c$	$2.24 \pm .06^c$
T_2	$0.00 \pm .00^a$	$0.55 \pm .04^c$	$2.31 \pm .05^d$	$1.76 \pm .07^a$	$1.43 \pm .03$	$4.76 \pm .07$	$2.06 \pm .06^d$
T_3	$5.00 \pm .00^d$	$0.50 \pm .01^{bc}$	$1.91 \pm .05^{ab}$	$1.41 \pm .05^b$	$1.59 \pm .36$	$2.97 \pm .08^a$	$1.55 \pm .01^a$
T_4	$10.53 \pm .00^e$	$0.44 \pm .03^{ab}$	$1.76 \pm .06^b$	$1.30 \pm .05^b$	$1.11 \pm .04$	$2.56 \pm .05^b$	$1.45 \pm .04^a$

a b, c, d, e. means with different superscript and within the same column are significantly different ($P<0.05$).

Table 3 - pH and Microbial Loads of Digester of Gastro-Intestinal Tract of Broilers

Treatment group	Crop	Gizzard	Duodenum	Ileum	Caecum	Microbial
Control	$7.13 \pm .00^c$	$4.57 \pm .00^d$	$5.37 \pm .01^a$	$5.57 \pm .01^e$	$7.16 \pm .001^e$	$41.01 \times 10^7 \pm .01^e$
T_1	$5.21 \pm .01^b$	$4.28 \pm .01^a$	$5.87 \pm .01^d$	$4.93 \pm .01^b$	$6.57 \pm .001^b$	$36.01 \times 10^7 \pm .01^d$
T_2	$5.11 \pm .01^a$	$4.43 \pm .01^c$	$5.76 \pm .01^c$	$5.01 \pm .01^c$	$6.72 \pm .01^c$	$31.01 \times 10^7 \pm .01^c$
T_3	$5.11 \pm .01^a$	$4.56 \pm .01^d$	$5.54 \pm .01^b$	$5.45 \pm .01^d$	$7.07 \pm .01^d$	$28.01 \times 10^7 \pm .01^b$
T_4	$5.21 \pm .01^b$	$4.57 \pm .00^d$	$5.16 \pm .01^e$	$4.70 \pm .00^a$	$6.11 \pm .01^a$	$12.01 \times 10^6 \pm .01^a$

a,b,c,d,e means with different superscript and within the same column are significantly different

Table 4 showed the effect of benzoic acid on the weight of various organs of broiler birds. The organs measured were crop, gizzard, heart, spleen and kidney. There was no significant difference ($P>0.05$) in the weight of spleen across the treatments. Treatment 4 had a decrease in the weight of organs, while Treatment 2 had an increase in the weight of the organs when compared with the control. Thus benzoic acid at various inclusion levels had an effect on the organ size of broiler birds. Therefore, 1.2% inclusion level of benzoic acid is an important approach to improve performance in poultry production (Ricke, 2003). When fed above this dosage it will result to reduction of growth and weight gain which might be due to its toxicity to animals.

Table 4 - Weight of Various Organs in Broiler Binds (Gms)

Treatment	Crops (gms)	Gizzard (gms)	Heart (gms)	Spleen (gms)	Kidney (gms)
Control	43.11 ± 0.01^b	84.13 ± 2.03^b	8.88 ± 0.87^{ab}	$2.05 \pm .00$	47.75 ± 1.41^{bc}
T_1	$47.32 \pm .01^d$	82.48 ± 0.93^b	11.81 ± 1.00^c	2.65 ± 0.48	51.94 ± 1.47^c
T_2	$56.11 \pm .01^e$	$101.72 \pm .41^d$	15.70 ± 0.72^d	4.58 ± 1.57	71.15 ± 1.00^d
T_3	$45.01 \pm .01^c$	77.92 ± 0.22^b	10.66 ± 0.25^{bc}	2.15 ± 1.03	45.59 ± 1.42^b
T_4	$35.13 \pm .01^a$	32.62 ± 6.53^a	6.76 ± 0.31^a	1.97 ± 1.05	37.48 ± 0.70^a

a,b,c,d,e, means with different superscript and within the same column are significantly different ($P<0.05$)

Morphological evaluations showed that significant difference ($P< 0.05$) was found in duodenum and jejunum villous among treatments. The average length of villous in the duodenum, jejunum and ileum was 1396, 1165 and 721 μm, respectively. Earlier workers {Pelicano et al (2005); Loddi et al (2004)} also noted higher villous height in the duodenum and jejunum with most organic acidifiers added to broiler diets. The increase in villous height of the different segments of the small intestine may be attributable to the intestinal epithelium acting as a natural barrier against pathogenic bacteria toxic substances that are present in the intestinal lumen. Therefore, benzoic acid reduce the growth of many pathogenic or non- pathogenic intestinal bacteria, therefore, reduce intestinal colonization and reduce infectious processes, ultimately decrease inflammatory processes at the intestinal

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mucosa, which increase villous height and function of secretion, digestion and absorption of nutrients can be appropriately performed by the mucosa (Iji and Tivey 1998; Pelicano et al 2005; Loddi et al 2004).

CONCLUSION

Birds given benzoic acid supplementation in their diet act as a good substitute for antibiotic growth promoter and helped improve the growth performance and gut health of the broilers. It reduced pathogenic microbes that compete with the broiler for nutrient. The best result was achieved at 1.2% inclusion level of benzoic acid in the broiler diet.

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EFFECT OF SEASON AND HARVESTING METHOD ON CHEMICAL COMPOSITION, PREDICTED METABOLIZABLE ENERGY AND IN VITRO ORGANIC MATTER DIGESTIBILITYOF ROTATIONALLY GRAZED TROPICAL PASTURES

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ABSTRACT: *The nutritive value of pastures is influenced by several factors. The objective of this study was to quantify the effects of season, and harvesting method on the nutritive value of rotationally grazed tropical pastures. Herbage was harvested at ground level (G-L) and by hand-plucking (H-P) during the dry, intermediate and wet seasons from 5 dairy and 2 beef farms. Nutritive value was evaluated by quantifying crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), predicted metabolizable energy (ME) and 12, 24 and 48 h in vitro organic matter digestibility (IVOMD). Season and harvesting method significantly (P < 0.05) affected chemical composition on all farms. Crude protein and ME content were 36 % and 27 % higher in H-P herbage than G-L herbage, respectively. Crude protein concentration of G-L and H-P harvested herbage was highest in the wet season. ME increased from dry to intermediate season then declined in the wet season. H-P herbage NDF, ADF and ADL was 9.6 %, 9.9 % and 9.7 %, respectively, lower than G-L herbage across all farms and seasons. ADF (351 – 403 g/kg DM) and ADL (43.0 - 90.3g/kg DM) contents were lowest in the wet season. Approximately 60 – 65 % of final IVOMD for G-L and H-P herbage occurred within 12 h post incubation across all farms. The 12 h IVOMD of H-P herbage was 17 % – 25 % higher than G-L harvested herbage. The 12, 24 and 48 h IVOMD of both H-P and G-L herbage were highest in the intermediate season. Dry and wet season IVOMD did not differ (P > 0.05) on most farms. It is concluded that H-P herbage is of superior quality to herbage cut at ground level. This indicates that rotational grazing is the most suitable system of feeding unless sward structure is augmented by mowing to reduce accumulation of residual dry matter. The nutritive value of these tropical pastures was found to be highest during the intermediate season and lowest in the dry season*

ORIGINAL ARTICLE

Key words: *Harvesting Method, Season, Nutritive Value, Tropical Pastures*

INTRODUCTION

A reliable supply of good quality pasture is critical for successful pasture-based production systems. However, in the tropics, the nutritive characteristics of pasture forage fluctuate throughout the year. This is likely to result in an increase in cost of feeding and reduced profitability, as farmers revert to commercial supplementary feeds to offset herbage deficit. Failure to supplement animals leads to a sharp decline in animal performance. Optimum production responses from pasture require intimate knowledge of pasture nutritive value combined with appropriate management strategies for its exploitation. Rotational grazing is traditionally the preferred system of managing pastures in Jamaica. Under this system, dairy cows remain in one paddock for a maximum of 24 – 48 h before being moved to another paddock. The grazing duration for beef cattle is generally longer (3 – 7 days). Rotational grazing is presumed to afford animals an opportunity to practice selective grazing. As a result, under medium and low grazing pressure, the nutritive value of the ingested herbage might be substantially higher than that of the total herbage offered – as conventionally measured at ground level (Sollenberger and Burns, 2001).

It has been shown that tropical pastures exhibit a distinctly vertical heterogeneity in chemical composition and digestibility (Newman et al., 2003; Bernard et al., 2004) as well as in morphological composition (Sollenberger and Burns, 2001). The upper sward horizons contain a greater proportion of green leaf than at the lower levels of the

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canopy. Therefore, evaluation of rotationally grazed tropical pastures harvested at ground level will under-estimate the nutritive value of the pastures consumed by the grazing animal particularly when herbage supply is not limiting. On the other hand, simulated grazed samples harvested by hand-plucking may give a more accurate representation of the pasture most likely to be consumed when tropical pastures are rotationally grazed. This can suggest that pasture evaluation from ground level harvesting is more suited for "cut-and-carry" system. Sustained performance of grazing animals is mediated by the nutritive value of the available herbage, in particular its protein and energy contents throughout the year.

From a previous study of seasonal variation in nutritive value of whole grass samples collected from Jamaican pastures (Hughes et al., 2011), it was found that crude protein was lowest while fiber and lignin were highest during the dry season. Digestibility (*in vitro*) was not different between dry and wet season but was highest in the intermediate season. Apart from this study, current information on the nutritive value of pastures in Jamaica is lacking. In addition, very little is known of the differences in nutritive value between the total pasture presented to the animal for grazing and that which is more likely to be consumed under existing grazing systems for beef and dairy cattle throughout the year. This information would be useful for developing more efficient and effective systems of pasture utilization which is prerequisite to being able to more accurately predict nutrient intake from pastures by the grazing animal. Also, this information can assist to more precisely determine the type and level of supplementation which might be needed to compensate for nutrient and herbage deficits at different times of the year in order to consistently meet production targets. The objective of this study was therefore to quantitatively determine and compare the nutritive value of the total pastures presented for grazing under rotational grazing system versus simulated-grazed samples collected by hand-plucking and the extent of these differences between season on commercial beef and dairy farms in Jamaica.

MATERIALS AND METHODS

Site description

The study was conducted on 5 dairy farms; Serge Island Dairies (17° 56' 52"N, 76° 28' 46"W), FM Jones Dairy (17° 57' 0" N, 76° 15' 0" W), Edward's Dairy (18° 19' 0" N, 77° 59' 0" W), Ponderosa Dairy, (18° 6' 0" N, 77° 1' 0" W) and Unity Valley Dairy, (18° 15' 0" N, 77° 7' 0" W) and 2 beef farms; Grove Place (18° 7' 0" N, 77° 31' 0" W) and Barkeith Farms, (17° 58' 0" N, 77° 45' 0" W). Pastures were fenced into several paddocks and rotationally grazed by small to large herds, ranging approximately 26 – 209 lactating dairy cows and 53 – 300 adult breeding beef animals. Dairy cows were predominantly of the Jamaica Hope breed and beef cattle were a mixture of Jamaica Red and Jamaica Brahman breeds. Variations in pasture and grazing management between seasons were negligible (Hughes et al., 2011). Soil samples taken in 2009 showed that the soils on the farms were slightly acidic to neutral pH (5.3 - 7.6) and that nitrogen, phosphorus and potassium ranged from 0.20 - 0.42 %, 9 - 141 ppm and 0.14 – 0.39 ppm, respectively. Rainfall during the experimental period and the long-term (1971 – 2000) monthly mean for each site was described in Hughes et al., (2011). The period between January to March, May to July and September - November represented the dry, intermediate and wet seasons, respectively. Total rainfall during the study period (mm) at FM Jones Dairy, Serge Island Dairies Ltd., Ponderosa Dairy, Unity Valley Dairy, Edwards Dairy, Grove Place and Barkeith Farms was recorded at 2 406, 1 916, 2 219, 2 209, 2 962, 1 948 and 1 657, respectively.

Grass sampling

Sampling during the dry, intermediate and wet season was done between January - March, May - July and September - November, respectively. The same pastures were sampled on all occasions. Sampling was done to coincide with the normal grazing cycle of the respective farm, thus representing the forage presented to the grazing animal during the respective season. This was done during the last two weeks of the respective sampling month between 12 and 24 hours prior to grazing. Prior to sampling, the pastures were notionally divided into two equal-sized halves. Harvested samples were bulked for each half and sampling frequency within season were used as the replicates (r = 4). Observably weed infested and hard to reach areas (such as inundated sections) were isolated and not included in the sampling.

Harvesting methods

Grass samples were collected by cutting at ground level (G-L) and by hand-plucking (H-P) to simulate grazing. The G-L sampling method was done according to Hughes *et al.* (2011). Hand-plucked samples were collected by "plucking" grass herbage by hand (to simulate the grazing action of cattle) from at least 20 randomly selected locations within either half of the pasture while walking in a zig-zag pattern. These samples comprised mainly the upper portions of the sward canopy and represented an estimate of the forage that would most likely be consumed by the grazing cattle (Cook, 1964). These "plucks" were pooled to give an average representation of the respective half. Hand-plucked samples were collected by the same individual on all occasions.

Sample preparation and analysis of chemical composition

After harvesting, the samples were transported to the Animal Nutrition Laboratory at the Bodles Agricultural Research Station (17° 56' 0" N, 77° 7' 0" W) where they were temporarily stored in a deep freezer at -4 ^{0}C prior to drying at 60 ^{0}C in a force draft oven to constant weight. Dried samples were then ground in a stainless steel hammer

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mill (Thomas Wiley Laboratory mill, model 4; Thomas Scientific USA) to pass through a 1 mm sieve in preparation for chemical analysis. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined by the filter bag technique using the ANKOM^{2000} Fiber Analyzer (model: A2000I) (ANKOM Technology, Macedon NY). Sodium sulphite and amylase (α) were included in the NDF analysis. Acid detergent lignin [72% H_2SO_4 - (ADL)] was determined according to Van Soest et al. (1991). Acid detergent lignin was expressed on an ash-free basis while NDF and ADF values were expressed inclusive of residual ash. Nitrogen was determined at the analytical laboratory of the Bureau of Standard, Jamaica, by the Kjeldahl method (AOAC, 2005; 976.05) using an automated steam distillation/titration unit (FOSS – Kjeltec 2300 Analyzer) with 1% boric acid as the receiving solution and 0.1 M hydrochloric acid as the titrant. The end point was determined photometrically. Crude protein content was calculated by multiplying the nitrogen content by 6.25 (CP = N × 6.25).

In vitro organic matter digestibility

In vitro organic matter digestibility (IVOMD g/kg) determinations were conducted at the Bodles Animal Nutrition Laboratory using the modification of the Tilley and Terry (1963) procedure of Moore *et al.,* (1972). Approximately 0.5 g grass samples were weighed into 100 ml round-bottom plastic tubes to which 50 ml of incubation medium (rumen fluid and buffered McDougal's artificial saliva) was added. The incubation medium was prepared in a 1:4 ratio; i.e. 10 ml rumen fluid to 40 ml buffer solution. One ml 4 % calcium chloride solution was added per litre of incubation medium prior to use. Anaerobic condition was maintained by flushing the medium with CO_2. The tubes were incubated in a water bath at 39 ^{0}C. Microbial digestion of forage organic matter was measured at 12, 24 and 48 h post incubation. This was followed by the addition of 6 ml of 20 % HCL and 2 ml of 5 % pepsin. Tubes were incubated again at 39° C for 48 hours, after which their contents were filtered and oven dried for 24 hours at 105 ^{0}C. The dried residue was weighed before being ashed in a muffle furnace for 6 hours at 600 ^{0}C and reweighed. *In vitro* organic matter digestibility (IVOMD) was estimated as the loss of organic matter after microbial and pepsin digestion and was expressed as a ratio of sample organic matter content before digestion.

Metabolizable energy

Metabolizable energy (ME) was predicted from digestible organic matter in the dry matter (DOMD) content of the forages after 48 h incubation in buffered rumen fluid according to the following predictive equation proposed by McDonald *et al.,* (2002):

ME (MJ/kg DM) = 0.016 DOMD;

where DOMD is expressed in grams digestible organic matter per kg dry matter.

The validity of the McDonald et al., (2002) equation for grasses under Jamaican conditions was assessed by comparison with ME derived from gross energy values (Minson, 1979). Gross energy determinations (MJ/kg DM) were conducted using the Parr 1261 Adiabatic Bomb Calorimeter at the Chemistry Department, UWI, Mona Campus, Jamaica. Metabolizable energy was derived from bomb calorimetric values as follows:

1. Digestible energy (DE) = gross energy (GE) x IVOMD (after correcting GE for ash)
2. ME = 0.81DE (Minson, 1979)

Statistical analysis

Statistical analysis was done separately for each farm using the Minitab 15 software (Minitab 2007). The level of significance was set at $P < 0.05$. Proximate chemical components, predicted metabolizable energy and IVOMD were analyzed by analysis of variance (ANOVA) according to the general linear model procedure with season (dry, intermediate and wet), harvesting method (hand-plucking and ground level harvesting) and their interactions as the fixed effect as represented by the mathematical model:

$Y_{ijk} = \mu + S_i\ (i = 1\text{–}3) + H_j\ (j = 1\text{-}2) + S_i \times H_j + E_{ijk}$

From the model, Y_{ijk} = dependent variable, μ = overall mean, S_i = effect of season, H_j = effect of harvest method, $S_i \times H_j$ = interactive effects of season and harvest method and E_{ijk}, = random error. Incubation time as a main effect was not of interest thus analysis was done separately for each incubation time. Treatment means were separated using Tukey's multiple comparison. Simple linear regression was performed using the Minitab 15 statistical software to determine the relationship ME (McDonald et al., 2002) and ME derived from GE. An assessment of the validity of the McDonald et al., (2002) equation for tropical grasses, under Jamaican conditions, was done by comparing the energy derived from bomb calorimetry {GE [MJ/kg DM]} (Minson, 1979) with predicted ME using Pearson's correlation coefficient and simple linear regression analysis.

RESULTS

Chemical composition

Comparisons of DM, CP, NDF, ADF, and ADL as influenced by harvesting method and season are presented in Figures 1 - 5. Herbage DM concentration was significantly influenced by season ($P < 0.05$) and harvesting method ($P < 0.05$) on all farms except Edwards Dairy and Grove Place where DM was influenced by season only (Figure 1). Significant season × harvesting method interaction on DM was found at FM Jones Dairy ($P = 0.030$) and Unity Valley Dairy ($P = 0.036$). Dry matter concentration of herbage harvested by H-P decreased from dry to wet season. The DM concentrations of H-P herbage were approximately 25% and 15% lower than G-L herbage in the dry and intermediate

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seasons, respectively. During the wet season, concentrations of herbage DM differed significantly between H-P and G-L samples (P < 0.05) only at Ponderosa Dairy and Barkeith Farms. Pasture herbage CP concentration was significantly (P < 0.05) affected by season and harvest method (Figure 2).

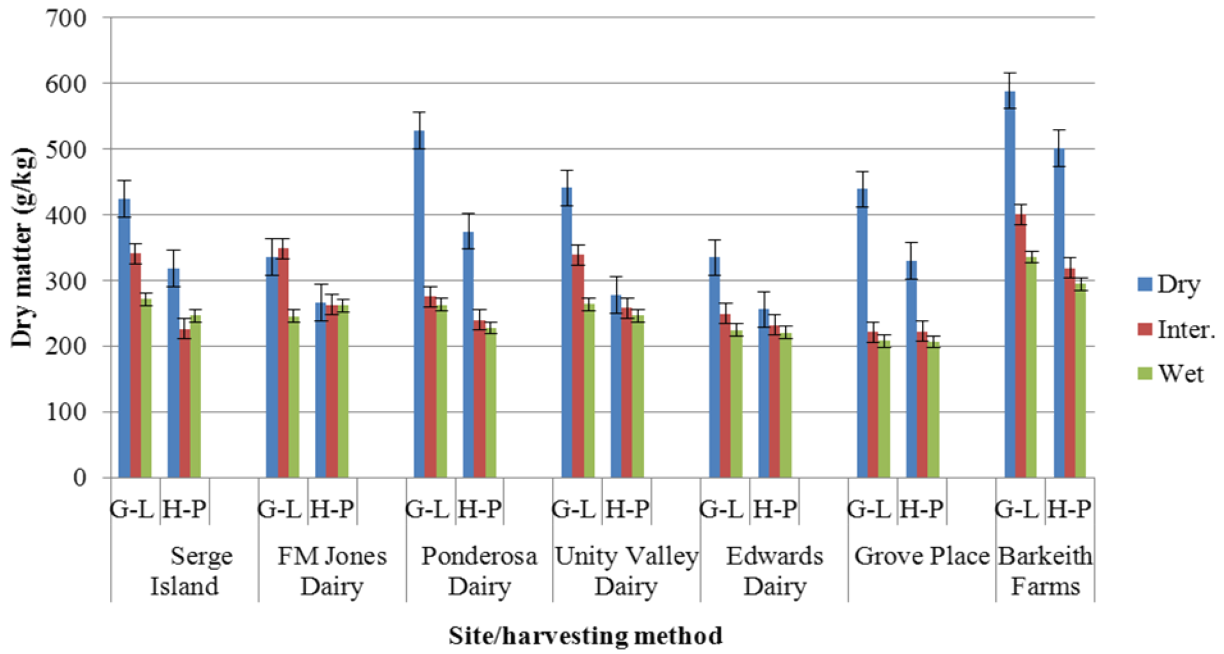

Figure 1 - Effect of season and harvesting method on dry matter concentration (g/kg) at the respective site

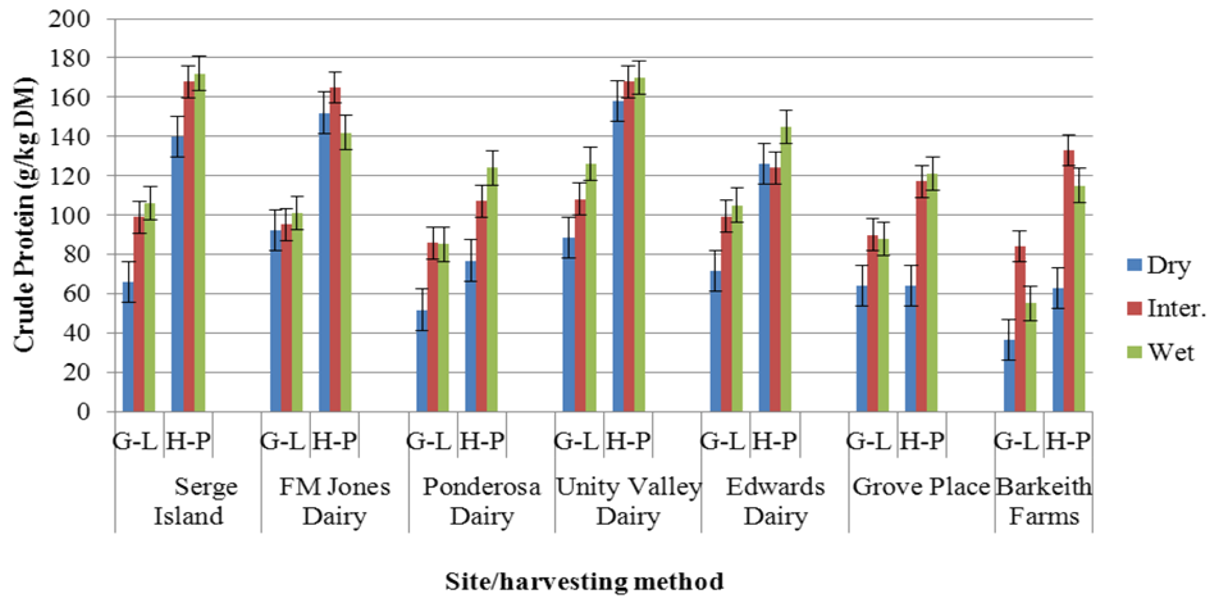

Figure 2 - Effect of season and harvesting method on crude protein concentration (g/kg) at the respective site

Wet and intermediate season H-P herbage CP concentrations differed significantly (P < 0.05) on all farms except Ponderosa Dairy and Edwards Dairy. Crude protein concentrations of H-P harvested herbage were lowest in the dry season. Season × harvesting method interaction on CP concentration was significant only at Edwards Dairy (P = 0.032). Hand - plucked herbage (62.7 ± 7 – 172 ± 8 g/kg DM) had significantly higher CP than those harvested at G-L (36.5 ± 1 – 126 ± 14 g/kg DM) on all farms across the three seasons. Concentrations of NDF were significantly (P < 0.05) affected by season and method of harvest at Edwards Dairy, Ponderosa Dairy and Grove Place (Figure 3). Season, harvesting method and their interaction, significantly (P < 0.05) influenced pasture NDF at Serge Island Dairies, FM Jones Dairy and Unity Valley Dairy. Neutral detergent fiber at Barkeith Farms was only affected by season (P = 0.001). Herbage harvested at ground-level had 14.6%, 8.1% and 5.6 % more NDF than hand - plucked herbage in the dry, intermediate and wet season, respectively. NDF in H-P herbage increased from dry (548 ± 12 – 672 ± 16 g/kg DM) to wet (681 ± 16 – 749 ± 12 g/kg DM) season. Season and harvesting method significantly (P < 0.05) influenced ADF content at Serge Island Dairies, Ponderosa Dairy, Unity Valley Dairy and Barkeith Farms (Figure 4).

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Acid detergent fiber concentrations were significantly affected by harvesting method at Edwards Dairy (P = 0.000), Grove Place (P = 0.001) and FM Jones Dairy (P = 0.004).

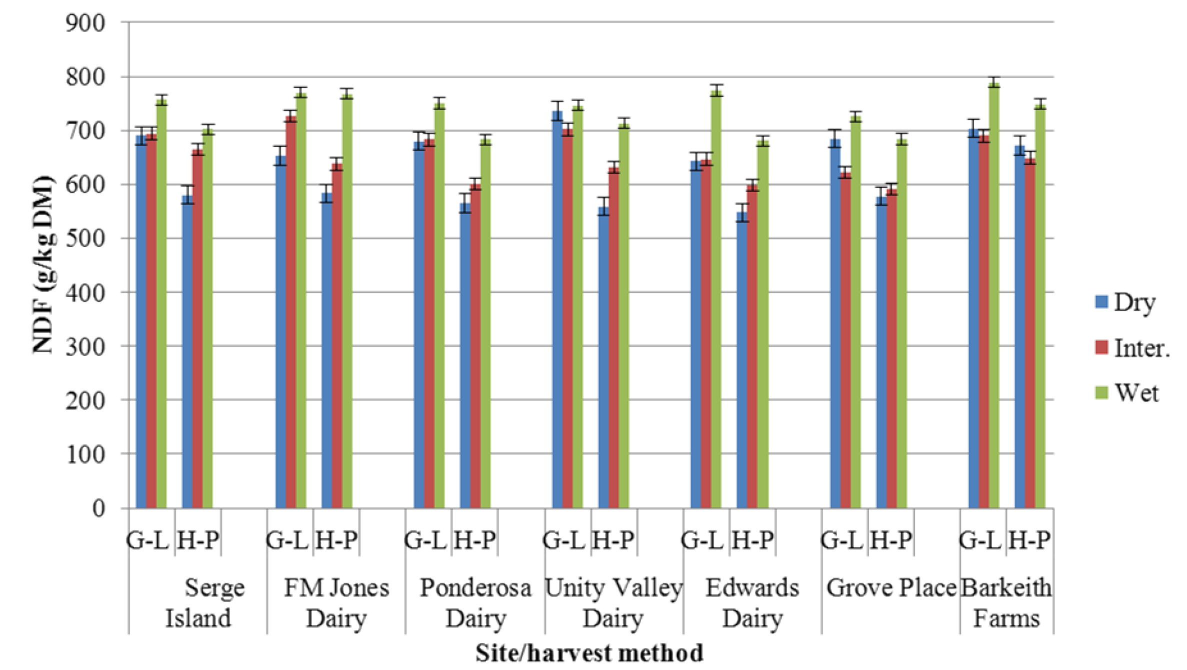

Figure 3. Effect of season and harvesting method on neutral detergent fiber (NDF) concentration (g/kg) at the respective site

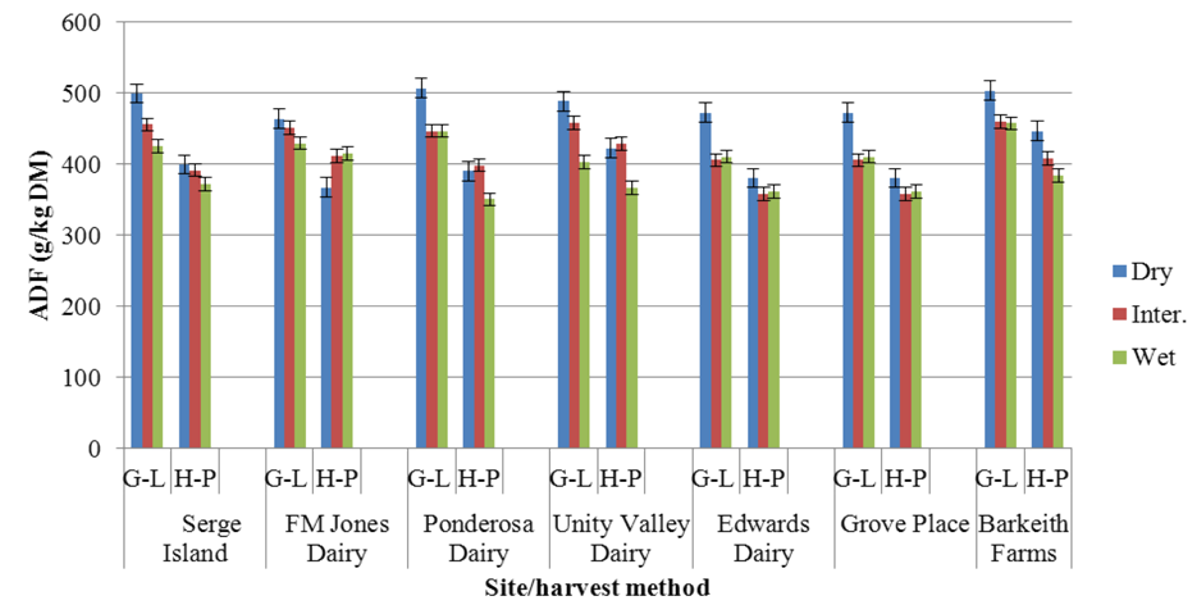

Figure 4. Effect of season and harvesting method on acid detergent fiber (ADF) concentration (g/kg) at the respective site

Acid detergent fiber concentrations in G-L harvested herbage were significantly (P < 0.05) higher (403 ± 16 – 507 ± 15 g/kg DM) than those harvested by H-P (351 ± 14 – 447 ± 18 g/kg DM) on all farms except for FM Jones Dairy. Acid detergent fiber concentrations decreased from dry to wet season for H-P harvested herbage on all farms except at Ponderosa Dairy and Unity Valley Dairy where ADF was highest during the intermediate season. Concentrations of ADL were significantly (P < 0.05) affected by season and harvesting method at Serge Island Dairies, FM Jones Dairy, Grove Place and Barkeith Farms (Figure 5). Harvesting method significantly (P < 0.05) influenced ADL concentration at Edwards Dairy and Ponderosa Dairy. Season × harvest method interaction was significant for ADL (P = 0.032) at Ponderosa Dairy. Dry and wet season H-P harvested herbage ADL differed significantly (P < 0.05) only at Grove Place.

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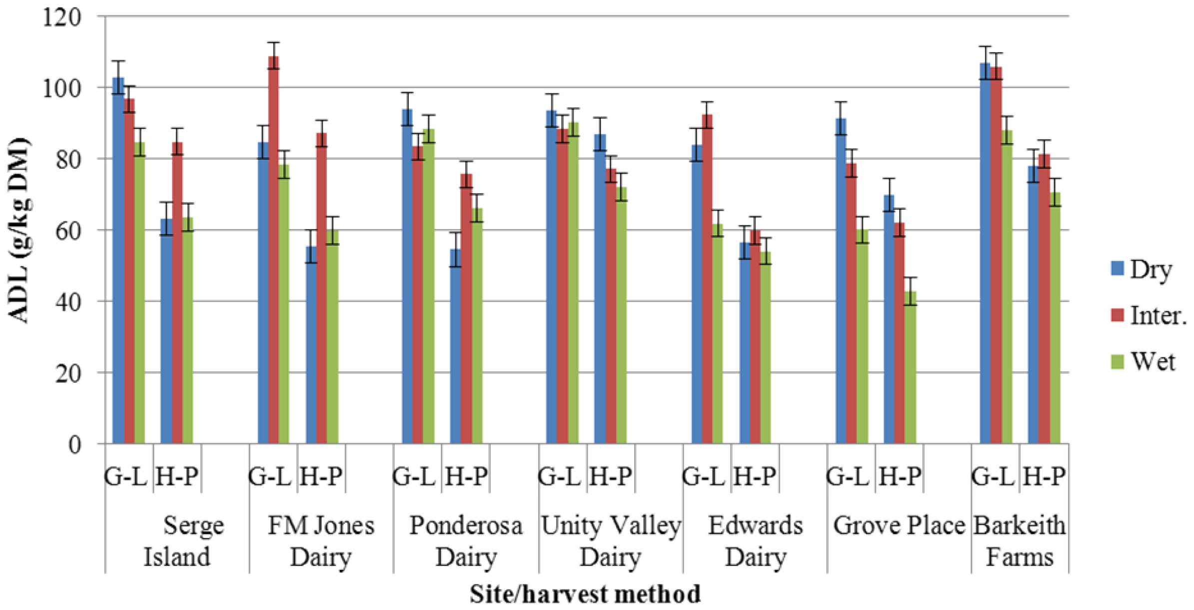

Figure 5 - Effect of season and harvesting method on acid detergent lignin (ADL) concentration (g/kg) at the respective site

***In vitro* organic matter digestibility (IVOMD)**

Digestibility after 12 h incubation: The effect of season and harvesting method on IVOMD after 12 h incubation ($IVOMD_{12}$) is presented in Table 1. Season and harvesting method significantly ($P < 0.05$) affected $IVOMD_{12}$ on all farms. Interactive effect of season × harvest method was significant ($P = 0.047$) only at Serge Island Dairies. Ground-level harvested herbage $IVOMD_{12}$ increased from dry (204 ± 7 – 299 ± 29 g/kg) to intermediate (281 ± 33 – 372 ± 13 g/kg) season then decreased in the wet (210 ± 10 – 268 ± 11 g/kg) season. Similarly, H-P herbage $IVOMD_{12}$ increased from dry (237 ± 5 – 380 ± 19 g/kg) to intermediate (355 ± 17 – 440 ± 12 g/kg) season then decreased in the wet (258 ± 17 – 355 ± 4 g/kg) season. Hand plucked harvested herbage $IVOMD_{12}$ was significantly greater ($P < 0.05$) than G-L herbage on all farms. Dry and wet season G-L harvested herbage $IVOMD_{12}$ differed only at Unity Valley Dairy ($P = 0.028$).

Table 1 - Effect of season and harvesting method (G-L & H-P) on *in vitro* organic matter digestibility (Mean ± SEM) after 12 h incubation

Farm	Season/harvesting method					
	Dry Season		Intermediate season		Wet Season	
	G-L	H-P	G-L	H-P	G-L	H-P
Serge Island Dairies	23 5±27^{a}	377±16^{b}	367±21^{b}	440±12^{c}	268±11^{a}	326± 4^{d}
FM Jones Dairy	274±26^{a}	380±19^{b}	285±30^{a}	374±14^{b}	210±10^{c}	262± 5^{a}
Ponderosa Dairy	236 ±25^{a}	289±18^{b}	314±16^{bd}	370±20^{c}	254±2^{a}	330± 3^{d}
Unity Valley Dairy	234±12^{a}	349±52^{bc}	315±34^{b}	401± 21^{c}	267±11^{d}	299±23^{d}
Edwards Dairy	299±29^{a}	360±9^{b}	372±13^{bc}	383±8^{c}	260±28^{a}	355±4^{b}
Grove Place	247±37^{a}	306±13^{b}	303±18^{b}	355±17^{c}	217±13^{a}	284±10^{b}
Barkeith Farms	204 ±7^{a}	237±5^{c}	281±33^{b}	360±44^{d}	215±17^{a}	258±17^{bc}

^{a,b,c,d,}: Items within row for the respective farm with different superscripts differ significantly ($P < 0.05$)

Digestibility after 24 h incubation: *In vitro* organic matter digestibility after 24 h incubation ($IVOMD_{24}$) was significantly ($P < 0.05$) influenced by season and harvesting method on all farms (Table 2). Significant interactive effect between season × harvesting method was found at Edwards Dairy ($P = 0.003$) and Serge Island Dairies ($P = 0.024$). The $IVOMD_{24}$ of H-P harvested herbage was significantly higher ($P < 0.05$) than G-L harvested herbage except during the dry season at Ponderosa Dairy and the wet season at Unity Valley Dairy. Ground -level herbage $IVOMD^{24}$ increased from dry (285 ± 25 – 372 ± 22 g/kg) to intermediate (389 ± 38 – 455 ± 38 g/kg) season then decreased in the wet (233 ± 22 – 363 ± 9 g/kg) season. Similarly, H-P herbage $IVOMD_{24}$ increased from dry (331 ± 5 – 525 ± 11 g/kg) to intermediate (491 ± 40 – 562 ± 32 g/kg) season then decreased in the wet (325 ± 20 – 425 ± 8 g/kg) season. Dry and wet season $IVOMD_{24}$ for both G-L and H-P harvested herbage were not significantly different ($P > 0.05$) at Ponderosa Dairy and Barkeith Farms. Similarly, there were no significant differences ($P > 0.05$) between dry and wet season G-L herbage $IVOMD_{24}$ at Serge Island Dairies, Unity Valley Dairy and Grove Place.

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Table 2 - Effect of season and harvesting method (G-L & H-P) on *in vitro* organic matter digestibility (Mean ± SEM) after 24 h incubation

Farm	Dry Season		Intermediate season		Wet Season	
	G-L	H-P	G-L	H-P	G-L	H-P
Serge Island Dairies	313±18[a]	498±10[b]	455±38[b]	545±17[c]	311±10[a]	380±12[d]
FM Jones Dairy	362±22[a]	513±14[b]	389±38[a]	562±32[c]	277±12[d]	337±12[a]
Ponderosa Dairy	309±47[a]	375±34[ab]	408±28[b]	522±22[c]	330±16[a]	389±14[b]
Unity Valley Dairy	372±22[a]	483±17[b]	430±34[b]	522±16[c]	363±9[a]	382±6[a]
Edwards Dairy	369±20[a]	525±11[b]	454±12[c]	501±10[b]	329±6[d]	425±8[c]
Grove Place	346±55[ad]	435±15[b]	432±12[b]	492±23[c]	305±13[a]	336±8[d]
Barkeith Farms	285 ± 25[a]	331 ± 5[b]	404±36[c]	491±40[d]	233±22[a]	325±20[b]

Season/harvesting method

a,b,c,d: Items within row for the respective farm with different superscripts differ significantly (P < 0.05)

Digestibility after 48 h incubation: *In vitro* organic matter digestibility after 48h incubation ($IVOMD_{48}$) was significantly ($P < 0.05$) affected by season, harvest method ($P < 0.05$) and their interaction ($P < 0.05$) at FM Jones Dairy and Edwards Dairy (Table 3). *In vitro* organic matter digestibility ($IVOMD_{48}$) at Unity Valley Dairy was significantly ($P < 0.05$) affected by harvesting method ($P = 0.000$) and season × harvesting method interaction ($P = 0.011$). Season and harvesting method significantly influenced $IVOMD_{48}$ ($P < 0.05$) on the other farms. "Hand – plucked" herbage $IVOMD_{48}$ was significantly ($P < 0.05$) higher than G-L harvested herbage on all farms. The $IVOMD_{48}$ of G-L harvested herbage increased from dry (312 ± 13 – 494 ± 8g/kg) to intermediate (444 ± 24 – 613 ± 8g/kg) season then decreased in the wet (326 ± 19 – 489 ± 15g/kg) season. Hand – plucked herbage $IVOMD_{48}$ followed the same pattern; increasing from the dry (451 ± 16 – 676 ± 10g/kg) to intermediate (589 ± 26 – 672 ± 15g/kg) season then fell in the wet (447 ± 6 – 617 ± 6g/kg) season except for FM Jones Dairy where H-P herbage $IVOMD_{48}$ decreased from dry to wet season. Dry and wet season $IVOMD_{48}$ for G-L harvested herbage was significantly different ($P = 0.028$) only at Unity Valley Dairy.

Table 3 - Effect of season and harvesting method (G-L & H-P) on *in vitro* organic matter digestibility (Mean ± SEM) after 48 h incubation

Farm	Dry Season		Intermediate season		Wet Season	
	G-L	H-P	G-L	H-P	G-L	H-P
Serge Island Dairies	380±24[a]	592±16[b]	472±18[c]	640±1[d]	437±10[c]	568±39[b]
FM Jones Dairy	465±32[ad]	661±12[b]	444±24[a]	662±18[b]	434±10[a]	494±18[d]
Ponderosa Dairy	413±28[a]	561±32[b]	588±34[c]	654±22[d]	449±9[ac]	603±12[e]
Unity Valley Dairy	405±25[a]	600±22[b]	478±16[c]	619±26[b]	489±15[c]	547±13[d]
Edwards Dairy	494±8[a]	676±10[b]	577±7[c]	672±15[b]	478±24[a]	617±6[d]
Grove Place	474±73[a]	622±29[bc]	613±8[b]	650±16[c]	462±26[a]	571±3[d]
Barkeith Farms	321±13[a]	451±16[b]	444±25[b]	589±34[c]	326±19[a]	447±6[b]

Season/harvesting method

a,b,c,d: Items within row for the respective farm with different superscripts differ significantly (P < 0.05)

Metabolizable energy

Metabolizable energy (McDonald *et al.,* 2002) after 48h ruminal *in vitro* fermentation was significantly affected by season ($P < 0.05$) and harvesting method ($P < 0.05$) on all farms (Table 4). Interactive effect of season × harvesting method was significant at Edwards Dairy ($P = 0.005$), Unity Valley Dairy ($P = 0.018$) and FM Jones Dairy ($P = 0.008$). Metabolizable energy of H-P harvested herbage (6.7 ± 0.1 – 10 ± 0.1MJ/kg DM) was higher than G-L harvested herbage (4.8 ± 0.2 – 9.1 ± 0.1MJ/kg DM) on all farms across the three seasons except for Grove Place during the intermediate season. Ground level harvested herbage ME ranged from 4.8 ± 0.2 -7.4 ± 0.1 MJ/kg DM in the dry season, 6.6 ± 0.4 - 9.1 ± 0.1 MJ/kg DM in the intermediate season and 4.9 ± 0.3 - 7.3 ± 0.2 MJ/kg DM in the wet season. The ME of herbage harvested by H-P varied from 6.8 ± 0.2 - 10.0 ± 0.1 MJ/kg DM, 8.7 ± 0.5 - 9.9 ± 0.2 MJ/kg DM and 6.7 ± 0.1 - 9.1 ± 0.1 MJ/kg DM in the dry, intermediate and wet season, respectively.

Table 4 - Effect of season and harvest method on metabolizable energy (MJ/kg DM) [McDonald et al., 2002] of tropical pastures grazed by beef and dairy cattle in Jamaica

Farm	Dry		Intermediate		Wet	
	G-L	H-P	G-L	H-P	G-L	H-P
Serge Island Dairies	5.7 ± 0.3[a]	8.7 ± 0.2[d]	7.1 ± 0.3[b]	9.4 ± 0.1[e]	6.5 ± 0.2[c]	8.3 ± 0.6[d]
FM Jones Dairy	7.0± 0.4[ab]	9.8 ± 0.2[c]	6.7 ± 0.3[b]	9.3 ± 0.3[c]	6.5 ± 0.1[b]	7.4 ± 0.2[a]
Ponderosa Dairy	6.2 ± 0.4[a]	8.2 ± 0.4[c]	7.2 ± 0.5[b]	9.7 ± 0.3[d]	6.7 ± 0.1[a]	9.0 ± 0.1[d]
Unity Valley Dairy	6.1 ± 0.4[a]	8.8 ± 0.4[c]	7.1 ± 0.2[b]	9.1 ± 0.4[c]	7.3 ± 0.2[b]	8.2 ± 0.2[d]
Edwards Dairy	7.4 ± 0.1[a]	10.0 ± 0.1[c]	8.5 ± 0.1[b]	9.9 ± 0.2[c]	7.1 ± 0.3[a]	9.1 ± 0.1[d]
Grove Place	7.1 ± 1.1[a]	9.2 ± 0.4[bc]	9.1 ± 0.1[b]	9.6 ± 0.3[b]	6.8 ± 0.4[a]	8.5 ± 0.1[c]
Barkeith Farms	4.8 ± 0.2[a]	6.8 ± 0.2[b]	6.6 ± 0.4[b]	8.7 ± 0.5[c]	4.9 ± 0.3[a]	6.7 ± 0.1[b]

Season/harvesting method

a,b,c,d: Items within row for the respective farm with different superscripts differ significantly (P < 0.05)

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Significant difference ($P < 0.05$) between dry and intermediate season ME for H-P harvested herbage was observed only on Serge Island Dairies, Ponderosa Dairy and Barkeith Farms. The relationship between ME derived from GE (Y) (Minson, 1979) and that calculated from IVOMD (X) (McDonald et al., 2002) (Figure 6) was described by the simple linear regression:

$Y = - 0.072 + 0.927X$ ($R^2 = 0.752$); $P > 0.05$

The relationship between the ME derived from both methods was highly correlated with correlation coefficient of $r^2 = 0.867$.

DISCUSSION

Chemical composition

Observable differences in pasture chemical composition between farms can be attributable to differences in pasture species, management, climate, and soil type. For example, pastures at Ponderosa Dairy, Edwards Dairy and Grove Place were planted to *Brachiaria spp* while the remaining farms had *Cynodon spp*. On the beef farms (Grove Place and Barkeith Farms), pastures are grazed for longer periods and at longer intervals than on the dairy farms. The difference in chemical composition between H-P and G-L herbage "within site" highlights the contrast in nutritive value of the total herbage offered versus potentially grazed herbage.

It has been previously pointed out that tropical grasses are distinctly vertically heterogeneous in chemical composition and morphology (Stobbs 1975; Sollenberger and Burns 2001). Herbage harvested by "hand-plucking" would have comprised mainly of portions of the upper sward canopy; hence a higher proportion of leaf than stem. In fact, Holderbaum *et al.,* (1992) showed that leaf percentage may be as much as three times greater in the upper half than in the lower half of a *Limpograss (Hermarthria altissima)* canopy. Several authors (Laredo and Minson, 1973; Moreia *et al.,* 2004; Hare *et al.,* 2009) have confirmed that the concentrations of cell wall fractions (NDF, ADF and lignin) of tropical grasses are usually lower and crude protein (Moreia *et al.,* 2004; Newman *et al.,* 2003; Hare *et al.,* 2009) usually higher in leaf than stem. This is expected to positively influence diet selection of the grazing animal (Weir and Torell 1959; Stobbs, 1975; Burns *et al.,* 1992). In fact, Laredo and Minson (1973) separated leaves and stems of similar digestibility from five grasses and found that intake of leaf was 46% higher than stem when fed to sheep. Stobbs, (1975) noted that under rotational grazing, cattle graze the uppermost leaves first, followed by leaf-bearing stems. This grazing behaviour was identified as critical to the animal being able to satisfy its nutrient and intake requirements (Stobbs, 1975). The lower DM of H-P herbage in the current study may have been the result of higher moisture content of the upper-most leafy portion of the grass canopy, particularly during the intermediate and wet seasons. Higher CP concentration of H-P herbage in this study is consistent with literature (Holderbaum *et al.,* 1992; Newman *et al.,* 2002) and is also attributable to the upper horizons of the sward canopy having a greater proportion of green leaf than stem. Holderbaum *et al.,* (1992) observed a 43 % decrease in CP concentration from top to bottom of a *Limpograss* canopy.

The mean CP concentration of H-P herbage in the current study exceeded the minimum threshold level of 80 g/kg which might limit intake of tropical forages (Milford and Minson, 1966; Minson, 1980) and that which is needed to maintain optimum rumen function (Minson and Milford, 1967). In fact, H-P herbage in the present study can supplied CP more than adequate to support average daily milk yields above 15 litres per cow (NRC, 2001). Average daily milk yield of 15 liters per cow is well above current levels of production on Jamaican dairy farms (Miller, pers. comm). This, however, was not the case with G-L herbage, particularly during the dry season where CP was generally below the 80 g/kg threshold. The moderate to high CP concentrations of H-P herbage suggest that the level of production that can be sustained is dependent on the availability of such herbage in sufficient quantity to satisfy the DM intake requirement of the grazing animal.

The chemical components of H-P herbage appeared to be less sensitive to seasonal variations compared to G-L herbage. This observation was supported by Telford *et al.,* (1975) who reported that the diet selected by esophageal-fistulated cows and calves grazing *Cynodon dactylon* fertilized at three different N rates, did not vary much over two grazing trials at different times of the year. This implies that if afforded the opportunity, the grazing animal will consistently select herbage of the highest quality throughout the year, subject to the availability of adequate herbage to select from. The observation in the present study that NDF in both H-P and G-L was highest during the wet season contradicts earlier reports (Tekletsadik *et al.,* 2004; Mtui *et al.,* 2009; Lopez-Gonzalez *et al.,* 2010) in which NDF was significantly higher in the dry compared to wet season. This might have been the result of hemicellulose concentration which tends to be high in rapidly growing grass. Rapid growth rates are mostly observed in the wet season or in pastures under irrigation. Reports in the literature confirm ADF and ADL of tropical grasses being lowest in the wet season (Relling *et al.,* 2001; Mtui *et al.,* 2009). Faster rate of maturity resulting in rapid lignification (Van Soest *et al.,* 1991) due to higher temperatures and severe moisture stress in the dry season could account for this.

In vitro organic matter digestibility (IVOMD)

Digestibility after 12 h incubation: Approximately 60 - 65% of the OM of both G-L and H-P herbage was digested within the first 12h of incubation. This was in agreement with several other reports which demonstrated that the rate of forage digestion is highest during the earlier stages of incubation (Prigge *et al.,* 1984; Kamalak *et al.,* 2005a; Kamalak *et al.,* 2005b). In fact, Kamalak *et al.,* (2005a) reported that alfalfa hay and silage *in vitro* digestibility after 12h incubation was approximately 78% of the digestibility (56.3 and 61.2%, respectively) recorded after 48 hours incubation using the gas production technique. This high initial rate of forage digestion represents microbial degradation of the rapidly soluble forage fraction (Van Soest, 1967; Mertens and Ely, 1982) that is readily available for animal use. Prigge *et al.,* (1984) showed that total VFA from fistulated wethers and steers, peaked at 12 h post feeding a diet of perennial ryegrass (*Lolium* perenne) or swtichgrass (*Panicum vigatum L.*) hay. Juarez Lagunes *et al.,* (1999) estimated the digestion rate of non-structural carbohydrates (NSC) of *Digitaria decumbens* to be around 13.5 % DM/hour.

However, the rate of digestion at early incubation intervals seems to be dependent on the ratio of total cell wall components to NSC which might have accounted for the differences in IVOMD between G-L and H-P herbage within and between seasons.

Digestibility after 24 h incubation: Forage digestibility at 24 h might better represent digestibility by ruminant livestock compared to 48 h which may over-estimate, or 12h which may under-estimate digestibility. Several reports have suggested that the actual rumen retention time of forages by cattle is closer to 24 h (Prigge *et al.,* 1984; Prigge *et al.,* 1990; Kokkonen *et al.,* 2000). From the study of Prigge *et al.,* (1990) rumen retention time of forage diets containing 100 % alfalfa, 50 : 50 alfalfa : switchgrass, 25 : 75 alfalfa : switchgrass and 100 % switchgrass combinations fed to three fistulated cattle were 24.3, 24.8, 24.7 and 29.8 hours, respectively. It must be noted that these forages were of superior quality to those investigated in the present study, particularly the G-L herbage. This implies that the rumen retention time of H-P herbage might be shorter than that of G-L herbage.

The positive relationship between forage digestibility and intake (Laredo and Minson 1975; Cheeke, 1999) and inverse correlation with rumen retention time (Laredo and Minson 1973) would suggest that intake by grazing cattle might be expected to be greater for herbage of similar quality to that of hand-plucked samples compared to G-L herbage and correspondingly, greater in the intermediate season compared to wet and dry season. *In vitro* organic matter digestibility after 24 h incubation of H-P herbage from the present study, particularly those from the intermediate season, falls within ranges reported by Holechek *et al.,* (1989) and Kamalak *et al.,* (2005a). Similarly, $IVOMD_{24}$ of G-L herbage was comparable to 24 h digestibility of wheat and barley straw but inferior to alfalfa hay and silage and maize silage reported by Kamalak *et al.,* (2005b). These differences are mainly associated with the contrasting chemical compositions, primarily fibre fractions of the different forages.

Digestibility after 48 h incubation: The low $IVOMD_{48}$ of G-L herbage is mainly a function of the high cell wall components (NDF, ADF and ADL) which has been shown to negatively affect forage digestibility (Van Soest, 1967; Van Soest, 1994; Jung and Allen, 1995). Lignin, in particular, is the main factor that limits forage digestibility (Jung and Allen, 1995). In addition, low CP has a negative effect on forage digestibility (Minson, 1980). However, it is important to note that the relationship between forage digestibility and lignin concentration is non-linear, which implies a spatial and a chemical effect of lignin on forage digestion (Van Soest, 1967; Dryden, 2008). This could be the reason for the higher $IVOMD_{48}$ observed in the dry compared to the wet season despite similar ADL concentrations in both seasons. Van Soest (1994) pointed out that grasses and legumes of similar digestibility differ in chemical composition, with legume cell wall containing about twice the lignin as grass but ferments at a faster rate than grasses at the same stage of maturity. This suggests that forages with the lowest lignin are not necessarily the most digestible. The difference in $IVOMD^{48}$ between G-L and H-P herbage is possibly due in part to the higher proportion of leaf versus stem in the upper sward canopy represented by H-P herbage. Indeed, Newman, *et al.,* (2003) showed that IVOMD was generally greater for herbage from the upper 25 % versus next lower 50 % of a continuously stocked *Limpograss* pasture canopy.

In a study reported by Lopez-Gonzalez *et al.,* (2010) i*n vitro* organic matter digestibility after 48 h incubation of *Cynodon plectostachyus* harvested at ground level, was higher than that of G-L herbage in the present study, while dry and wet season $IVOMD_{48}$ of H-P herbage was within range of the findings of Dixon and Coates (2010) for dry matter digestibility (measured by faecal NIRS) of the diet of heifers grazing buffel grass pastures *(C. ciliaris).*

Metabolizable energy

Moir *et al.,* (1979) and Kolver, (2003) indicated that the quantity of metabolizable energy (ME) supplied is the first limiting factor to milk production from pasture-based systems. The higher ME of H-P compared to G-L herbage is attributed to the higher *in vitro* digestibility of the H-P herbage, since ME was a derivative of IVOMD. McDonald *et al.,* (2002) pointed out that the main factors affecting the ME value of feedstuff are those which influence its digestibility. Feedstuffs with low energy density are usually more fibrous and are used less efficiently (Dryden, 2008). Hence, if animals are forced to consume herbage approximating the poorer quality G-L herbage, this might well result in a decrease in the quantum of energy available for milk production and growth. Using the Cornell Net Carbohydrate and Protein System, Juarez Lagunes *et al.,* (1999) predicted that the volume of milk attainable from tropical pastures based on the ME supplied, decreased by 35 % when NDF increased from 600 to 800 g/kg DM. This relationship was in agreement with an earlier finding by Moir *et al.,* (1979) and has more recently been corroborated by Meeske *et al.,* (2006). Metabolizable energy values of Kikuyu grass *(Pennisetum clandestinum)* leaf (11 MJ/kg DM^{-1}) and stem (9 MJ/kg DM^{-1}) reported by Moir *et al.,* (1979) were higher than H-P (6.7 – 10 MJ/kg DM) and G-L (4.8 – 9.1 MJ/kg DM) herbage, respectively. Other authors (Meeske *et al.,* 2006; Cardenas-Medina *et al.,* 2010) reported ME values from tropical grasses within range of those observed in the present study. Based upon NRC (2001) the range of ME [NE_l from NRC converted to ME (Dryden, 2008)] in G-L and H-P herbage during the dry season, is likely to limit milk

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production (4% fat-corrected) from a typical Jamaica Hope cow to approximately 4 - 6 litres/day and 6 - 8 litres/day, respectively.
During the intermediate and wet season, milk production from herbage with similar ME content to G-L and H-P could potentially peak at between 6.5 and 9 litres/day, respectively, provided DMI is sufficient. Jamaican pastures of the type assessed in the present study could potentially support moderate to high levels of beef production. Herbage similar to that collected by "hand-plucking" should provide enough ME (4.5 – 11.9 MJ/kg DM) to maintain ADG of 0.5 – 1.0 kg/day (NRC, 1996) for a typical Jamaica Red cattle (300 – 400 kg BW) provided DM of 3.5 – 8.5 kg is consumed daily. However, the fibrous nature of these grasses might be a limiting factor in achieving the required DMI (Jung and Allen, 1995; Dewhurst *et al.,* 2009) to achieve these levels of production. Under typical grazing management in Jamaica, in which beef cattle are allowed to graze one paddock for as long as six days; intake of the required level of ME might be inhibited after the first two days of grazing as the proportion of available leaf declines (Chacon and Stobbs, 1976). This might also be injurious to the leaf initials thus resulting in sward deterioration (Chacon and Stobbs, 1976). Therefore, farmers need to limit grazing duration to below three days in order to optimize nutrient intake. Jamaican researchers have, in the past, relied on gross energy determination (by adiabatic bomb calorimetry) to estimate ME. Determination of GE is, however, costly and time consuming. Estimation of metabolizable energy using the McDonald equation offers a simpler and more convenient method for predicting ME of feedstuffs with similar accuracy; since the difference between both methods has been found to be non- significant ($P < 0.05$).

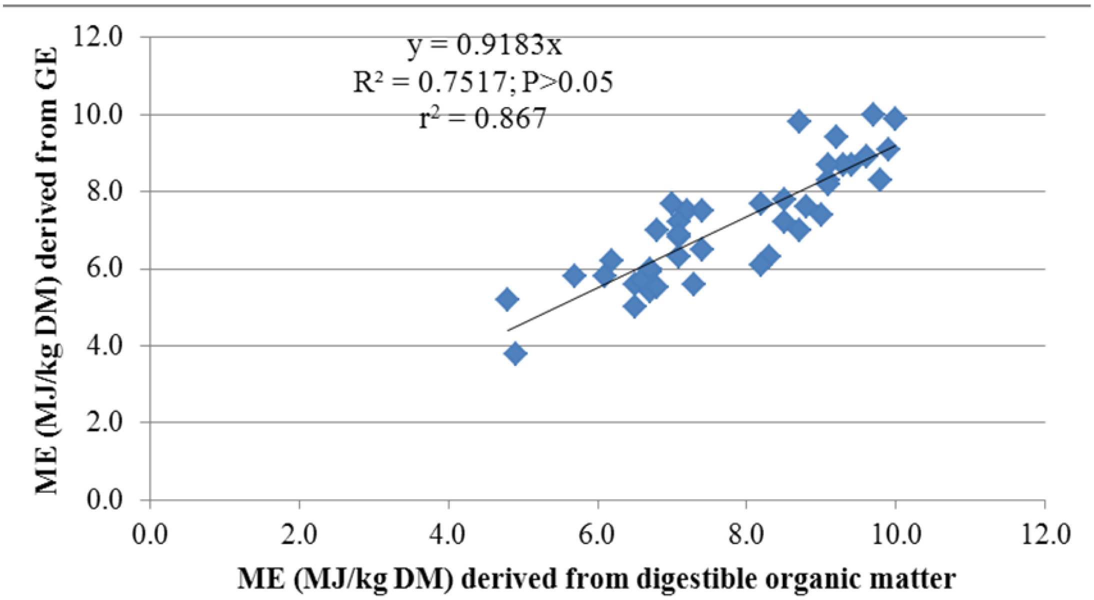

Figure 6 Relationship between ME (MJ/kg DM) derived from GE and ME (MJ/kg DM) derived from digestible organic matter

CONCLUSION

This study has demonstrated that sampling rotationally grazed tropical pastures at ground level, significantly under-estimates the nutritive value of the herbage likely to be harvested at grazing by cattle. The nutritive value of G-L harvested herbage was consistently low; with particular reference to CP, *in vitro* OM digestibility and ME concentrations. Nutritive value of hand- plucked herbage indicate great potential for sustaining moderate to high levels of milk and beef production. This highlights the importance of a previous recommendation by Hughes et al., (2011) to mow pastures at least once annually to increase the proportion green leaf relative to stems and residual OM offered for grazing. Current national production levels for milk (2 422 L/ha.) and beef (136.5 kg/ha), highlight the fact that Jamaican pasture lands are under-utilized. These performance levels indicate that only 30 % and 20 % of the productive capacity of Jamaican pasture lands is exploited for milk and beef production, respectively (Jennings, pers. comm.). The nutritive value of grazed pasture is more accurately assessed through the use of hand-pluck grass samples. Analysis of samples harvested at ground level significantly understates the productive potential of tropical pasture systems.

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HAEMATOLOGICAL INDICES OF CAPTIVE BLACK NECK OSTRICHES

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ORIGINAL ARTICLE

ABSTRACT: *This study was conducted at Sudan University of Science and Technology College of Veterinary Medicine and Animal Production Department of fisheries science and wildlife in June 2011 to determine hematological values of Black Neck Ostrich Struthio Camelus massaicus collected from El Safa farm North Khartoum. Values of some hematological parameters of 14 Black Neck Ostrich 7 male and 7 female age from 3-4 year, and 70–75 kg in weight were examined to determine the mean values obtained for White Blood cells Count (WBC), Erythrocytes Count (RBC), Hemoglobin Concentration Rates (Hb), Packed Cell Volume (PCV), Mean Corpuscular Volume (MCV/cl) and Erythrocytes Sedimentation Rate (ESR). The result of this study show that there are no significant different in all blood values between samples collected from male and female at p (P<0.0°), expect in Red Blood Cells (RBC) there is significant different at (P<0.05). The main target of this study is to comparison between hematological values of Black Neck Ostrich in both male and female.*

Key words: *Hematological, Ostrich, Parameters, Captivity, Birds*

INTRODUCTION

Clinical haematology has been used for many years in avian medicine for evaluation of health in birds. Hematological and biochemical values can be helpful in assessing infection, organ function and many diseases. The fact that physiological and pathological factors may cause qualitative and quantitative changes in hematological values makes such studies an important aspect of the diagnostic panel and of the monitoring of sick birds (Levi et al., 1989; Perelman, 1999). Qualitative and quantitative hematologic changes in ostriches depend on age, sex, different physiological and pathologic status, stress, nutrition and conditions in particular geographic areas. The results of hematologic parameters in the blood of ostriches should be strictly interpreted because they are necessary together with good anamnesis and physical examination for reaching a proper diagnosis (Perelman, 1999; Raukar, 2004).

Ostriches are peculiar flightless birds with vestigial wings and have well-developed legs. They are the largest living birds, and their adult body weight is ranging from 70 kg to 150 kg (Palomeque et al., 1991; Spinu et al., 1999). Since rapid growth and size achieved at slaughter age are important properties of ostriches, they are considered as a considerable commercial species characterised by economic advantages with relatively low costs. Moreover, ostrich meat is high in protein and low in fat, and its taste is appreciated by consumers (Minelli et al., 1995).

The hematological parameters and the levels of certain plasma metabolites may provide highly valuable information on the physiological status and allow the detection of possible diseases (Jenni-Elermann, 1998; Spinu et al., 1999). Clinical hematology and blood chemistry are known to be influenced by various factors such as diseases, nutritional status, body condition, sex, age, diet, circadian rhythms, captivity etc. (Woerpel et al., 1984; Palomeque et al., 1991; Tully et al., 1998; Spinu et al., 1999; Quintavalla et al., 2001). Therefore, determination of blood constituents for birds are not only relevant diagnostic tools in veterinary medicine, but can also be used as physiological indicators (Perelman, 1999).

The aim of the present study was to present values of certain blood hematological parameters in Black Neck Ostriches between male and female. For this purpose, some haematological parameters used as diagnostic tools in avian medicine were determined.

MATERIAL AND METHODS

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Research was carried out on 14 clinically healthy 3-4 years old sexed Black Neck ostriches species *Struthio camelus massaicus* 7 male and 7 female weighted about 70-75 kg. The birds were kept in El Safa farm Northern Khartoum, Sudan at least about two year.

hematological investigations were conducted in physiology laboratory at college of veterinary medicine and animal production in June 201 ١ to determining the following parameters of total number of Red Blood Cells (RBC), total number of White Blood Cells (WBC), Packed Cells Volume (PCV), ESR, Mean Corpuscular Volume Cells (MCVC) and Means Corpuscular Hemoglobin Concentration (MCHC) we collected individual samples of blood on heparin, which were processed by classical hematological techniques (5, 9). The finding data of this experiment were analyzed by T- test (student test) and SPSS version 17 as described by Comez and Comez 1984.

RESULTS

Results of total erythrocyte count (TRBC), hemoglobin concentration (Hb), hematocrit (Hct), the mean corpuscular values (MCV, MCH, MCHC) and (ESR) in blood of 14 examined old ostriches 7 male and 7 female are presented in Table 1., Figure 1 and 2.

The reported results show the following: the lowest value for erythrocyte count in female was 16.8 $\pm 8.7^{b}$/L and the highest value in male was 19.66 ± 7.7^{a} /L. The lowest level of hemoglobin concentration (H b) was 79.3 g/L in male and the highest level was 80.03 g/L in female.

The mean value of the MCV was 8.6 fL and the standard deviation was 1.14 fL in male. The mean value for the MCV was 5.35 fL and the standard deviation was 1.5% (Table 1).

The mean value of the MCH was 31.8 pg and the standard deviation was 0.45 pg in male and mean value of the MCH was 31.8 pg and the standard deviation was 0.49 pg in female.

The mean value of the total White blood Cells(WBC) was 3010.57 and the standard deviation was 365.28 in male and the mean value of the (WBC) in female was 3013.23 and the standard deviation was 344.63.

The mean value of the PCV was 41.66 and the standard deviation was3.9 in male. The mean value for the PCV was 42.0.1 and the standard deviation was 6.1 in female (Table 1).

The mean value of the ESR was 1.36 and the standard deviation was0.45 in male. The mean value for the ESR was 1.40 and the standard deviation was 0.03 in female (Table 1).

Table 1 - Haematological values of Black Neck Ostrich samples collected from El Safa ostrich farm

Parameters	Units	Male	Female	Sig
RBC	10^6	19.66 ± 7.7^{a}	16.77 ± 8.7^{b}	*
WBC	10^3	3010.57±365.28	3013.00±344.63	NS
PCV	%	41.66±3.9	42.00±6.1	NS
Hb	%	79.3±3.9	80.03±3.0	NS
ESR	Mm/h	1.36±0.45	1.40±0.03	NS
MCVC	10^{-4}(cm)	8.6±1.14	5.35±1.5	NS
MCHC	%	31.8±0.45	31.80±0.49	NS

a,b: within the same row followed by different superscript are significantly different (P≤0.05). NS: No significant, *: significant at P<0.05.

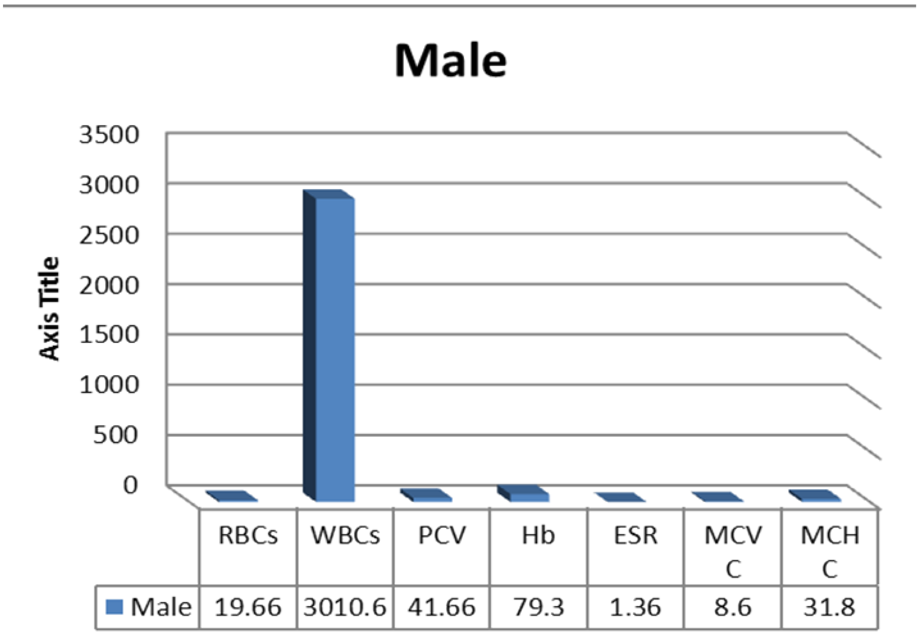

Figure 1 - Hematological values of Black Neck Ostrich male

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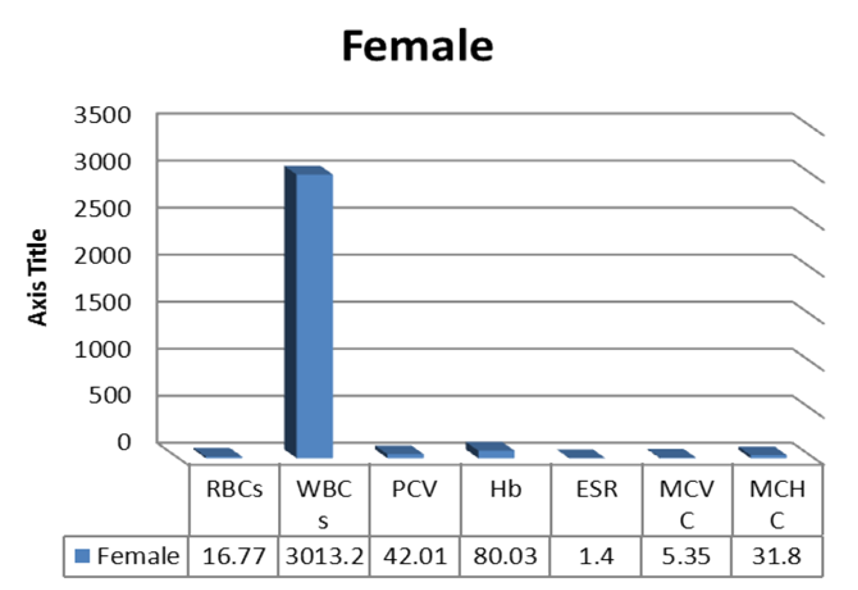

Figure 1 - Hematological values of Black Neck Ostrich female

DISCUSSION

Hematological studies have been widely used as means of assessing the state of health of Ostrich and the establishment of the hematological characteristics of Avian generally serves as a standard for physiology, pathological or toxicological studies.

The main objective of this study is comparison of blood parameters of Black Neck Ostrich collected from El Safa farm the results obtained revealed no significant different (P<0.05) between the male and female in all parameters examined except (RBC) there is high significant different between male and female.

In case of White Blood Cells (RBCs) there was significant different in $RWBC_s$ count between male and female, White Blood cells in male and female were count at high range (19.66 ± 7.7^{a}), (16.77 ± 8.7^{b}) respectively in ostrich male and female were an agreement with Palomeque et al. (1991) who find that the average RBC length and width observed slightly larger in adult avian.

Also in case of Red Blood Cells (WBCs) there was no significant different in $TRBC_s$ count between male and female, Red Blood cells in male and female were count at range (3010.57±365.28), (3013±344.63) respectively in the studied ostrich,our findings were similar to those reported by Palomeque et al. (1991) and Spinu et al. (1999), but were higher than those of Levy et al. (1989a) and Polat et al. (2001). Although Levy et al. (1989a) reported that growers may have relatively higher numbers of white blood cells.

The result revealed that there was no significant different in PCV% between male and female (P≤0.05). PCV% in male and female were count at range (41.66±3.9), (42.0±6.1) respectively this finding with agreement to palomeque et al. (1991) and Brown and Jones (1996) who reported mean PVC% similar to our finding.

In this study, comparing the haematocrit with sex groups, it was found that haematocrit values in the ostrich male were similar to ostrich female, the revealed no significant different in haematocrit between the two group (P<0.05). The mean haematocrit values were similar to those reported by (Palomeque et al. 1991; Brown and Jones 1996), but were higher than the values noted by Levy et al. (1989a) for ostrich chicks. In addition, for most birds, it was reported that the values of haematocrit are greater in adults than in juveniles (Palomeque et al. 1991; Peremann, 1999). The age-related increase in haematocrit values might be due to the greater oxygen demand of young ostriches for activity. Besides, Brown and Jones (1996) mentioned that haematocrit in ostriches is well regulated and even ehydrated. Birds show no or little haemoconcentration. The findings in this study for the MCH and MCHC were in agreement with those previously obtained by Palomeque et al. (1991), while the values for MCV were slightly lower in ostrich female than male. Perelman (1999) stated that the MCV, MCH and MCHC in ostriches tend to increase with age, but we study mature bird with same age.

The obtained that there was no significant different in haemoglbin concentration (Hb) between male and female (P≤0.05). Haemoglobin concentration (Hb) in male and female were count at range (79.3±3.9), (80.03±3.0) respectively this finding is agreement some authors have reported that haemoglobin levels of ostriches were within the range of most birds (Palomeque et al., 1991; Perelman, 1999). The values for the haemoglobin concentration were in accordance with those of Levy et al. (1989a). Although our findings were lower than the values obtained by Alomeque et al. (1991) for juvenile and adult ostriches, it was higher than those determined by Polat et al. (2001) for adult ostriches. This may be ascribed to differences in breed and in the physical and environmental condition.

The present study obtained that there is no significant between mean value of the ESR in ostrich male and female. The mean value for the ESR was (1.36±0.45), (1.40±0.03) respectively the findings in this study for the ESR were in agreement with those previously obtained by Palomeque et al. (1991).

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FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF SUDAN BAGGARA BULLS FED VARYING LEVELS OF PELLETED SORGHUM STRAW

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ABSTRACT: Thirty six entire Sudan Baggara bulls of an average weight 201.53±6.85 kg and 2.5 year age were divided into four groups of nine animals each. These bulls were fed varying levels of pelleted sorghum straw (roughage portion) with a concentrate molasses based mash diet to examine the effect of nutrition on their feedlot performance and carcass characteristics. Results showed that, feeding of varying levels sorghum straw did not affect dry matter intake (DMI), average daily gain (ADG) and feed conversion ratio (FCR). Carcass characteristics and meat quality attributes were not affected by the treatments, but showed variable results.

ORIGINAL ARTICLE

Key words: *Bulls, Pelleting, Molasses, Feedlot, Carcass Characteristics*

INTRODUCTION

Sorghum straw is an agricultural by-product remaining after harvesting the cereal crop. It is an aerial part of sorghum plant that, either left in the field to be ploughed later in the soil or being grazed by animals. In Sudan sorghum straw were harvested two weeks after grain harvest and may be subjected to further processing like chopping or pelleting to be fed to animals. Abdlrahman et al. (1981) reported that Sudan produces about 64% of all the amount of sorghums straw in the Arab world, but its use as an animal feed is abundant in spite of the high transportation costs. Chemically sorghum straw is primarily composed of cellulose, hemicellulose and lignin in addition to protein, sugar and ash (Elkhidir et al., 1984). The objectives of this study were to examine the effect of pelleting sorghum straw at varying levels on feedlot performance, carcass characteristics and meat quality of Sudan Baggara bulls.

Materials and Methods

This experiment was conducted at the Animal Production Research Centre, KuKu (APRC), Khartoum North during (July – October 2006). Thirty six entire Sudan Baggara bulls of 2.5 year old and with an average body weight of 201.53±6.85 kg were used in this experiment. The bulls belong to the commercial herd of (APRC) purchased from the local market of Omdurman (Elmoelih). They were trekked to the site of experiment and accommodated into four feeding groups of nine animals each, further subdivided into three subgroups of three animals each in shaded pens (4 x 3 m). An adaptation period of three weeks was allowed to the animal prior to commencement of the feeding trial. The four feeding systems were offered molasses based-diet mash + 10, 20, 30 and 40% pelleted sorghum straw roughage, for group A, B, C and D, respectively. The molasses based diet was composed of 50% molasses, 39% wheat bran, 5% groundnut cakes, 3% urea, 1% and common salt. Sorghum straw pellets offered separately as a roughage portion at first then followed by the molasses-based diet at 7:00 am daily. The molasses and urea were incorporated as major source of energy and nitrogen, respectively. The total metabolizable energy (ME) for the molasses diet and sorghum straw pellets was 11.1 and 6.7 MJ/kg DM, respectively as shown in Table (1). The experiment continued for 60 days during which measurement of dry matter intake (DMI), average daily gain (ADG), feed conversion ratio (FCR) were recorded. The bulls were slaughtered at a finishing live weight of 260 kg,

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while the carcass cuts was performed following the MLC (1974) method for beef carcass. Chemical composition of the meat was done as described by AOAC (1975) method. Meat quality attributes, water holding capacity (WHC), cooking loss determination, objective measurement of tenderness and sensory evaluation were performed and calculated.

Statistical analysis

Data was statistically analyzed by Stat soft, Inc (1995) for windows (computer program manual). Least squares means were calculated and significance was declared at (P<0.05).

Table 1 - Chemical composition of the experimental diet

Component (%)	Molasses concentrate Mash	Sorghum straw Pellets
Dry matter (DM)	88.4	95.6
Ash	6.2	7.88
Crude protein (CP)	19.6	5.81
Ether extract (EE)	2.12	2.15
Nitrogen free extract (NFE)	56.2	40.8
Metabolizable energy (MJ/kgDM)	11.1	6.7

RESULTS

The experimental diets indicated no differences in feedlot performance of Sudan Baggara bulls in average daily gain (ADG), total live weight gain, dry matter intake (DMI) and the feed conversion ratio (FCR) as shown in Table (2).

Results of the carcass yield and whole sale cuts of the slaughtered bulls were not affected by the dietary treatments as shown in Table (3). Similar results obtained from non-carcass components of the slaughtered bulls, although group A showed high mean values in all parameters investigated compared to other groups and the differences was not statistically significant (P>0.05, Table 4).

Carcass yield and characteristics of Sudan Baggara bulls are shown in Table (5). High slaughter weight observed in group D, while group A showed high values of empty body weight, hot and cold carcass weight as well as dressing percentage and shrinkage percent. No significant differences were found among the experimental groups.

Table 2 - Feedlot performance of Sudan Baggara bulls fed varying level of sorghum straw pellets

Parameters (kg)	Means ± SD			
	A	B	C	D
No. of animals	9	9	9	9
Period (days)	60	60	60	60
Initial live wt (kg)	201±5.65	199±5.46	202±9.05	202±7.12
Final wt (kg)	259±1.67	266±2.50	259±3.63	262±2.50
ADG (kg)	0.96±0.13	1.02±0.17	0.84±0.16	0.91±0.14
Total gain (kg)	56.7±5.00	61.1±4.86	55.6±8.46	59.5±0.08
Total DMI kg/head/day	658±66.3	654.5±7.2	55.6±8.46	59.4±8.08
DMI kg/head/day	9.97±1.63	9.75±1.62	9.74±1.75	9.70±0.90
FCR kg/feed/kg gain	10.4±0.92	9.6 ±0.75	11.7±2.06	10.6±1.65

In this and subsequent tables: A, B, C and D are four rations of molasses based-diet mash (10, 20, 30 and 40 %) pelleted sorghum respectively. SD= Standard Deviation.

Table 3 - Carcass yield of the whole sale cuts of the slaughtered bulls (percent of cold side weight)

Parameters (kg)	Means±SD			
	A	B	C	D
Skin	2.13±0.1	2.08±0.2	2.10±0.1	2.15±0.2
Neck	3.68±0.4	3.65±0.6	3.49±0.6	3.25±0.3
Chuck	6.84±1.0	7.09±1.0	7.30±0.4	7.08±0.7
Clod	4.18±0.6	4.01±0.4	4.13±0.5	7.08±0.7
Ext. roasting ribs	4.09±0.6	4.18±0.6	4.61±0.6	4.37±0.7
Thick ribs	3.54±0.6	3.62±0.5	3.42±0.5	4.56±0.5
Thin ribs	2.06±0.3	1.93±0.3	1.99±0.2	2.01±0.2
Brisket	5.41±0.5	5.35±0.6	5.63±0.6	5.54±0.3
Thin flank	3.95±0.4	4.25±0.2	3.88±0.1	39.3±0.4
Thick flank	3.95±0.4	4.25±0.2	3.88±0.3	2.97±0.3
Sirloin	4.13±0.5	3.98±0.4	4.22±0.3	4.14±0.4
Tope & silver side	11.2±0.4	11.1±0.7	11.2±0.4	11.7±0.5

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Table 4 - Non carcass components of the slaughtered bulls fed varying sorghum straw levels (percent of empty body weight EBW)				
Parameters	Means ± SD			
(kg)	A	B	C	D
Hide wt	20.5±1.9	20.4±2.3	20.3±1.4	19.3±2.6
Head wt	15.7±0.6	15.8±0.3	15.1±0.6	15.6±1.2
Four feet wt	5.99±0.5	5.85±0.3	5.97±0.4	6.08 ±0.5
Stomach wt (full)	29.7±3.7	30.2±5.6	31.8±3.8	33.7±6.1
Stomach wt (empty)	7.71±1.2	7.63±0.7	7.51±0.9	7.17±0.9
Intestine wt	15.4±1.9	14.2±1.7	15.6±2.3	15.2±2.6
Mesenteric fat	1.16±0.3	0.92±0.2	0.23±2.2	0.22±2.3
Omental fat	3.19±0.8	3.03±0.4	2.22±0.6	2.32±0.5
Kidney fat	2.37±0.7	2.44±0.5	2.22±0.5	2.30±0.5
Kidney wt	0.66±1.6	0.67±0.1	0.64±0.1	0.68±0.1
Liver wt	4.38±0.6	4.20±0.6	3.97±0.4	4.11±0.4
Heart wt	0.92±0.1	0.86±0.1	0.84±0.1	0.91±0.1

Table 5 - Carcass yield and characteristics of Sudan Baggara bulls				
Item	Mean ± SD			
	A	B	C	D
Slaughter wt (kg)	259.4±1.67	206±2.5	257.8±3.63	261.7±2.5
Empty body wt (kg)	230.1	231	225.9	227.8
Hot carcass wt (kg)	138.9±5.26	136.9±6.34	135.3±3.69	136.8±3.11
Cold carcass wt (kg)	134.7±5.1	133.3±6.6	132±3.9	133.7±3.3
Hot carcass dressing (%)	53	52	52	52
Cold carcass dressing (%)	51	51	51	51
Shrinkage %	3.32±0.5	2.96±0.4	2.66±0.6	2.6±0.9

Bulls in group B appeared to contain more fat (6.93) than others but no difference were observed (P>0.05). The percentage of meat, bone and connective tissue did not affected by the treatment and appeared to be similar (Table (6). The study found high values of water holding capacity (WHC) in group C and lower in group D which received high amount of sorghum straw. However, cooking loss was higher in group C and D. No significant differences were observed between groups (P>0.05, Table 7). Juiciness and tenderness of meat were higher in group A (6.79, 6.99) and B (6.40, 6.74), respectively than in groups C (4.18, 4.40) and D (3.43, 3.76). The same pattern was found in the panelist score for overall acceptability (Table 8). These parameters were not affected by the experimental diets (P>0.05). Table (9) illustrates meat chemical composition of *longissimus dorsi* muscle of Baggara bulls. High moisture content (75.6 %) found in group C and high crude protein (22.6 %) in group B and D. No significant differences were found between treatments (P>0.05).

DISCUSSION

Feedlot performance

Feeding varying levels of sorghum straw pellets did not affect the finishing period and all bulls reached the target weight (260 kg). The dry matter intake reported in this study showed variable values, It was higher in group C (30% sorghum straw) and D (40% sorghum straw) compared to group A (10% Sorghum Straw) and B (20% Sorghum straw). This might be attributed to the lower energy content and higher fibre content in diet C and D. These results were consistent with those reported by Martens (1985), Merchen et al. (1987), Ketelaars and Tolkamp (1996) and McDonald et al. (2002). Feed intake increases as the concentration of energy in the diet decreased as reported by Mohamed (1999) and shown in Table (1).

Table 6 - Composition of high priced whole sale cut (9 - 10 and 11^{th} rib cut) as percent of the cut weight.				
Parameters	Means ±SD			
	A	B	C	D
Muscles	61.2± 5.6	58.3± 5.7	59.4± 5.8	60.8± 2.9
Bone	25.3± 3.4	25.0± 4.4	25.7± 5.5	24.8± 2.4
Connective tissue (C.T)	7.74± 5.1	7.58± 2.6	6.70± 1.4	7.18± 1.2
Fat	4.80± 1.8	6.93± 2.6	4.77± 0.8	4.93± 2.6

The average daily gain was not affected by the treatment diets (P>0.05) and these were in line with the findings of Elshafie and Mcleroy (1964), Mukhtar and Eltiriefie (1970), Eltahir (1994) and Guma (1996). However, the present results were lower than the average daily gain reported for the same breed by Gaili and Osman (1977), Mustafa (1980), Abdelgalil (1997) and Babiker (2008). Feed conversion ratio obtained in this study was affected by the experimental diets which were 9.6 kg in group B as the best value (20% sorghum straw) and 11.1 kg in group C as the least value. This may be attributed to high fibre content in the treatment diets according to the concentration of the sorghum straw. It also indicates that sorghum straw at 20% improved feed conversion ratio and seemed to

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be the optimum level when added to molasses based concentrate diet. These findings were within the range (7.29–11.3 kg) reported by Morre (1991) for Sudan Baggara cattle.

Table 7- Meat quality attribute of *Longissimus dorsi* muscle of Sudan Baggara bulls fed varying levels of sorghum straw pellets.

Parameters	Means ± SD			
	A	B	C	D
Color				
L	33.2± 2.3	34.0± 1.3	34.2± 1.5	34.1± 1.7
A	19.4± 1.7	18.8± 1.6	18.3± 2.6	18.5± 2.5
B	8.28± 0.9	7.86± 0.8	8.00± 0.3	8.09± 1.5
WHC	2.07± 0.5	1.90± 0.4	2.10± 0.2	1.47± 0.3
Cooking loss	34.7± 0.5	34.9± 0.5	36.7± 0.7	37.0± 1.9

Table 8 - Subjective evaluation of *Longissimus dorsi* muscle Sudan Baggara bulls fed varying levels of sorghum straw pellets.

Parameters	Means ±SD			
	A	B	C	D
Colour	5.34± 0.4	6.25± 0.6	5.44± 0.5	5.04± 0.4
Flavour	4.43± 1.1	4.72± 0.4	5.36± 0.3	5.01± 0.5
Juiciness	6.79± 0.3	6.40± 0.7	4.18± 0.5	3.43± 0.4
Tenderness	6.99± 0.2	6.74± 0.4	4.40± 0.4	3.76± 0.0
Overall acceptability	6.50± 0.2	7.00± 0.5	4.00± 0.4	3.50± 0.4

Sample evaluation for color (1 = extremely dark brown, 7 = brown), juiciness (1 = dry, 7 = very juicy), flavor intensity (1=bland, 6 = extremely intense), tenderness (1 = tough, 7 = tender) and over all acceptability (1 = unacceptable 7 = acceptable).

Table 9- Chemical composition of *Longissimus dorsi* muscle of Sudan Baggara bulls fed varying levels of sorghum straw pellets (percent of fresh muscle weight)

Parameters (%)	Means ±SD			
	A	B	C	D
Moisture	74.9± 0.7	75.3± 1.0	75.6± 0.3	75.2± 0.8
Crude Protein	22.1± 1.7	22.6± 1.1	21.9± 1.1	22.6± 1.4
Intramuscular fat	2.07±1.1	2.43±1.1	1.59±0.5	2.18±0.9
Ash	1.57± 2.1	0.88± 0.3	1.00± 0.4	0.90± 0.2

Results related to carcass yield were not influenced by the treated diets, however, bulls in group A and B showed slight increase in the empty bodyweight over group C and D. This may be partially attributed to the high gut fill of group C (30% sorghum straw) and D (40% sorghum straw). This goes in line with Stobo (1964) who found an association between the fibre content of the diet and rumen fill. No differences in the dressing percentage of Sudan Baggara bulls reported in this study, this may be due to the similar slaughter weight (260 kg). These findings goes in accord with Preston and Wills (1974) who reported that dressing percentage increased with the increase of live weight. In addition, the percentage of shrinkage of slaughtered bulls was affected by slaughter weight rather than the treatment. These finding is consistent with the results of Eltahir (2007) who reported that subcutaneous fat reduces the moisture evaporation when bulls slaughtered at heavier weights.

Results of meat quality attributes in this study indicated that, bulls fed high energy and protein levels showed improved water holding capacity (WHC) and lower cooking loss. This was in agreement with the conclusion obtained by Ahmed (2003) for the same breed. Panelists preferred meat obtained from bulls fed 10 and 20% sorghum straw pellets than that of 30 and 40% sorghum straw. This might be attributed to the higher juiciness and tenderness of the meat of the former bulls.

It could be concluded that pelleting of sorghum straw could improve the nutritive value and palatability for the animal. Furthermore, sorghum straw could be added to the diet to a level of 40% without negative effect, but good results could be obtained at level 20% sorghum straw.

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PREDICTION OF LIVE BODY WEIGHT FROM LINEAR BODY MEASUREMENTS OF WEST AFRICAN LONG-LEGGED AND WEST AFRICAN DWARF SHEEP IN NORTHERN GHANA

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ABSTRACT: *The knowledge of live weight of animals is so important in the livestock production and marketing practices that this study was undertaken to develop models for predicting the weight of sheep at market ages. Data comprising of the weight and linear body measurements were collected on the West African Long-Legged (WALL) and the West African Dwarf (WAD) sheep from Pong-Tamale and subjected to regression analyses. The results revealed that heart girth was the best predictor of liveweight, with prediction accuracies of 92.36% for two years old WALL sheep and 81.20% for one year old WAD sheep, while wither height was the second most important trait in liveweight prediction, in simple linear models. The quadratic models of the single-trait models also had heart girth as the best predictor of liveweight, recording 92.92% accuracy for one year old WALL sheep. Only two traits were mostly required for weight estimation in the multiple-trait models, and the best model was obtained from two years old WALL where heart girth and body length accounted for about 95.53% in prediction accuracy. The multiple-trait quadratic models were generally better in liveweight prediction compared to the respective linear models. Clearly, weight estimation was more accurate among the WALL than the WAD sheep, and also among the younger sheep regardless of the breed. The variations in the models suggest that breed and age of sheep had influence on the type of models required to predict their live body weight.*

ORIGINAL ARTICLE

Key words: *Estimation, Linear models, Livestock, Liveweight, Multiple regression, Quadratic model*

INTRODUCTION

The knowledge of weight estimation in sheep is paramount in sheep production as it is useful in the control and management of the herd during the entire rearing process. It has been used in administering medications, nutritional rationing and marketing of sheep. The prices of animals depend mainly on body weight. In Ghana, only the few large-scale livestock farms have proper weighing scales or bridges and market their animals based on weight. Within the rural communities, proper weighing scales or bridges are neither available nor affordable, but even if they were, it would be inconveniencing and a huge task to carry and assembly them, each time to weigh animals especially during marketing. Middlemen and butchers therefore move around the villages buying animals from farmers whose pricing system is often based on visual appraisal, a practice which does not favour farmers.

Measurement of linear body parameters have been used to estimate necessary information (like weight and size) in sheep, while other information are estimated by observing certain parameters such as age estimation from the number and shape of teeth (incisors) (Hamito, 2009). Linear body measurements (LBM) can also be used to assess growth rate, feed utilization and carcass characteristics in farm animals (Brown et al., 1973). According to Essien and Adesope (2003), LBM are divided into two groups; these include skeletal and tissue measurements. Skeletal measurements include all the height and length measurements while tissue measurements include heart girth, chest depth, punch girth and width of hips.

Live weights and body measurements taken on live animals have been used expansively for a diversity of reasons both in experiments and in breeding and selection procedures (Cam et al., 2010a). The accuracy of functions used to predict live weight or growth characteristics from live animal measurements is of immense financial contribution to livestock production enterprises. When the producers and buyers of livestock are able to relate live animal measurements to growth characteristics, an optimum production and value-based trading systems will be realized from accurate predictions. This will ensure that livestock farmers are adequately rewarded

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rather than the middlemen and/or livestock product processors that tend to gain more profit in livestock production business, especially in the rural areas of developing countries (Afolayan et al., 2006; Safu et al., 2009).

A number of studies have been carried out on linear measurements in several African sheep breeds but little is known about the breeds available in Ghana. It is therefore important to study linear body measurements of local sheep breeds in Ghana, particularly the West African Long-Legged (WAD) also called Sahel and the West African Dwarf (WAD) also called Djallonke, because most traditional farmers lack weighing scale/bridge and adequate knowledge to understand its manipulation. Besides, little is known about works done with regards to the local breeds in Ghana. This study was therefore undertaken to develop models for predicting the weight of the Ghanaian local sheep at market ages.

MATERIALS AND METHODS

Management of experimental sheep

The sheep were managed semi-intensively, housed in properly constructed pens throughout the night and sometimes during the day when there was the need to restrict their movement. Feed and water were provided for the sheep *ad-libitum* throughout the year. Conventional disease and pests control regimes were practised.

Data collection

A total number of 293 sheep (WAD and WALL) were used for the study of which 74 were one year old, 58 were two years old and 161 were three years old and above. The ages of the one and two years old animals were determined from their birth records (birth date) while dentition was used for the three years old and above sheep as most of them had no birth records. The variables measured included, live body weight (LW), body length (BL), heart girth (HG), chest depth (CD), height at withers (HW), rump height (RH), neck girth (NG), pin-bone width (PBW), age and sex of each animal. The linear body dimensions were defined and measured according to Birteeb et al. (2012).

Statistical analysis

The data were grouped by breed and by age into six groups namely; Breed1-Age1 (one year old WALL), Breed1-Age2 (two years old WALL), Breed1-Age3 (three years old and above WALL), Breed2-Age1 (one year old WAD), Breed2-Age2 (two years old WAD) and Breed2-Age3 (three years old and above WAD) for regression analyses. Each group was tested for normality assumption using the Kolmogorov-Smirnov test. With the exception of Breed1-Age1 and Breed2-Age3, the LW of all other sheep groups were not normally distributed and so were log-transformed in order to stabilise the variance and avoid violating the normality assumption required for regression analysis. Hence predicted LW must be antilog-transformed to obtain live body weight (in kg) of sheep in the four groups. Each simple linear regression was run using PROC REG procedure. The selection of significant variables in the multiple linear regressions was achieved by the use of the SELECTION=STEPWISE option of PROC REG. All variables selected in the linear models were then included in the quadratic regression models, which were analysed using the PROC GLM procedure. The regression model for the i^{th} group of sheep in the simple linear regression is:

$$y_{ij} = \mu_i + \beta_i x_{ij} + \varepsilon_{ij} \ ; \qquad \varepsilon_i \sim N(0, \sigma^2) \qquad \text{...... [1]}$$

Where y_{ij} = the weight of the j^{th} individual in the i^{th} group

μ_i = the average weight (intercept) of the i^{th} group

β_i = the regression coefficient for the i^{th} group

x_{ij} = the trait (HG, HW, RH or BL) value of the j^{th} individual in the i^{th} group

ε_{ij} = the error associated with the weight of the j^{th} individual in the i^{th} group

The quadratic form of model [1] is given by:

$$y_{ij} = \mu_i + \beta_{i1} x_{ij} + \beta_{i2} x_{ij}^2 + \varepsilon_{ij} \qquad \text{...... [2]}$$

For the multiple linear regression, the model is given by:

$$y_{ij} = \mu_i + \beta_{i1}(HG_{ij}) + \beta_{i2}(HW_{ij}) + \beta_{i3}(RH_{ij}) + \beta_{i4}(BL_{ij}) + \beta_{i5}(NG_{ij}) + \varepsilon_{ij} \qquad \text{...... [3]}$$

Given that out of the five (5) traits in equation [3] above, only x_1, x_2,..., x_k are the *k* (*k*<5) traits that are selected and retained through the stepwise regression procedure, then the quadratic regression model of these selected traits would be:

$$y_{ij} = \mu_i + \beta_{i1} x_{1ij} + \beta_{i2} x_{2ij} + \ldots + \beta_{ik} x_{kij} + \beta_{i(k+1)} x_{1ij}^2 + \beta_{i(k+2)} x_{2ij}^2 + \ldots + \beta_{i(k+k)} x_{kij}^2 + \varepsilon_{ij} \qquad \text{...... [4]}$$

RESULTS

Morphological traits

The effects of breed and age on the morphological traits are presented in Table 1. The breed significantly (P<0.05) affected all morphological traits as higher values were recorded for WALL sheep against smaller values for the WAD sheep. Similarly, mature animals had higher (P<0.05) mean values for all body measurements than young animals. The heart girth was the most varied trait whereas the pin-bone-width was the least varied among all the traits irrespective of the breed or the age.

Table 1 – Least square means (±S.E.) of liveweight (kg) and linear body traits (cm) of Ghanaian sheep as affected by breed and age

Parameters / Traits	Breed		Age	
	WAD	WALL	Young	Mature
Liveweight (LW)	21.69±0.48[b]	27.54±0.80[a]	16.39±0.70[b]	32.84±0.61[a]
Height at withers (HW)	56.98±0.39[b]	65.33±0.66[a]	56.18±0.57[b]	66.13±0.50[a]
Rump Height (RH)	55.83±0.49[b]	66.25±0.82[a]	56.24±0.72[b]	65.84±0.63[a]
Body Length (BL)	55.15±0.46[b]	60.12±0.77[a]	52.10±0.68[b]	63.18±0.59[a]
Heart girth (HG)	65.77±0.58[b]	71.67±0.97[a]	60.38±0.85[b]	77.07±0.75[a]
Neck Girth (NG)	37.15±0.39[b]	39.31±0.65[a]	32.45±0.57[b]	44.01±0.50[a]
Check Depth (CD)	25.26±0.24[b]	29.77±0.40[a]	24.12±0.35[b]	30.91±0.30[a]
Pin-Bone Width (PBW)	11.94±0.11[b]	12.99±0.19[a]	11.28±0.17[b]	13.65±0.15[a]

[a,b]Means within the same row having different superscripts differ significantly (*P* < 0.05) between the two breeds and ages. S.E. = standard error.

Liveweight prediction based on linear models

Using one trait as a regressor, the results revealed that the linear regression of LW on HG had the highest adjusted coefficient of determination, while the second most important trait for predicting LW was HW for Breed1-Age1 (Table 2). With HG as the regressor in predicting live weight of a one year old and two years old WALL sheep in this study, the respective models can be written from the tables as follows:

$$\widehat{LW} = 0.63(HG) - 21.966$$

$$\widehat{LW} = antilog\,(\widehat{lw}) = 0.218 + 0.016(HG) \quad \text{......... [5]}$$

Where $\widehat{LW}$ = predicted live body weight of sheep

$\widehat{lw}$ = predicted live body weight (this value is in logarithms form).

With the exception of models of Breed1-Age1 (1 year old WALL) and Breed2-Age3 (3 years old or more WAD), the predicted LW of all other models (in Tables 2 and 3) must be antilog-transformed to obtain the predicted live weight (kg) because their LW's were log-transformed before used for the regression analysis.

The trend of importance of the traits in LW prediction among the two years old WALL sheep was very similar to that of the one year old WALL sheep, with HG being outstanding among other traits in estimation of LW. However, all the traits appeared to predict LW better in the two years old than the one year old and three years old and above WALL sheep (Table 2). Interestingly, BL assumed more importance in predicting LW than RH in the three or more years old WALL sheep.

The trend of importance of weight prediction using the linear body traits of WAD sheep was very similar to that of the WALL except that the amount of variations explained by the regressors were generally lower in the former (Table 3). Expectedly, HG was the best trait for predicting LW across all ages for the WAD breed of sheep. Clearly BL and RH are not good predictors of LW especially in the older (three years and above) WAD sheep in this study.

Table 2 – Regression of body weight on body traits in WALL sheep

Age (years)	Variable	Linear			Quadratic			
		α	b_1	R^2_{adj}	α	b_1	b_2	R^2_{adj}
1	HG	-21.966	0.630	86.03	62.306	-2.153	0.023	92.92
	HW	-43.518	1.035	68.78	219.655	-8.159	0.080	71.58
	RH	-41.075	0.977	66.56	295.416	-10.630	0.010	72.29
	BL	-25.075	0.797	53.20	168.299	-6.913	0.076	59.42
2	HG	0.218	0.016	92.36	0.633	0.005	2.3E-4	91.60
	HW	-0.010	0.022	82.23	2.500	-0.054	6.4E-4	81.81
	RH	0.058	0.020	80.43	0.634	0.003	1.2E-4	78.36
	BL	0.061	0.022	76.60	1.931	-0.038	4.7E-4	74.82
≥ 3	HG	0.469	0.013	84.61	0.982	0.001	1.2E-4	84.33
	HW	0.507	0.015	72.58	0.629	0.011	2.4E-5	71.73
	RH	1.041	0.007	49.04	1.657	-0.017	2.1E-4	72.35
	BL	0.633	0.014	61.99	2.924	-0.056	5.3E-4	64.88

[1]All models were highly significant at 0.01 level; [2] α = intercept of the model. [3] b_i = parameter estimate of the *i*[th] variable.
[4] $pE - q = p \times 10^{-q}$, where *p* and *q* are constants and *E* is exponent.

The results of the multiple linear regression of LW on the body traits are presented in Table 4. Through the stepwise regression procedure, the results indicated that only two traits were required to predict LW in all the sheep and across all ages, except in the one year old WAD where three traits (HG, HW and BL) were required (Table 4). It is interesting to note that HG was the single most important trait required alongside other traits for weight estimation in all the sheep samples in these study. Even though BL predicted LW abysmally when it was used as the only regressor (Tables 2 and 3), paradoxically it was retained alongside HG in most of the samples (Table 4). This implies that BL is important in weight prediction when used alongside HG than when used alone.

Table 3 – Regression of body weight on body traits in WAD sheep

Age (years)	Variable	Linear			Quadratic			
		α	b_1	R^2_{adj}	α	b_1	b_2	R^2_{adj}
1	HG	0.114	0.018	81.20	-1.242	0.064	-3.8E-4	83.66
	HW	-0.447	0.030	67.70	1.050	-0.026	5.2E-4	67.38
	RH	-0.372	0.029	66.86	1.186	-0.030	5.7E-4	66.63
	BL	0.024	0.022	60.58	-1.230	0.071	-4.7E-4	61.07
2	HG	0.465	0.013	63.38	1.751	-0.025	2.8E-4	64.11
	HW	0.175	0.020	47.50	0.524	0.008	1.0E-4	46.33
	RH	0.269	0.019	40.86	0.053	0.027	-6.7E-5	39.52
	BL	0.579	0.014	54.54	0.199	0.027	-1.2E-4	53.69
≥ 3	HG	-6.263	0.436	39.62	114.978	-3.298	0.029	49.82
	HW	-11.619	0.596	35.22	22.948	-0.616	0.011	34.96
	RH	-10.465	0.587	34.86	25.512	-0.697	0.011	34.66
	BL	-3.178	0.460	25.34	-50.055	2.123	-0.015	25.37

[1]All models were highly significant at 0.01 level. [2]α = intercept of the model. [3]b_i = parameter estimate of the i^{th} variable. [4]$pE-q = p\times 10^{-q}$, where *p* and *q* are constants and *E* is exponent.

The combination of HG and BL ensured a better estimation of live weight among the two years old WALL sheep than any other group. NG together with HG was quite important in predicting LW in the one year old WALL sheep, while RH was an important trait for predicting LW in the oldest (3 years old and above) WALL sheep where it was retained together with HG .

Liveweight prediction based on quadratic models

The results of the quadratic regressions of the traits (associated with the linear models) are presented in Tables 2, 3 and 4. The quadratic models for predicting the weight of a yearling WALL sheep using HG (Table 2) and HG and NG (Table 4) are given respectively by:

$$\widehat{LW} = 62.306 - 2.153(HG) + 0.023(HG^2) \quad \text{...... [6]}$$

$$\widehat{LW} = 18.691 - 3.573(HG) + 5.424(NG) + 0.035(HG^2) - 0.087(NG^2) \quad \text{...... [7]}$$

Notably the parameter estimates (b_i) of the quadratic terms of the models whose LW were log-transformed were quite negligible and had to be given in standard form. The R^2_{adj} values associated with the quadratic models of the yearling WALL sheep were generally higher than those associated with the linear models (Tables 2 and 4). Nevertheless, weight estimations by linear models were quite better than those from quadratic models for the two years old WALL sheep. A remarkable observation among the three years and above WALL sheep was the good performance of the quadratic model of RH compared to its linear model in LW prediction (Table 2). Within each age group of the WAD sheep, the HW and RH accounted for almost the same variation in their linear and quadratic models (Table 3). In the use of one trait, the best quadratic model for the WAD sheep was obtained from the use of HG (Table 3) while the best quadratic model from the multiple traits was obtained using HG, HW and BL as regressors (Table 4). For the yearlings of both breeds, most of the quadratic models predicted liveweight better than their corresponding linear models. In general, liveweight estimations were better in WALL sheep than in WAD sheep, even though the combination of traits in the equations differed between the two breeds across all ages.

DISCUSSION

Variations within and among animal genotypes is fundamental to breed characterisation and adaptation to particular ecological zones all over the world. Nonetheless, any variation within or among any species is best and easily evidenced in the morphological characteristics of members of the species. In this study, the differences observed in the linear body dimensions due to breed and age were equally reported by Benyi (1997), Olatunji-Akioye and Adeyemo (2009) and Birteeb et al. (2012). The superiority of matured animals over young ones have been attributed to the effects of age as an important factor influencing body conformation (Birteeb et al., 2012). The Sahelian breed of this study was very similar in body size to the Yankasa breed in Nigeria (Afolayan et al., 2006). However, the two breeds under this study were clearly far smaller when compared to the Zulu sheep from South Africa (Kunene et al., 2007).

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Table 4 – Multiple regression of body weight on body traits of sheep

Age	Breed	Model	Variables	Parameter estimates α	b_1	b_2	b_3	b_4	b_5	b_6	R^2_{adj}
1	WALL	Linear	HG+NG	-25.242	0.417	0.516	-	-	-	-	89.21
		Quadratic	HG+NG+HG²+NG²	18.691	-3.573	5.424	0.035	-0.087	-	-	93.72
	WAD	Linear	HG+HW+BL	-0.214	0.012	0.007	0.006	-	-	-	85.28
		Quadratic	HG+BL+HW+HG²+BL²+HW²	1.079	0.064	0.015	-0.107	-4.3E-4	-8.3E-5	1.1E-3	87.32
2	WALL	Linear	HG+BL	-59.979	0.702	0.576	-	-	-	-	95.53
		Quadratic	HG+BL+HG²+BL²	-23.938	1.631	-1.684	-0.007	0.019	-	-	94.39
	WAD	Linear	HG+BL	0.337	0.009	0.007	-	-	-	-	72.11
		Quadratic	HG+BL+HG²+BL²	1.056	-0.043	0.044	3.8E-4	-3.3E-4	-	-	73.92
≥ 3	WALL	Linear	HG+RH	0.480	0.011	0.002	-	-	-	-	86.72
		Quadratic	HG+RH+HG²+RH²	1.111	-0.003	-3.0E-5	8.1E-5	2.1E-5	-	-	86.36
	WAD	Linear	HG+BL	-19.994	0.368	0.329	-	-	-	-	51.64
		Quadratic	HG+BL+HG²+BL²	33.502	-2.593	1.891	0.023	-0.014	-	-	57.37

[1]All models were highly significant at 0.01 level. [2] α = intercept of the model. [3] b_i = parameter estimate of the i^{th} variable. [4] $pE-q = p \times 10^{-q}$, where p and q are constants and E is exponent.

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The live body weight (LW) of sheep is the single most important growth and economic trait that most stockmen and processors of sheep products pay keen attention to. Even though the use of conventional weighing scales is the best way of determining LW of an animal, LW estimation from linear body measurements is gaining grounds of late (Afolayan et al., 2006; Kunene et al., 2007; Hamito, 2009). In this study HG was the most important trait in predicting live body weight of sheep with higher accuracies in simple linear regressions irrespective of the breed or age of the sheep. With HG as a predictor, the R^2_{adj} values for all sets of WALL sheep herein were higher than the R^2 values of 39%, 78% and 80% respectively, reported for three populations of commercial sheep in Nigeria by Olatunji-Akioye and Adeyemo (2009). About 88% accuracy of predicting live body weight from HG was reported in Yankasa sheep of Nigeria (Afolayan et al., 2006). In an earlier study of two breeds of goats in Ghana, Benyi (1997) reported LW prediction accuracy of 90.40% and 92.01% from HG which was comparable to the performance of HG in this study even though Benyi's work was on a different genus (*Capra*).

From the R^2_{adj} values, it is clear that live body weight could be predicted from the other traits (HW, RH and BL) with a reasonable accuracy in the sheep under the present study, except in the oldest class (3 years and above) WAD sheep, where the predictive abilities of all the traits were awfully low. These low prediction accuracies were only comparable to the 39% obtained for commercial sheep (Olatunji-Akioye and Adeyemo, 2009) but far lower than those reported for animals from on-farm or on-station by Benyi (1997), Adeyinka and Mohammed (2006) and Afolayan et al. (2006). It implied that all the traits were not good predictors of live body weight of WAD sheep that were over two years old. Kunene et al. (2007) and Olatunji-Akioye and Adeyemo (2009) attributed the lower predictability of live body weight from linear body dimensions of sheep to wider variations in the actual (observed) live weight caused by differences in environmental conditions. However, the sheep in the present study were all housed and reared under the same environmental conditions. It is therefore conceivable that an unidentified underlying factor may be implicated.

The palpable significance of HG was particularly illustrated in the multiple linear regressions, where it was required alongside another trait, especially BL, to predict LW in all the samples of sheep. The two traits (HG and BL) are a representation of body volume index of the animal (Baffour-Awuah et al., 1999), and can be seen to be indispensable in liveweight prediction of sheep. This finding is in agreement with other researches where heart girth was found to be the most important and single variable for predicting body weight (Benyi, 1997; Afolayan et al., 2006; Olatunji-Akioye and Adeyemo, 2009). For the one year old WAD sheep, the selected weight predicting traits represent the main body dimensions, which suggest that the entire body conformation of a one year old WAD is required for attainment of higher accuracy in LW prediction. Adeyinka and Mohammed (2006) suggested that the addition of other linear measurements (like height at withers and body length) to heart girth could improve the predictability of the resultant equations. Such a suggestion was supported by the findings of the present study since the multiple (two or three traits) linear models predicted live body weight of sheep better than most of the simple (one trait) linear models. However, a further addition of traits to a model in this study did not suggest further and better improvement in live body weight predictability because the prediction accuracy from the only three-trait (HG, HW and BL) model for one year old WAD sheep was not much better than that obtained from the use of only HG in a simple linear model for the same group of animals.

In this study, the number and particular type of traits required in a model depended on the breed and age of the sheep population, which was in line with the findings of most researchers (Benyi, 1997; Thiruvenkadan, 2005; Kunene et al., 2007; Hamito, 2009) who suggested the development of separate models for different breeds, different sexes and different ages of livestock. The existence of seasonal variations between body weight and body measurements of small ruminants even led to the development of different weight prediction equations for the same set of animals at different seasons (Bassano et al., 2001; Adeyinka and Mohammed, 2006). The present study also revealed that liveweight prediction was generally more accurate among two years old WALL sheep, and one year old WAD sheep in the two breeds. The use of these linear models suggested that the best time to sell sheep on the bases of their liveweight is when they are just attaining maturity weight, especially at one year old for WAD, and two years old for WALL sheep because their liveweight could best be predicted during these ages respectively. Unless weighing scales are available, it may not be economical to keep and raise sheep beyond two years because the liveweight predictability of such older sheep is quite low and livestock producers, majority of whom are rural folk, may not be able to price their stock appropriately, besides incurring more cost to feed and manage the animals up to that age.

The predictive accuracies of the quadratic models in the one year old WALL were higher than those of the linear models, with the heart girth being the best predictor. The performance of HG as a predictor for the entire WALL and the one year old WAD sheep in this study were higher than 73% for billy goats but quite lower than 99% for nanny goats reported by Adeyinka and Mohammed (2006). Such variations may arise partly from the differences in the genus of the animals, but also from the seasonal variations in the weights of animals since the animals and data gathering periods may vary from one study to another. In an earlier study, Adeyinka and Mohammed (2006) observed that season affected liveweight and hence the accuracy of its prediction from linear body measurements.

The results suggested that among the two years old WALL sheep, liveweight prediction is easier and better done with the use of linear models than quadratic models irrespective of the linear body measurement (trait) used as the regressor. It is noteworthy that the choice of the model type (linear or quadratic) based on the accuracy of

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liveweight prediction, is affected by the particular sheep population involved and the type of body traits used as the predictor variable(s). The superiority of a quadratic model was palpable in the three years old and above WALL sheep where the accuracy of liveweight prediction from RH was explicitly better in a quadratic model than in a linear model. In multiple regressions of the traits most of the quadratic models had higher predictive accuracies than the respective linear models, implying that when more than one linear body trait are used as the regressors, weight of sheep is better estimated with nonlinear models (Kum et al., 2010).

This confirmed the report of Benyi (1997) that geometric models were better than linear models in liveweight prediction. All the predictive accuracies obtained in the present study were lower than 98% and 99% reported for WAD and Sahel x WAD breeds of goat in southern Ghana (Benyi, 1997). HG and HW each predicted liveweight better in the younger WALL sheep under this study as compared to their respective performance of 89% and 71% obtained in Yankasa sheep of Nigeria (Afolayan et al., 2006). It cannot be said that either one of the model types (linear or quadratic) is completely superior to the other in prediction of live body weight of sheep across all breeds and ages under the current study. This is because model performance seems to be influenced by the age and the particular body trait(s) of the animal. Nevertheless the best prediction linear and quadratic models were obtained from the two years old WALL sheep using HG and BL as the regressors.

CONCLUSION

Among the linear body measurement traits, heart girth was the best predictor of liveweight irrespective of the breed or age of the sheep in this study. In multiple linear regressions, the two main traits required to predict liveweight accurately were heart girth and body length. This study also revealed that in each breed, weight estimation was better in the growing (1 – 2 years) sheep groups than the matured ones (3 years and above). The best liveweight prediction model was a linear model for the two years old WALL sheep, and liveweight predictability accuracies were generally better for the WALL than the WAD sheep.

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FACTORS AFFECTING MILK PRODUCTION TRAITS OF SAANEN GOAT RAISED UNDER SUDAN - SEMI ARID CONDITIONS

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ORIGINAL ARTICLE

ABSTRACT: *The aim of this study is to investigate the genetic and environmental factors affecting milk production characteristics of Saanen goats raised under Sudan conditions. It also aims at estimating heritabilities, phenotypic, genetic and environmental correlations among milk production traits. Means for total milk yield, lactation length and daily milk were 340.78±11.35 kg, 203.99±7.66 days and 1.50±0.05 kg, respectively. The season, year of calving and parity number had significant influence on total milk yield and daily milk yield. The lactation length was significantly (P<0.05) affected by season, year of kidding and origin of birth, and was insignificantly (P>0.05) influenced by parity number. The origin of birth insignificantly affected total milk yield and daily milk yield. The study concludes that the Saanen breed can effectively raise milk production in the state.*

Key words: *Milk yield, Lactation length, Heritability, Daily milk yield, Goats.*

INTRODUCTION

Goat genetic resources play an important socio-economic role in many rural parts of the world in contributing to food and nutrition security (Ogola and Kosgey, 2012). In the developing countries, research and development investments to improve the relatively low level of goat productivity do not match their potential importance, resulting in many goat breeds that are not genetically explored (Abdel Aziz, 2010). Saanen is probably the most developed dairy breed. Among goat breeds it occupies the place that the Holstein-Friesian has among cattle breeds (Weppert, 1998). The present paper aims to identify the main factors influencing milk production and to estimate genetic parameters such as heritability, genetic and environmental correlations among production traits.

MATERIAL AND METHODS

Farm location and History of foundation herd

Data utilized in this study were extracted from the Goat Improvement Project records, a governmental farm belonging to the Ministry of Agriculture, Animal Wealth and Irrigation, Khartoum state. The farm is located in Khartoum North (Hilat Kuku), Khartoum state, Sudan. The latitude, longitude and altitude are 15˚ 36´ N, 32˚ 33´ and E 382 m (1253 ft). A total number of 404 performance records of Saanen goats were used; covering the period from 2004 to 2011. Saanen goats were imported from the Netherlands in three batches (the first was in 2004; 15 pregnant females and 20 males, second; 20 pregnant females and 80 males and the last batch was in June 2006; 80 pregnant females and 20 males). The main objectives of the project were genetic improvement of the local goats and in consequence improve the nutritional status of poor families, increase their incomes, create job opportunities for post graduates, increase milk supply in Khartoum state, provide training and extension for goat breeders and collect data for research.

The annual precipitation in Khartoum State is 164 mm; average temperature is 29.8° C with maximum high temperature of 42° C and minimum low temperature of 16° C. The average relative humidity during the year is 21.8% ranging from 13% in March and April to 42% in August. On average there are 3664 sunshine hours annually (*2008-2012 climatetemp.info*).

Management system

Goats were kept in groups in a metal frame building. The roof is made of iron sheets and is 2.95 m high the floor is of concrete; the fencing is made of metal bars about 1.5 cm high. Feeders and water troughs were placed in the shaded area. Milking was carried out twice daily (6:00 AM and 2:00 PM) using portable milking machines for goats. Daily milk yield was recoded for each animal. Artificial insemination (A.I) was adopted in the farm; selected bucks were used for collection of semen to inseminate goats using fresh semen. The favored breeding season is

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wet summer (July – Oct.) in order that the does give birth in the winter season. Heat was detected by using teaser bucks every day at early morning. Forty days after insemination pregnancy was diagnosed using an ultra sound machine. The goats are raised in a confined system receiving green forages such as Alfalfa (*Medicago Sativa*) and Rhodes grass offered twice a day about 3% of body weight. Also dairy goat concentrate ration was given to the animals according to their physiological status and milk yield. The concentrate contains on average 15-17% crude protein and 11.2MJ/Kg metabolizable energy. Water and mineral salt are given *ad libitum.* Pregnant does were dried 45 to 60 days before the next kidding. Pregnant females received a concentrate diet 2 weeks before delivery as steaming up. Bucks were given 1 kg / day of concentrates during the breeding season. All animals in the farm were regularly vaccinated against the major epidemic diseases in the Sudan *vis*: *Pese des Petits Ruminants* (P.P.R), anthrax, sheep pox and haemorrhagic septicemia. Drenching pendazole and spraying with thypermethrin were used to control internal and external parasites. The pen floor was disinfected periodically with phonic acid.

Statistical analysis

Data were extracted from farm records and were classified according to season of kidding into three seasons; dry summer from March to June; wet summer from July to Oct. and winter from Nov. to December. The data were also classified according to year of kidding (from 2004 to 2011) into eight groups. According to parity number the data were classified into six parities. The data of total and daily milk yield were classified into three groups according to lactation length. The data were analyzed using Harvey's (1990) Least Squares computer programme. The analysis of variance was completed according to the following statistical model:

$Yijklmnp = \mu + B_i + S_j + Y_k + P_m + L_n + e_{ijklmnp}$

Where:

$Y_{ijklmnp}$ = observation; μ = overall mean; B_i = the fixed effect of the ith origin of birth (i= 1 and 2); S_j= the fixed effect of the jth season of kidding (j= 1, 2 and 3); Y_k= the fixed effect of the kth year of Kidding (k= 1, 2, ….7); P_m= the fixed effect of the mth parity number (m= 1, 2, …..6); L_n= the fixed effect of the nth lactation length group (1, 2 and 3); $e_{ijklmnp}$ = the random error term

All fixed effects were used for the total and daily milk yield, but the effect of lactation length group was removed from model of lactation length. The genetic parameters (heritabilities, phenotypic, genetic and environmental correlations) were estimated by paternal half sibs and full sibs' methods according to the following model:

$Y_{ij} = S_i + D_j : S_i + e_{ij}$

Where:

Y_{ij} = observation; S_i = the random effect of the ith sire; D_j:S_i= the random effect of the jth dam nested to the ith sire; e_{ij} = the random error term

RESULTS

The least squares means and standard errors of total milk yield (kg) are shown in Table 1. The overall mean of total milk yield was 340.78±11.35 kg / lactation. Analysis of variance results revealed that the origin of birth had insignificant (P>0.05) influence on total milk yield, while the season and year of kidding, parity number and lactation length significantly affected (P<0.05) total milk yield. The goats that kidded in winter yielded significantly higher milk (377.47 kg), followed by those which kidded in the dry summer (340.41 kg); while those kidded in wet summer gave significantly lower milk yield per lactation (304.47 kg). The results showed a significantly decreasing trend of milk yield with advancing year of kidding. The total milk yield increased with increasing parity number and the highest milk yield was recorded in the fourth and fifth lactations and after that it decreased slightly. Also the results revealed that the milk yield increased with increasing lactation length with the third group (>300 days) having a significantly higher milk yield, followed by the second group (180-300 days), and the first group (<180 days).

The overall mean of daily milk yield was 1.50±0.05 kg. Analysis of variance results revealed that the origin of birth and lactation length had an insignificant (P>0.05) influence on daily milk yield, while season of kidding, year of kidding and parity number had a significant (P<0.05) effect on daily milk yield. The results also showed that the imported and locally born does had similar daily milk yield. On the other hand; the does which kidded in winter had the highest yield (1.31 kg), followed by those which kidded in dry summer (1.52 kg), while those kidded in wet summer gave the lowest milk yield (1.68 kg). The does during the early years of the project recorded significantly (P<0.05) higher daily milk yield compared to those raised during the middle years while does during the late years yielded the lowest daily milk. The least daily milk yield was in the first parity (1.29 kg) and it increased with advancing parity and the highest daily milk yield was recorded in the fifth and sixth parities.

The results presented in table 1 show that the average lactation period was 203.99±7.66 day. Analysis of variance results revealed that the origin of birth, year and season of kidding had significant influence on lactation length. However, parity number had insignificant (P>0.05) influence on lactation length. The results also indicate that the imported does had short lactation length in comparison with the locally born does. The does which kidded in winter had the highest lactation length (235.37 day), followed by those which kidded in dry summer (204.0 day), while those kidded in wet summer had the east lactation length (172.6 day). The parity order had no significant effect (P>0.05) on lactation length.

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Table 2 shows the heritability of milk yield, daily milk yield and lactation length (0.443, 0.822 and 0.337 respectively). The genetic correlation of milk yield with daily milk yield was high and positive (0.74) and the genetic correlation of milk yield with lactation length was positive, but low (0.216). The genetic correlation between daily milk yield and lactation length was negative (-0.446). Milk yield had a positive phenotypic correlation with daily milk yield (0.589). The phenotypic correlation of milk yield with lactation length was moderately high and positive (0.639). However; the correlation of daily milk yield with lactation length was low and negative (-0.169).

Table 1 - Factors affecting total milk yield (kg), daily milk yield (kg) and lactation length (days) of Saanen goats raised under Sudan conditions

Item		Milk yield	Daily milk yield	Lactation length
	N	LS Mean ±SE	LS Mean ±se	LS Mean ±se
Origin		NS	NS	*
Imported	211	$329.98^{a}\pm11.01$	$1.50^{a}\pm0.04$	$188.82^{b}\pm7.17$
Locally born	193	$351.58^{a}\pm15.15$	$1.50^{a}\pm0.06$	$219.16^{a}\pm10.54$
Season of kidding:		**	**	**
Dry summer	139	$340.41^{b}\pm13.15$	$1.52^{b}\pm0.05$	$204.00^{b}\pm8.74$
Wet summer	46	$304.47^{c}\pm20.64$	$1.31^{c}\pm0.08$	$172.60^{c}\pm13.99$
Winter	219	$377.47^{a}\pm10.31$	$1.68^{a}\pm0.04$	$235.37^{a}\pm7.14$
Year of kidding:		**	**	**
2004	6	$407.00^{a}\pm45.57$	$2.26^{a}\pm0.18$	$116.52^{b}\pm31.37$
2005	32	$460.83^{a}\pm24.13$	$1.90^{b}\pm0.10$	$209.15^{a}\pm16.78$
2006	80	$424.79^{a}\pm18.76$	$1.74^{b}\pm0.07$	$210.15^{a}\pm13.04$
2007	60	$323.68^{b}\pm15.93$	$1.45^{c}\pm0.06$	$195.21^{a}\pm10.99$
2008	69	$297.36^{bc}\pm14.78$	$1.29^{c}\pm0.06$	$196.30^{a}\pm9.86$
2009	82	$286.13^{bc}\pm13.08$	$1.20^{d}\pm0.06$	$239.21^{a}\pm9.12$
2010	55	$262.49^{c}\pm15.41$	$1.07^{d}\pm0.06$	$239.29^{a}\pm10.78$
2011	20	$263.99^{bc}\pm24.27$	$1.08^{d}\pm0.10$	$225.93^{a}\pm16.55$
Parity:		**	*	NS
1st	155	$278.97^{b}\pm11.28$	$1.29^{c}\pm0.04$	$206.12^{a}\pm7.67$
2nd	94	$342.34^{a}\pm13.88$	$1.48^{ab}\pm0.06$	$209.41^{a}\pm9.42$
3rd	63	$328.24^{a}\pm16.33$	$1.40^{bc}\pm0.06$	$207.79^{a}\pm11.22$
4th	44	$368.30^{a}\pm19.16$	$1.57^{ab}\pm0.08$	$212.23^{a}\pm13.24$
5th	25	$368.58^{a}\pm23.63$	$1.64^{a}\pm0.09$	$194.41^{a}\pm16.49$
6th	23	$358.27^{a}\pm25.18$	$1.61^{a}\pm0.10$	$193.97^{a}\pm17.58$
Lactation length group:		**	NS	-
1st < 180 days	108	$208.26^{c}\pm13.17$	$1.53^{a}\pm0.05$	-
2nd 181 – 300 days	227	$348.06^{b}\pm12.54$	$1.51^{a}\pm0.05$	-
3rd > 300 days	69	$466.02^{a}\pm17.09$	$1.46^{a}\pm0.07$	-
Overall mean	404	340.78±11.35	1.50±0.05	203.99±7.66
CV (%)		31.17	27.84	30.32

LS Mean ± se: least squares means and standard errors. [a,b] Means with same superscripts within each item were not significantly (P<0.05) different. *, ** and NS: significant at P<0.01, P<0.001 and not significant at P>0.05

Table 2 - Heritabilities, genetic and phenotypic correlations for milk production traits estimated from the full sibs' and half sibs' methods (n=172)

Method	Traits	Milk yield	Daily milk	Lactation length
Full sibs	Milk yield	0.44±0.17	0.74	0.22
	Daily milk	0.59	0.82±0.18	- 0.45
	Lactation length	0.64	- 0.17	0.34±0.17
Paternal half-sibs	Milk yield	0.73±0.34	0.07	0.21
	Daily milk	0.59	1.40±0.38	- 0.60
	Lactation length	0.64	- 0.17	0.68±0.34

♀Parameters estimated by full sibs' method, heritabilities were presented in diagonal, genetic and phenotypic correlations were presented above and below diagonal respectively.

Table 3 presents the environmental correlations among the three traits. The results show that the environmental correlation between milk yield and daily milk yield was positive (0.454) and that between milk yield with lactation length was however, high and positive (0.914) the environmental correlation between daily milk yield with lactation length was low and positive (0.192).

Table 3 - Environmental correlations♀ among milk production traits (n=172)

Traits	Milk yield	Daily milk	Lactation length
Milk yield		0.454	0.914
Daily milk	0.259		0.192
Lactation length	0.164	NE	

♀ Correlations which estimated by full sibs' method above diagonal; while those estimated by paternal half sibs' method below diagonal; NE: not estimated

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DISCUSSION

The mean of milk yield obtained in this study (340.78±11.35 kg) is lower than that obtained by Ali et al. (1983) (787 kg) in the United States, Bolacali and Kucuk (2012) (383.05 kg) in Eastern Anatolia region, turkey and Boichard et al. (1989) (490 kg) in France. On the other hand it is close to the estimate that mentioned by Pesce Delfino et al. (2011). The average lactation length (203.99±7.66day) is less than the finding of Pesce Delfino et al. (2011) who estimated that the average lactation length was 230 days. It is also less than the estimate of Bolacali and Kucuk (2012) (273.12 days), Ali et al. (1983) (231days) and Boichard et al. (1989) (238 days). Daily milk yield in the present study was 1.5±0.05kg which was higher than that of Bolacali and Kucuk (2012) (1.37 kg) and higher than the estimate of Saanen goats in South Africa noted by Norris et al. (2010) (1.45 ±0.27 kg). Boro et al. (2009) in Croatia gave a higher value (2.63 kg/day) than that obtained in the present study.

The effect of year and season of kidding on milk yield traits was significant. This may be due to the variability in climatic conditions, fluctuations in the availability of nutrients and flock composition over the years. The increased milk production during winter might be to the lower ambient temperatures, availability of feeds and lower incidence of diseases, while the lower milk production during wet summer may have resulted from the stress of high temperature and humidity, prevalence of external and internal parasites and scarcity of feedstuffs. The increasing trend of milk production with increasing parity order may be result of better udder development and growth in size of the animal. It should be emphasized that although the milk production of the temperate breed observed in this study is lower than that in its home country, the yield is still much higher than the milk production of the indigenous goat.

The heritability estimates of milk yield traits in this study are higher than those found by Pesce Delfino et al. (2011). They reported that the estimates of heritability were 0.21 and 0.15 for milk yield and lactation length respectively. Also, the heritability of milk yield is higher than the findings of Belichon et al. (1999) who reported that heritability of milk yield was 0.32±0.17. Tholon et al. (2001) estimated that the heritability of milk yield was 0.37. The high values of heritability in the present study may be due to the small size of the data set.

In conclusion, the milk production data obtained in the current study from Saanen goats raised in Khartoum state, Sudan have revealed that Saanen goats can be used for goat milk production in the region. The milk production performance of the Saanen goat breed was superior to that of crossbred and local goat.

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CARCASS CHARACTERISTICS OF DESERT SHEEP UNDER RANGE CONDITIONS IN NORTH KORDOFAN STATE, SUDAN

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ABSTRACT: *This experiment was conducted to study the performance, carcass characteristics and meat quality attributes of desert sheep raised under range conditions around El Nuhood. Thirty desert sheep (15 males and 15 females) of almost the same age (about 8 months) were used in a 16 weeks study period. The sheep were randomly allocated to three groups (treatments) of ten animals (5 males and 5 females). The three groups were allowed to graze on natural range grasses at night only and were kept under shade during the day from 7:00 am to 6:00 pm. The first group was allowed water every 2-3 days and was considered as control. The second group was allowed access to water daily. The third group was allowed daily access to water and received concentrates supplement. At the end of the experimental period, eighteen animals (nine males and nine females) were randomly taken, weighed and slaughtered to study the carcass characteristics. The results included that were significant (P<0.05) differences among the treatment groups with regard to the warm carcass, cold carcass and empty body weight. There were significant (P<0.05) differences between females and males of the three treatments in slaughter weight, warm carcass weight and cold carcass weight. Males obtained higher weights than females. The dressing percentage on the basis of warm carcass and cold carcass was significantly (P<0.05) different in the three treatments. The gut fill expressed as a percentage of empty body weight was significantly (P<0.05) different among the three treatments. These results concluded that management strategy which involves shorter watering intervals and feed supplementation will probably reflect positively on the performance, carcass characteristic of Hamari sheep under range conditions.*

ORIGINAL ARTICLE

Key words: *Dessert sheep, Performance, Carcass characteristic, Concentrate ration, Sudan*

INTRODUCTION

Sudan and Africa is largest country, with nearly one million square miles area (more than 2.5 million square kilometers). It also has one of the largest livestock populations. This wealth was estimated in year 2004, to a number of 47.043, 39.952, 38.325 and 3.203 million head for sheep, goats, cattle and camels, respectively (El-Samani, 2005). This livestock shares with about 22.3% in total national production and the animal exported share about 18.2% of total exported about 38% of agriculture. The livestock industry is of great importance to the Sudanese economy as it is one of the main sources of food, employment and foreign currency. Proper exploitation of these livestock can contribute greatly towards the alleviation of the present world deficient in animal protein which is expected to grow continuously due to low livestock productivity, increase in per capital consumption of meat, due to improvement in the standard of living of many people and increase in the human population of the world (FAO, 1994).

In spite of the importance of sheep they are still raised under nomadic condition with traditional methods of management and national grazing. Many socio-economic factors affected mobility of nomadic flocks including national pasture. The specific problem regarding sheep nutrition under range land condition is that of feed shortage and nutrient deficiencies. This situation is critical during the dry season which extends from November-June. This is reflected in seasonality of reproduction, high mortality rate in both young and adult animals and low reproductive performance (EL Hag et al., 1998). Rarely farmers provide their animals with different supplements during the

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critical period of feed shortage. Supplements used are mainly oilseed cakes and cereal grains. The objectives of this research are:

1- To study the effect of feed supplementation and husbandry practices on the general performance and meat quality attributes of desert sheep of hamari subtype.

2- To compare the performance and carcass characteristics of male and female desert sheep of the same age and raised under the same environmental condition.

3- To adopt an applied extension for sheep producers of the importance of concentrate supplementation to grazing sheep under range system.

4- To improve the economical condition of Sudan in general and sheep producers in particular by increasing sheep numbers.

MATERIAL AND METHODS

The study was conducted in Mhagor-Area about 30 km south of El-Nuhood (lies within latitudes 11.5-13.75 N° and longitudes 27-29.5 E°) about 900 km west to Khartoum. Average annual rainfall is 300 and 400 mm in the north and southern parts respectively. Average maximum temperature is 24-39°C during most of the year, with peaks above 36°C during April, May and June. The soil types varied from sandy (Goze) dissected by batches of loamy sands (Gardud or gurraba) in the southern part. The main cash crop grown in the locality is mainly millets, sorghum, watermelon, rosella (*Hibiscus sabdariffa*) and groundnut. Large amounts of agricultural post harvesting residues are produced such as groundnut and *Hibiscus sabdariffa* (karkadeh) hay which are used on a large scale for feeding animals.

Experimental animal's management

Thirty desert sheep (15 males +15 females) of the same age (about 8 months) were used in this study. The animals were ear tagged and randomly divided into three groups according to age and body weight and designed as A, B and C respectively, each group consist of 10 animals (5 male and 5 female). The first group (Group A) was allowed to drink water every day and was supplemented with additional concentrates, consisting of 40% durra grains, 30% groundnut cake, 29% groundnut hulls and 1% salts. Every head from this group was given 750g concentrates daily. The second group (group B) was allowed to drink water every day without supplementation. The third group (group C) was allowed to drink water at 2-3 days intervals without supplementation. This group was considered as control. All the groups were allowed to graze at night on natural grasses available on pasture and kept in shade during the day from 7:00 am to 6:00 pm. At the end of the adaptation period, the animals were individually weighed after an overnight fast to give the initial live weight.

Slaughter procedure and data collection

After 16 weeks when the animals reached the age of one year, six animals (three males and three females) from each group were randomly slaughtered. The animals were slaughtered every day in the morning after twelve hours fast from feeding, except water. The animals were weight before slaughter to give slaughter weight. After complete bleeding the head was removed at the atlanto-oxcepital joint, and after skinning all thoracic and abdominal organs were removed leaving the kidneys and kidney knob channel intact in the carcass. The hot carcass weights were immediately recorded and the carcasses were moved for chilling at 4°C for 24 hours. The head, four feet, skin, heart, lungs and trachea, liver, pancreas, spleen, omentum and messentery were separated and weighed. The alimentary tract was weighed full, then emptied and re-weighed and the gut "fill" weight was determined by difference. The empty body weight (EBW) was calculated by subtractive the gut fill from the slaughter weight. To avoid weight losses due to evaporation all organs and offal's were weighed immediately after dressing and each weight was recorded. Cold carcass weight was recorded after 24 hours chilling. The tail was removed at its articulation and weight. Kidneys and kidney knob channel fat were also removed and weighed. The prepared carcass was split along the vertebral column into left and right sides. The right half of the carcass was weighed and cut according to (Smith et al., 1978) into major cuts that included leg, sirloin, loin, rack and shoulder, minor cuts included, shank, breast, flank and neck. The thickness of subcutaneous fat for the sections was recorded by a vernia, at 12-13 ribs longissmus dorsi the subcutaneous fat was removed using scalpel and forceps. Each cut was weighed and dissected into fat, muscle, bone and trim, and separately.

Statistical analysis

Statistically analyzed according to complete randomizes design using Statistical Package for the Social Sciences, software package (SPSS version 10 1996) in factorial arrangement using LSD was also used to test means significance differences, analysis of covariance was carried out.

RESULTS AND DISCUSSION

Effects of the three different management systems on carcass characteristics:

There were significant differences ($P<0.05$) among the treatment groups with regard to the warm carcass, cold carcass, half carcass and empty body weight in treatments A, B and C, respectively (Table 1). This finding is in agreement with Ahmed (1993) who found that, there were significant differences in warm carcass and cold carcass

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weights when Sudan desert lambs were fed sorghum grains and molasses at ratios of, 40:0, 20:20 and 0:40. Mansour et al. (1988b) who found that, lambs fed rations containing 45% and 30% groundnut hay gave slaughter weight of 31.5 and 32.1 kg and hot carcass of 13.3 and 14 kg, respectively. Similarly, Mohamed (2002) reported that, slaughter weight, empty body weight and hot carcass were 34, 29.5 and 16 kg for pen fed Kabashi lambs, and were 33.17, 27.6 and 13.8 kg for pen fed Hamari lambs. Their values were 29.1, 22.7 and 11.2 kg for free grazing Kabashi lambs and 28.5, 22.7 and 10.7 kg for free grazing Hamari, respectively. Mansour (1987) reported a mean slaughter weight of 32.3 kg yield 15.9 kg warm carcass with dressing percentage of 49.1 (on empty body weight). The results are in disagreement with, Marouf (1996) who found that there were no significant difference among treatment groups in slaughter weight and carcass weight (cold or warm). These differences may be due to rations age or physical conditions.

The results observed that there were significant ($P<0.05$) differences between females and males of the three treatments in slaughter weight, hot carcass weight cold carcass weight, half carcass weight, gut fill weight and empty body weight (Table 2). Males obtained higher weights than females. This result is in harmony with the results of Mohamed (2004) who found that the average hot and cold carcass weights were significantly ($P<0.05$) heavier in male than in female lambs. The results are in disagreement with Beshir (1996) who found that there were no significant differences among treatment groups in slaughter weight and carcass weight (cold or warm). These differences may be due to rations and age of animals or physical conditions.

Table 1 - Effects of the three different management systems on carcass characteristics

Trait	Sl.wt	Hot.wt	Cold.wt	Half.wt	Gut fill.wt	EBW
A	43.04^a	21.58^a	20.79	10.08^a	7.18^a	35.86^a
B	41.63^b	19.58^b	18.58	9.06^b	8.02^a	33.61^b
C	36.38^c	16.67^c	16.25	7.75^c	7.75^c	28.63^a
S.E	1.11*	0.40*	0.45*	0.14*	0.87*	1.17*

^{abc} *Values in same columns with different superscripts differ at P<0.05*. Sl.wt = Slaughter weight (kg). Hot.wt= Hot carcass weight (kg). Cold.wt= Cold carcass weight (kg). Half.wt= Half carcass weight (kg). Gut.wt= Gut fill weight (kg). EBW= Empty body weight (kg). S.E = Standard error of the mean.

Table 2 Effects within sex and management systems on different parameters

Sex	Treatment	Slaughter Wt (kg)	Hot carcass wt (kg)	Cold carcass wt (kg)	Half carcass wt (kg)	Gut fill wt (kg)	EBW (kg)
Femae	A	42.25^a	22.67^a	21.50^a	10.83^a	5.72^c	36.53
	B	42.25^a	17.67^b	17.17^b	8.00^b	6.52^a	35.73
	C	36.08^c	15.83^c	15.50^c	7.33^c	6.00^b	30.08
	S.E	1.56*	1.56*	0.64*	0.19*	1.23*	1.01*
Male	A	45.57^a	20.50^b	20.08^b	9.33^b	8.63^b	36.94
	B	45.25^a	21.50^a	21.00^a	10.13^a	9.53^a	35.72
	C	36.67^c	17.50^c	17.00^c	8.17^c	6.33^c	30.34
	S.E	84.77*	0.56*	0.64*	0.19*	1.23*	1.01*

^{abc} *Values in same raw with different superscripts differ at P<0.05*

Dressing percentage of desert sheep

The dressing percentage on the basis of warm carcass and cold carcass was significantly ($P<0.05$) different in the three treatments. The means of the three management systems A, B and C were 50.14, 47.03 and 45.82% on the basis of warm carcass, and 48.30, 44.63 and 44.67% on the basis of cold carcass, respectively (Table. 3). This is in agreement with the results of Ahmed and Suleiman (1988) and Mansour et al (1988a) reported a dressing percentage of up to 54.3 in fattened lambs. The result also supported by El karim and Owen (1987) who reported respective dressing percentages of 45.06 and 43.35 for Sudan Desert sheep ecotypes Watish and Shugor. Similarly, El-Hag (1981) found a dressing percentage of 46.3- 47.5.

Table 3 - Dressing percentage of desert sheep (Hamari sub type)

Parameters	A	B	C	S.E	L.S
Hot%	50.30^a	47.03^b	45.82^c	1.15	*
Cold%	48.30^a	44.63c	44.67^b	1.06	*
Hot/EBW%	60.18	58.26	55.18	1.14	NS
Cold/EBW%	57.98	55.28	53.79	1.04	NS
Gut fill as(%) of EBW	20.02^c	23.86^b	27.06^a	1.11	*

^{abc} *Values in same raw with different superscripts differ at P<0.05*

The gut fill expressed as a percentage of empty body weight was significantly ($P<0.05$) different among the three treatments. Its values were 20.02, 23.86 and 27.06% for treatments A, B and C, respectively (Table. 3). This finding is in agreement with the reported of El Khidir et al (1984) and Osman (1985) in Sudan Desert sheep which ranged between 17- 28%. El-Khidir (1989) reported a gut fill of 21.2, 18.4 and 17.0 in Sudan Desert sheep.

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On the other hand the dressing percentage calculated as a proportion of empty body weight (hot/ EBW) was 60.18, 58.26 and 55.18 on the basis of hot carcass, and 57.98, 55.28 and 53.79 on cold carcass basis (cold/EBW) in the three treatments A, B and C, respectively (Table 3). This is in agreement with the findings reported by Ahmed (1993) of 56.55, 55.5 and 54.7 for treatments A, B and C, respectively. These results are also similar to the results of El-Amin (1981) who found that, the dressing-out percentage ranged 52.8-56.6, and similar to the 53% dressing percentage reported by Gaili (1977) in Sudan Desert sheep.

Non-carcass components of desert sheep:

The results of non-carcass components expressed as percentage of empty body weight are summarized in (Table. 4). There were no significant differences among the treatments except tail, lung and trachea, testicles, mesenteric fat and skin which showed significant ($P<0.05$) differences among the three treatments. Their values were 1.87, 1.79 and 1.93% for the tail, 2.11, 2.37 and 1.95% for the lung and trachea, 2.71, 1.59 and 1.61% for the genital organs, 1.06, 1.30 and 1.08% for the messentric fat and 8, 7.71 and 8.52% for the skin, in treatments A, B and C, respectively (Table. 4). These results are in agreement with the result of El -Typeb et al (1987) who reported that the percentage of lung and trachea, testicles and tail was 8.24, 1.20 and 2.10, respectively. Also Mansour et al (1988b) found that, lung and trachea, sex organs, and mesenteric fat percentage were 2.70, 1.12 and 1.08%, respectively.

Table 4 - Effect of management systems on non-carcass components (as percentage of empty body weight) of desert sheep

Parameters	A	B	C	S.E	L.S
Rumen full	18.18	21.83	21.97	0.72	N.S
Rumen empty	3.63	4.25	4.51	0.09	N.S
Intestine full	8.48	9.67	8.98	0.21	N.S
Intestine empty	3.01	3.57	4.02	0.08	N.S
Tail	1.87^b	1.79^c	1.93^a	59.94	**
Liver	1.37	1.54	1.66	26.11	N.S
Heart	2.27	1.80	1.72	13.03	N.S
Lung and trachea	2.11^b	2.37^a	1.95^c	32.08	**
Kidney	1.27	1.15	1.07	3.96	N.S
Reproductive organs	2.71^a	1.59^b	1.61^b	27.74	*
Mesenteric fat	1.06^b	1.30^a	1.08^b	39.09	**
Head	6.83	7.02	7.93	0.09	N.S
Skin	8.00^a	7.71^b	8.52^a	0.11	***
Four feet	3.12	3	3.26	0.44	N.S
Gut fill%	20.02^c	23.86^b	27.06^a	1.11	*

abc Values in same raw with different superscripts differ at P<0.05

Table 5 - Effect of sex on non-carcass components of desert sheep

Parameters	Females	Males	S.E	L.S
Rumen full (kg)	5.79^b	7.64^a	0.63	*
Rumen empty kg)	1.27	1.42	0.08	NS
Intestine full (kg)	2.85^b	3.05^a	0.19	*
Intestine empty(kg)	1.18	1.11	0.07	NS
Tail wt (g)	572.2^b	646.82^a	52.86	*
Liver wt (g)	466.67^b	522.22^a	13.62	*
Heart wt (g)	144.44	150.0	23.03	NS
Lung and trachea (g)	638.89^b	769.44^a	11.49	*
Kidney wt (g)	84.08	90.71	3.50	NS
Reproductive organs wt(g)	162.22^a	136.11^b	24.46	*
Mesenteric fat wt(g)	383.33^a	366.11^b	34.47	*
Omentum fat wt (g)	600^a	516.67^b	34.47	**
K.N.C.F wt(g)	518.96^a	410.84^b	53.89	**
Spleen wt (g)	48.89^b	410.84^a	5.30	*
Subcutaneous fat (dm^3)	0.34	0.27	0.03	NS
Head wt (kg)	2.24	2.47	0.08	NS
For feet wt (g)	888.89^b	1147.22^a	44.48	**

abc Values in same raw with different superscripts differ at P<0.05

There were significant ($P<0.05$) differences in the non-carcass components of rumen full, intestine full, tail weight, liver weight, lung and trachea, genital organs, mesenteric fat, omentum fat, kidney knob channel fat, spleen and four feet (Table 5). Females had the highest weight in reproductive organs, mesenteric fat, omentum fat and

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kidney knob channel fat compared to males. This result is in agreement with the results of Mohamed (2004) who found that, the mesenteric fat, omentum and kidney knob and channel fats were heavier in ewes than in the rams. The results are also similar to Kashan et al (2005) who reported that the percentage of inter muscular fat, and internal fat in males were 7.1, and 6.6 and the corresponding values in females were 9.1, and 11.7, respectively.

The study revealed no significant (P>0.05) differences within females in the three treatments with regard to rumen full, rumen empty, intestine full, intestine empty, liver, heart, spleen, head and skin (Table 6) this attributed to age. However, there were significant (P>0.05) differences in lung and trachea, kidney, testicles, mesenteric fat, omentum fat, kidney knob channel fat and four feet. Females in treatment A recorded the highest weights compared to those in the other treatments. These differences may be due to the effects of the different rations. On the other hand, males showed no significant (P>0.05) differences among the three treatments in the rumen empty, intestine full, intestine empty, liver, heart, kidney, head and skin (Table7) this may be due to age also.

However, there were significant (P<0.05) differences in rumen full, lung and trachea, genital organs, mesenteric fat, omentum fat, kidney knob channel fat, spleen and four feet. These findings are in agreement with those of Mohamed (2002) who reported that there were no significant differences in head, empty stomach and spleen. However, there were significant differences in heart, testicles, mesenteric fat, kidney fat, tail, lung and trachea, pancreas, kidneys and empty intestines (Table 7).

Table 6 - The effect of management systems on female non-carcass components (as percentage of empty body weight)

Parameters	A	B	C	S.E	L.S
Rumen full	14.29	16.51	20.84	1.02	NS
Rumen empty	3.50	3.97	3.66	0.12	NS
Intestine full	7.80	8.45	8.91	0.30	NS
Intestine empty	2.93	3.16	4.49	0.11	NS
Tail	1.74	1.76	1.50	84.77	*
Liver	1.28	1.35	1.50	36.93	NS
Heart	1.2	1.1	1.5	18.4	NS
Lung and trachea	1.87b	2.00a	1.72c	45.37	*
Kidney	6.80b	6.50b	8.70a	5.60	*
Genital organs	1.50a	1.30b	1.30b	39.23	*
Mesenteric fat	1.23	90.20	1.05	55.28	*
Omentum fat	2.16a	2.02a	1.16b	123.71	*
K.N.C.F	2.03a	1.65b	1.08c	86.42	*
Spleen	3.7	3.9	3.2	8.5	NS
Head	6.52	5.93	7.41	0.12	NS
Skin	8.08	7.08	7.88	0.15	NS
Four feet	2.69a	1.62b	2.77a	71.33	*

[abc] Values in same raw with different superscripts differ at P<0.05

Table 7 - The effect of male and management systems on non-carcass components (as percentage of empty body weight)

Parameters	A	B	C	S.E	L.S
Rumen full	21.17[b]	24.58[a]	20.83[c]	1.02	*
Rumen empty	3.57	4.06	4.88	0.12	NS
Intestine full	8.74	9.74	8.08	0.30	NS
Intestine empty	2.98	3.58	3.13	0.11	NS
Tail	1.92[b]	1.91[b]	2.16[a]	84.77	*
Liver	1.40	1.54	1.65	36.93	NS
Heart	1.20	1.20	1.40	18.4	NS
Lung and trachea	2.26[a]	2.45[a]	1.98[b]	45.37	*
Kidney	6.70[c]	7.30[b]	9.50[a]	5.60	*
Genital organs	1.40a	1.20b	1.40a	39.23	*
Mesenteric fat	1.20b	2.50a	2.80a	55.28	*
Omentum fat	1.20	1.10	1.10	123.71	*
K.N.C.F	1.50a	1.17b	1.2b	86.42	*
Spleen	4.60b	5.90a	4.90b	8.5	*
Head	6.82	7.28	7.58	0.12	NS
Skin	7.53	7.42	8.31	0.15	NS
Four feet	3.34	3.29	3.41	71.33	*

[abc] Values in same raw with different superscripts differ at P<0.05

CONCLUSION

It could be concluded that the total carcass tissues among the three groups and within females and males of Hamari sheep supplemented with concentrates were greater than those grazed on natural pasture. Short watering intervals gave better results on slaughter weight and carcass weight of Hamari sheep compared to long watering intervals.

Recommendation

It could be recommended that the fattening program of the Hamari sheep that depend on natural pasture must be supplemented with concentrates with short watering intervals so as to improve the growth performance and carcass characteristics.

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EFFECT OF FEEDING DURATION ON PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING PIGS

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ORIGINAL ARTICLE

ABSTRACT: *A total of 36 Large White weaner male pigs of 8 weeks old were allotted to two groups (ad libitum feeding for 3 months and 80% ad libitum feeding for 5 months) in a Randomized Completely Design, to evaluate the effect of feeding duration on performance and carcass characteristics of growing pigs Each group consists of 18 pigs with initial average weight of 9.67±0.26 and was further replicated into 3 with 6 pigs per replicate. Data were collected on weekly basis and carcass characteristics were done at the end of 3rd and 5th months of feeding. Feed duration had significant (P<0.05) influence on final body weight, daily weight gain, Daily feed intake, water consumption and daily cost of feeding with higher values (54.17 kg, 349.42 g, 1.63 kg, 5.05 litres and ₦74.72), respectively recorded for pigs fed 80% ad libitum for 5 months. Higher values of bled weight (46. 78 kg) and carcass weight (35.44 kg) were noted for pigs fed 80% ad libitum for 5 months. Pigs fed 80% ad libitum for 5 months had higher value in head (12.42%), ham (14.40%), shoulder (13.92%) and feet (2.73%) weights compared to values documented for pigs fed ad libitum for 3 months. Better values for back fat thickness (0.43 cm) and fat-free index (49.69) were obtained among the pigs fed ad libitum for 3 months. Feeding duration greatly influenced performance and carcass parameters and should be used in improving the quality of carcass.*

Key words: *Feeding Duration, Ad Libitum, Pig, Performance, Carcass Characteristics*

INTRODUCTION

Inadequate animal protein remains a serious problem in the developing countries with about 36 million people dying yearly from causes directly or indirectly related to nutritional problems (UNIS, 2004). Many common health problems facing man can be prevented or alleviated with healthy diet. Insufficient or poorly constituted diet has deleterious effect on health causing deficiency diseases. Hence, the need to promote and enhance livestock production cannot be over emphasized in order that cheap animal protein can be made available at affordable price, thereby promoting healthy living by solving the problem of malnutrition.

There is no doubt that the solution to animal protein shortage rests in the promotion and more efficient production of all classes of meat animals. Pig is one of the veritable sources of animal protein. It represents one of the fastest ways of increasing the availability of animal protein since pigs grow at a fast rate and are highly more prolific than other livestock species (Ikani and Dafwang, 1995). Since pork is cheaper than beef, chicken, mutton, chevon and other animal protein sources, encouraging pork production and consumption will reduce the pressure on the demand for these meats thereby making them more available and at cheaper rates. To this effect a study was conducted to evaluate the effect of duration of feeding on performance and carcass characteristics of growing pigs.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out in the Piggery Unit of the Teaching and Research Farms Directorate (TREFAD), Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The farm lies within latitude 7° 10 N, longitude 3° 2 E and altitude 76 mm. It is located in the derived savannah zone of South-Western Nigeria. It has a humid climate with mean annual rainfall of about 1037 mm and temperature of about 34.7° C. The relative humidity ranges in the rainy season (late March-October) and dry season (November-early March) is between 63-96% and 55-82%, respectively with an annual average of 82% (Google Earth, 2012). The seasonal distribution of

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annual rainfall is approximately 44.96 mm in the late dry season (January-March); 212.4 mm in the early wet season (April-June); 259.3 mm in the late wet season (July-September) and 48.1 mm in the early dry season (October-December).

Experimental Animals and their Management

Thirty six weaner Large White male pigs of eight weeks old with mean body weight of 9.67±0.26 kg were randomly assigned to two treatments in a completely randomized design. The pigs were grouped based on weight equalization to two groups (*ad libitum* feeding for 3 months and 80% *ad libitum* feeding for 5 months) of eighteen pigs each. Each group was replicated thrice to consist of 6 pigs per replicate. The pigs were group fed and housed in naturally ventilated pens (3 pigs per pen) with floor size dimension of 3m x 2 m. Fresh water was supplied daily *ad libitum*.

Dietary Treatment

Feeding was carried out at 09:00 hours each day for three and five months depending on feeding duration. The carcass analysis of the pigs on *ad libitum* feeding was carried out at the end of 3rd month, while those on 80% *ad libitum* feeding was evaluated at the end of 5th month of the experiment. Diets were formulated to meet the body requirements of growing pigs. The ration contained 18% crude protein and metabolisable energy of 2906.00 kcal DE/kg as shown in Table 1.

Table 1 - Composition of Experimental Diets (%)

Ingredients	Grower ration
Maize	45.00
Groundnut cake	20.00
Wheat offal	20.00
Palm kernel cake	12.50
Bone meal	2.00
Premix*	0.35
Common salt	0.30
Lysine	0.05
Methionine	0.05
Total	100.00
Calculated Analysis	
Crude protein (%)	18.06
Crude fibre (%)	5.84
Calcium (%)	0.72
Phosphorus (%)	0.34
ME (Kcal DE kg)	2906.00

*To supply the following per kg diet: Vit. A 12600 IU; Vit. D_3 2800 IU; Vit. E 49 IU; Vit.K_3 2.8 mg; Vit. B_1 1.4 mg; Vit. B_2 5.6 mg; Vit. B_6 1.4 mg; Vit. B_{12} 0.014 mcg; Niacin 21 mg; Pantothenic Acid 14 mg; Folic Acid 1.4 mg; Biotin 0.028 mcg; Choline Chloride 70 mg; Manganese 70 mg; Zinc 140 mg; Iron 140 mg; Copper 140 mg; Iodine 1.4 mg; Selenium 0.28 mg; Cobalt 0.7 mg; Antioxidant 168 mg.

Data Collection

Feed intake was determined daily by subtracting the feed left-over from the feed supplied. Initial body weight of weaner pigs were taken using weighing scale with a 0.05 g precision and documented when the pigs arrived at the experimental site and weekly records of change in body weight were subsequently taking and documented. The feed conversion ratio was calculated as ratio of feed/gain.

Cost Estimation

The prevailing market prices of the ingredients at the time of study were used to calculate the unit cost of feed (₦/kg) and the cost of feed to produce a unit weight (₦/kg weight gain)

Carcass Characteristics

For carcass evaluation, six pigs were selected from each group (ad libitum feeding for 3 months and 80% ad libitum feeding for 5 months) and analysed for carcass parameters, cut-up parts and fat composition at the end of each feeding interval. The pigs were fasted for 16 hours, and the fasted weight of each pig meant for slaughtering was taken before they were stunned by percussion method and bled by incision using a sharp knife cutting through the jugular vein between the skull and the atlas. Complete bleeding and dehairing were done. The stomach of the pigs was opened along the greater curvature and emptied. The head was removed by section at the occipito-atlas joint and the feet by sawing through the hock joint at a right angle to the long axis of the leg. The carcass was divided longitudinally. The left half of the carcass was dissected as described by FAO (1991). Ham was separated by locating the division between the 2nd and 3rd sacral vertebrae and saw perpendicularly along axis of the ham. Shoulder of the pig was separated from the loin and belly by a straight cut between the second and third ribs and a straight cut 2.5 cm ventral to the ventral edge of the scapula. The parts were weighed and recorded. Back-fat depth was taken at the last rib using vernier calliper. The fat-free index was estimated using the formulae postulated by National Pork Producers Council (1994).

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Fat-free index = 50.767 + (0.035 x hot carcass weight, kg) – (8.979 x last rib midline back-fat on hot carcass, cm).

Dressing percentage = carcass weight/live weight x 100

Statistical Analysis

Data were processed by one-way analysis of variance using SAS [SAS Inst., Inc., Cary, NC, 1990]. Significantly ($P<0.05$) different means among variables were separated using New Duncans Multiple Range Test as contained in SAS (2000) package. The model used was: $Y_{ijk}=\mu + A_i + E_{ijk}$

Where, Y_{ijk} = individual observation; μ= general mean; A_i =effect of feeding duration; E_{ij} = experimental error

RESULT

Effect of Feeding Duration on Growth Performance of Growing Pigs

Feeding duration significantly ($P<0.05$) influenced final body weight, daily weight gain, daily feed intake, water intake and daily feed cost per day. These parameters significantly increased with increase in feeding duration. The higher observed means values for final body weight (54.17 kg), daily weight gain (349.42 g), feed intake (1.63 kg/pig/day), water intake (5.05 litres/pig/day) and daily feed cost (₦74.72) were obtained by the pigs fed 80% *ad libitum* for 5 months while the corresponding means values (49.17 kg, 302.25 g, 1.30 kg/pig/day, 3.46 litres/day and ₦63.97) respectively were documented for those fed *ad libitum* for 3 months.

Effect of Feeding Duration on Carcass Characteristics of Growing Pigs

Most parameters considered for carcass evaluation except initial body weight and dressing percentage were significantly ($P<0.05$) influenced by feeding duration. The final body weight, bled weight, and carcass weight significantly increased with increase in feeding duration while fat free index decreased with increase in feeding duration. The pigs fed 80% *ad libitum* for 5 months recorded higher means values on final body weight (53.44 kg), bled weight (46.78 kg) and carcass weight (35.44 kg) while their corresponding means values (41.00 kg, 37.80 kg and 26.78 kg) respectively were documented for those fed *ad libitum* for 3 months. Pigs fed 80% *ad libitum* for 5 months had higher head (12.42%), ham (14.40%), shoulder (13.92%) and feet (2.73%) weights compared to 11.05%, 13.73%, 12.61% and 2.61%, respectively recorded for pigs fed *ad libitum* for 3 months. Pigs fed *ad libitum* for 3 months had better means values in back fat thickness (0.43 cm) and fat free index (49.69) when compared to the values (0.83 cm and 47.40) respectively obtained for those fed 80% *ad libitum* for 5 months.

Table 2 - Effect of feeding duration on growth performance of growing pigs

Parameters \ Feeding Duration	*Ad libitum* feeding for 3 months	80% *ad libitum* feeding for 5 months	SEM
Initial body weight(kg)	9.50	9.83	0.26
Final body weight (kg)	49.17^b	54.17^a	0.99
Daily weight gain (g)	322.25	369.42	27.02
Daily feed intake (kg)	1.30^b	1.63^a	0.15
Feed conversion ratio	3.46	3.66	0.12
Water intake (litre/pig/day)	3.15^b	5.06^a	0.30
Daily feed cost (₦)	98.36^b	109.11^a	3.45
Cost/Kg weight (₦)	294.10^b	311.41^a	8.50

ab means within rows followed by different superscripts are significantly ($P<0.05$)different

Table 3 - Effect of feeding duration on carcass of growing pigs

Parameters \ Feeding Duration	*Ad libitum* feeding for 3 months	80% *ad libitum* feeding for 5 months	SEM
Final weight (kg)	41.00^b	53.44^a	1.60
Bled weight (kg)	37.80^b	46.78^a	1.84
Carcass weight (kg)	26.78^b	35.44^a	1.38
Dressed weight (%)	76.27	76.59	2.03
Cut-up parts[1]			
Head weight	11.05^b	12.42^a	0.28
Ham weight	13.73^b	14.41^a	0.37
Shoulder weight	12.61^b	13.92^a	0.30
Feet weight	2.61^b	2.73^a	0.03
Tail weight	0.29	0.24	0.01
Backfat depth (cm)	0.43^b	0.63^a	0.04
Fat-free index	49.69^a	48.40^b	0.11

ab means within rows followed by different superscripts are significantly ($P<0.05$)different

1,, values expressed as percentage of final body weight.

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DISCUSSION

Growth hyperplasia and hypertrophy are modulated by the rate of feed intake, digestion and utilization of nutrients as demonstrated in the better record obtained from the pigs fed 80% *ad libitum* for 5 months duration when compared to those fed *ad libitum* for 3 months duration in terms of feed intake, daily weight gain and final weight of the pigs. Growth is said to be the difference between anabolic and catabolic processes (Bastianelli and Sauvant, 1997). The proportion of feed intake that goes for maintenance increases with time. The amount of feed required for tissue maintenance and physiological need of the pigs increases over time. Hence, pigs take more feed for more rapid, efficient growth and increased intramuscular fat as it continued to age. Emmans and Kyriazakis (1999) assert that substantial increase in absolute energy requirement per day is fundamental for sustaining the growth rate of animal. Nutrients requirement of pigs continue to increase as they age, the significant increase in water intake by the pigs fed 80% *ad libitum* for 5 months duration over those fed *ad libitum* for 3 months can be associated to higher physiological needs of these pigs. Pigs increase dry matter intake with age and as well increase their water intake in order to meet up with the increasing metabolic functions, movements of nutrients in body tissues, removal of metabolic waste and for growth which are associated with digestion and utilization of feed. This assertion is in line with the findings of Czarick and Fairchild (2012) who reported that daily water consumption increase with animal age. The significant effect observed in the daily cost of feed (₦) and cost per unit weight gain (₦/kg) in term of duration of feeding on growth performance might have resulted from increase in the rate of feed intake over time. Richard et al. (1993) reported that the improvements in the growth rate, feed efficiency and carcass traits will more than pay for the changes in the rate of feed consumption. Sufficient offering of diet to pigs is important in optimizing overall growth performance. Feeding strongly influences the final cost per kilogram at slaughter (Daza et al., 2003).

The higher bled and carcass weights obtained by the pigs fed 80% *ad libitum* for 5 months duration over those fed *ad libitum* for 3 months must have been influenced by the difference in the final body weight of the pigs. This observation corroborates the findings of Gu et al. (1992), Virgile et al. (2003) and Correa et al. (2006) who asserted that the rate of growth with age is greater in carcass than for the whole body. Also, Lebret (2008) reported that restricted feed allowance strongly reduces growth rate but improves carcass quality. Head, ham, shoulder and feet weights significantly increased with increase in feeding duration. This might have resulted from better body conformation of pigs in relation to their body mass. Pigs with larger body weight produce carcasses with a higher relative share of head, ham, shoulder and feet weights. This observation is in line with the findings of Latorre et al. (2008) and Lo-Fiego et al. (2005) that reported increase in primal cut with increasing slaughter weight. From this study, back fat of pigs increases with an increasing age while fat free index decreases with increasing age. The rate of fat accumulation was more pronounced at latter age of the pigs. Since, body fat deposition rate increases with age, in contrast to protein deposition rate which remains almost constant during the growing-finishing period (Reeds et al., 1993). Early slaughtering of animal at lighter weight will improve the carcass quality of pork, reducing the fat content thereby improving the sensory quality traits in pigs. Teye (2009) reported that high quality pork and pork fat can be obtained when pigs are slaughtered at a suitable age. While Scot et al. (1983) and Numberg et al. (1998) observed minimal deposition of saturated fatty acid content in average aged pigs.

CONCLUSION

Feeding pigs 80% *ad liubitum* enhances the performance of pigs (feed intake, weight gain and water consumption rate) and carcass characteristics (bled and carcass weights) but compromised the fat composition. Hence, pigs meant for lean pork production should be given unrestricted feeding and slaughtered at lighter weight (50-60 kg) as fat deposition is a function of age and weight.

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INFLUENCE OF THE PROBIOTIC, RE 3 ON NUTRITIONAL PERFORMANCE, HEMATOLOGICAL, IMMUNE STATUS AND CARCASS CHARACTERISTICS OF RABBIT REARED UNDER TROPICAL CONDITIONS

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ORIGINAL ARTICLE

ABSTRACT: *Thirty-six heterogenous population of California White, New Zealand White and Chinchilla weaner cross-bred rabbits of mean weight of 550 g were randomly assigned to four treatments of nine animals per treatment. The study was structured in such a way that there were two controls i. e. To- (treatment group without any additive in the basal diet) and To+ (treatment group treated with coccidiostat prior to commencement of feeding trial and fed the basal diet). The test treatment groups consisted of T_1 (supplemented with 1.0 ml RE 3 per kg feed) and T_2 (supplemented with 1.5 ml RE 3 per kg feed). The feeding trial lasted for a period of four months after which nutritional indices, hematological, immune function as well as carcass characteristics of the rabbits were assessed. The results of the lymphoid organ and indices showed that all the rabbits had similar immune response regardless of treatment. That was to imply that the immune function and status of all the rabbits seemed to be at the same level regardless of the presence or absence of RE 3. Furthermore, RE 3 neither influenced the growth nor the feed intake while feed conversion efficiency of rabbits fed 1.0 ml RE 3 per kg feed (T_1) demonstrated significant ($P<0.05$) improvement. Rabbits fed treatment T_1 also showed higher significant ($P<0.05$) serum levels of white blood cells and lymphocytes compared to those fed the other treatments. Also, RE 3 as a probiotic did not influence live weight, full stomach, full gastrointestinal and carcass length. It, however, caused significant ($P<0.05$) changes in the warm and chilled dress weights relative to all the others fed the other treatments.*

Key words: *Rabbit, Probiotic, Immune status, Hematology, Carcass, Nutritional profile, Tropical conditions*

INTRODUCTION

As a result of the high reproductive capacity of rabbits (*Oryctolagus cunniculus*), it is seen as a highly profitable animal agricultural venture as well as a valuable model for a variety of studies particularly immune and toxicological research according to Pűschel et al. (2010). Nonetheless, they are reportedly more prone to viral, bacterial, fungal and parasitic diseases such as pasteurellosis and coccidiosis (Mailafia et al., 2010). The ability of the natural intestinal complex and dynamic microbial ecosystem to fight intestinal infections is reportedly not always effective and supplementation with probiotic bacteria has proven to support as well as aid treating infections at that level (Corcionivoschi et al., 2010). According to the EEC directive 70/524, several microorganisms (*Bacillus cereus*, *Bacillus substilis*, *Enterococcus faecium*, *Lactobacillus farciminis,* etc) have been authorized as new additive for feedstuffs (Auclair, 2011) and all these strains have been reported to demonstrate positive influence on different animal models namely broiler chicken, beef cattle, dairy cow, piglets, sows and rabbits.

Feed additives are a group of feed ingredients that can elicit a desired animal response in a non-nutrient role such as pH shift, growth or metabolic modifier (Hutjens, 1991). However, they are not a requirement or guarantee for high productivity or profitability. Studies carried out so far indicate that commercial probiotics offer increased specific micro-flora, increased productive parameters, enhance better sanitary conditions, maintain a balance and multiplication of the beneficial microbial population in the gastro-intestinal tract (GIT), alter pre-existing intestinal flora so as to provide an advantage to the host as well as shape the immune systems etc. (Corcionivoschi et al., 2010).

Investigations conducted on the probiotic, RE 3 in Ghana using different animal models have generated a myriad of responses in the form of growth rate improvement, efficiency of feed utilization in pigs and poultry, superior egg production and characteristics as well as lowered mortality in laying birds, weight gain and delayed

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weight loss under feed-stress conditions in sheep (Osei et al., 2008; Okai, 2010; Oppong-Anane, 2009). Evaluation of the efficacy of RE 3 on rabbit under this tropical environment is yet to be undertaken.

This study therefore, set out to assess the influence of RE 3 on the nutritional and carcass characteristics, hematological indices as well as immune profile of rabbits raised under the Ghanaian tropical conditions.

MATERIALS AND METHODS

Background to the Study Location

The work was conducted at the rabbitory of the CSIR-Animal Research Institute's Frafraha station, Accra which is located at the coastal savannah zone of Ghana. The meteorological conditions of the site is such that it has an annual rainfall of about 730 mm which is characterized by two rainy season patterns i. e. May – mid July (major) and mid-August – October (minor). The average temperature ranged between 24.7 (August) and 28 ^{o}C (March). The relative humidity generally stand at 65% (mid-afternoon) and 95% (night time) while wind speed usually ranges between 8 and 16 km/h (http://www.ama.ghanadistricts.gov.gh).

Experimental Design and Feeding Trial

Thirty-six heterogenous population of California White, New Zealand White and Chinchilla weaner cross-bred rabbits of 550 g average weight and aged 6 weeks were obtained from three Ministry of Food and Agriculture certified rabbit farms in Accra, Ghana. They were acclimatized on the Animal Research Institute rabbitory where the study was conducted for two weeks prior to commencement. During that period, all the rabbits were subjected to internal and external parasitic control treatment and they were fed on a compounded feed (Table 1).

They were all treated with internal and external parasite control during this period and fed compounded feed (Table 1). Four treatment groups comprising nine rabbits per treatment in a completely randomized block design format were made. Sex and weight of the animals were factored into the groupings. The treatments were made up of To- (control diet without any additive), To+ (positive control diet which had rabbits treated with the coccidiostat, Vitacox at a ratio of 1:1 continuously for three days followed by a booster on days 5 and 6 but fed diet with any additive inclusion), T_1 (1.0 ml RE 3 per kg compounded feed) and T_2 (1.5 ml RE 3 per kg compounded feed). The feeding trial covered four months and all the rabbits were given feed at 6% of their respective body weights and these were adjusted at weekly intervals. Water was freely provided.

Table 1 - Composition of rabbit diet

Ingredients	Percentage (%)
Maize	51
Soybean meal	14
Wheat bran	32
Dicalcium phosphate	1.20
Oyster shells	1.00
Iodated salt	0.35
Lysine	0.10
Methionine	0.10
*Premix	0.25
Total	100.00
Calculated analysis	
ME (MJ/Kg)	10.30
Crude Protein (%)	16.04
Crude fat (%)	3.39
Crude fibre (%)	4.90
Lysine (%)	0.70
Met + Cystine (%)	0.54
Calcium (%)	0.73
Available phosphorous (%)	0.41
Sodium (%)	0.17

*Premix: Vit. A - 12,000,000 IU; Vit. E - 15000 mg; Vit.$B_{ß}$ - 1500 mg; Niacin - 30,000 mg; Vit.B_6 - 1500 mg; Vit. D_3 - 4500,000 mg; Vit. K_3 - 3,000 mg; Pantothenic acid - 12000 mg; Vit.B_{12}, - 10,000 mg; Vit. B_2 - 6000 mg; Folic acid -,800 mg, Iron - 60,000 mg; Copper - 75,000 mg; Iodine - 750 mg; Manganese - 130,000 mg; Zinc - 70,000 mg; Selenium - 300mg; Calcium - 17.50%, Lysine - 1,330 mg; Methionine - 1,075 mg; ß-Corotenic acid - 350 mg

Data Collection and laboratory Analysis

As part of the monitoring and evaluating the efficacy of RE 3 as a growth promoting agent in rabbit production, weekly live weight, daily feed intake, daily leftover feed, morbidity and mortality were closely monitored and properly documented. Physical as well as behavioral changes in the rabbits throughout the course of the feeding trial were monitored and documented. At the end of the feeding trial, three rabbits from each treatment group were randomly selected and euthanized. 5 ml of blood was collected by cardiac puncture into labeled, sterile bottles containing EDTA (anti-coagulant) and used to determine the hematological parameters using an automated analyzer, Sysmex KX-210, Sysmex Corporation, Japan.

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The euthanized rabbits were then, weighed, sacrificed and eviscerated. The gastro-intestinal tract (GIT) of the rabbits was also removed and the empty, warm and chilled carcass weights determined and recorded. Also, the full stomach, brain, heart, liver, lung, kidney, testis, tongue, trachea and carcass length were similarly treated and the information generated recorded. The spleen was excised, blotted dry and weighed. The spleen index which contributed to the measure of the immune function of the animals was determined by the method as described by Lu et al. (1996).

Statistical analysis

The data collected were subjected to the one-way-analysis of variance (ANOVA) and the differences between the means assayed by the least significant differences using the Genstat statistical software (Genstat Statistical Package, 2008).

RESULTS AND DISCUSSION

Influence of RE 3 on Nutritional Parameters of rabbits

The nutritional performance of rabbits in response to the introduction of Re 3 as additive in diets is presented in Table 2. The results indicated that no significant ($P>0.05$) differences were observed in the daily feed intake values for all the treatments, neither were there any differences between the final body weights and the average daily weight gains of the rabbits in the four dietary treatment groups ($P>0.05$). However the average daily weight gains on T_1 tended to be superior to the other treatments. This is in agreement with the assertion that the administration of probiotic to fattening rabbits improves growth performance characteristics (Kritas et al., 2008). Efficiency of feed utilization was only significantly different ($P<0.05$) between T_1 and T_2, due possibly to the fact that the rabbits on T_1 made better use of the ingested feed than those on the other treatment groups. That is even though rabbits fed all the treatments had statistically similar ($P>0.05$) feed intake, average daily gain and total weight responses, those fed treatment T1 demonstrated statistically superior feed conversion efficiency ($P<0.05$).

Table 2 - Effect of RE3 on feed intake, live weight changes, feed conversion ratio and health of rabbits

Treatment	Initial Weight	Final Weight	Total Weight Gain	ADG	Total Feed Intake	Av. Daily Feed Intake	FCE	Mortality
To+	1,440	2,720	1,670	19.42	8,458	98.4	5.062^{b}	2 (22.22%)
To-	1,044	2,830	1,730	20.12	8,927	103.8	5.225^{ab}	1 (11.11%)
T1	1,033	2,765	1,755	20.41	8,201	95.4	4.739^{b}	0
T2	1,056	2,778	1,600	18.60	9,079	105.6	5.750^{a}	3
L.S.D.	–	471.0	349.7	0.004	1.340	15.58	0.680	–

Means in a column with similar or no superscripts are not significantly different ($P>0.05$). ADG = Average Daily Gain; FCE = Feed Conversion Efficiency; Av. Daily Feed Intake = Average Daily Feed Intake

Probiotics according to Metzler et al. (2005) are used as a nutritional technique to support host organisms during difficult physiological periods, attenuation of technological stress or prevent and combat diarrheal syndromes. Therefore, its usage does not seem to be focused directly on enhancing nutritional performance of animals. However, specific examples available literature indicate otherwise relative to some animal models such as weaned pigs (improved body weight gain and growth performance), birds (improved performance and productivity – growth, increases in egg production and feed conversion), cattle (increased feed intake and body weight and lambs (improvement in growth performance and meat production) [Philips et al., 1985; Lema et al., 2001; Baum et al., 2002; Konstantinov et al., 2004].

Further, the results also demonstrated that there was statistical insignificant differences ($P>0.05$) in the rate of mortality among the rabbits on all the treatment groups. This does not seem to corroborate findings of Kritas et al. (2008) who asserted that even when the health status of rabbits were satisfactory, mortality was significantly reduced after treatment with probiotics during the growing period.

Effect of RE 3 on hematological parameters of rabbits

Blood examination reportedly gives the opportunity to investigate the presence of several metabolites as well as other constituents and thus help in detecting conditions of stress, which could be nutritional, environmental or physical and that physiological parameters (hormones, heart rate, immune reactions) when considered in relation with other parameters (behavior, morbidity, etc.) can be used as a welfare indicator (Aderemi, 2004; Hoy and Verga, 2007; Archetti et al., 2008). Table 3 presents the hematological profile of rabbits fed RE 3 at inclusion rates of 1.0 and 1.5 ml per kg feed (T_1 and T_2 respectively). The results revealed that there were no treatment effects in the blood profile of the animals and that the values obtained in this study were within the normal references for rabbits (Ross et al., 1979; Mitruka and Rawnsle, 1997; Ahamefule et al., 2008, www.medirabbit.com). RE 3 as a probiotic can thus be said to sustain the normal hematopoietic function of rabbits at the inclusion rates of 1.0 to 1.5 ml per kg feed as no significant differences ($P>0.05$) were established among all the treatment groups. This notwithstanding, the study showed a significantly ($P<0.05$) higher levels of WBC and lymphocytes ($\times 10^3/\mu l$) for T_1 whilst the other treatments had values that fell within the reference range ($5 - 13 \times 10^3/\mu l$) for rabbits (http:www.medirabbit.com).

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Table 3 - Effect of RE 3 on hematological parameters of rabbits direct- fed for 4 months														
Treatment	Hb (%)	HCT (g/dl)	RBC ($\times 10^6/\mu l$)	RDW_SD (fl)	MCH (pg)	MCHC (g/dl)	MCV (fl)	MPV (fl)	PDW (fl)	PLT ($\times 10^3/\mu l$)	P_LCR (%)	WBC ($\times 10^6/\mu l$)	LYM ($\times 10^3/\mu l$)	LYM (%)
To+	12.87	40.70	6.12	30.03	20.90	31.67	66.10	6.73	7.93	365.00	6.33	6.97^{b}	3.73^{c}	53.4
To-	13.43	43.20	6.32	31.63	21.33	31.07	68.70	7.37	8.07	368.00	4.07	11.09^{a}	7.17^{ab}	65.7
T_1	13.80	44.20	6.48	30.70	21.30	31.23	68.13	7.07	8.17	320.00	4.43	13.33^{a}	8.37^{a}	63.0
T_2	12.10	38.20	5.59	31.83	21.63	31.67	68.33	6.53	7.40	445.00	5.53	11.93^{b}	6.47^{b}	55.5
L.S.D.	2.407	7.14	1.358	4.371	1.81	0.675	6.41	1.90	2.01	361.00	3.649	3.36	1.462	13.9

Means in a column with similar or no superscripts are not significantly different (P>0.05). Hb=Hemoglobin concentration; HCT=Hematocrit; RBC=Red blood cell; MCH=Mean cell hemoglobin; MCHC=Mean cell hemoglobin concentration; MCV=Mean cell volume; MPV=Mean platelets volume; PDW= platelets distribution width; PLT=Platelets; P_LCR=platelets large cell ratio; WBC= White blood cell; LYM= Lymphocytes

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High WBC count has been reported to be usually associated with microbial infection or the presence of foreign bodies or antigens in the circulatory system (Ahamefule et al., 2006). None of these scenarios could be the basis for the observed comparatively high WBC count as well as lymphocytes in rabbits fed treatment T_1. This could be the basis for stimulating and boosting the immune status of the rabbits on that treatment. This may, however, need confirmation from actual measurements of the specific immune responses (serum immunoglobulins such as IgM, etc.).

From the statistically insignificant variations in mortality rates observed among all the treatment groups coupled by relatively higher levels of WBC and lymphocytes, it would not be out of place to attest to the comparative effectiveness of RE 3 in maintaining the natural defense mechanism of rabbits introduced the product as part of the diet regimen. A similar observation was made in relation to pigs given 1.5 ml RE 3/kg feed (Owusu Amoah, 2010).

Effect of RE 3 on immune function of rabbits

Immune organs are those whose functions help maintain the normal immune status of the bodies of animals (Feng et al., 2007). In this regards, the weight of lymphoid organ as well as their indices commonly serve as a measure of the immune status (Pope, 1991). The results of the present work as presented in Table 4 showed that there were no significant (P>0.05) differences in the spleen indices as well as weights of spleen of the rabbits in the various treatment groups. Based on this, it could be inferred that the use of RE 3, at the inclusion rate of 1.0 and 1.5 ml/kg feed, elicited similar immune responses just as the coccidiostat-treated counterparts (To+).

Table 4 - The impact of RE3 on the immune status of rabbit

Treatment	Weight of Spleen (g)	Spleen Index
T_{0+}	1.67	0.60
T_{0-}	1.67	0.64
T_1	1.33	0.45
T_2	2.00	0.52
L.S.D.	1.88	0.77

The impact of RE 3 on the immune response of rabbits introduced to it does not seem to conform to the general impression about probiotics in terms of immune stimulation. Probiotic micro-organisms in the gut reportedly have the capacity to stimulate the immune system either by migrating through the gut wall as viable cells which multiply to a limited extent or antigens released by the dead organisms get absorbed and stimulate the immune system directly (www.albertaclassic.net/probiotics.php).

Influence of RE 3 on carcass characteristics and some vital organs of rabbits

Most of the carcass indices such as the full stomach, brain, liver, lungs, kidneys, heart, testicles, tongue and trachea and carcass length of the rabbits were similar in weight among all the dietary treatments (Table 5). This may imply that RE 3 does not induce any toxicological influence that could cause hypertrophy of organs or the level of RE 3 fed might not be sufficiently large enough to induce such a response. Histopathological examination of certain key organs of these rabbits as well as blood chemistry did not lend credence to organ injury or damage as RE 3 introduction as additive. The chilled carcass weight of rabbits fed 1.0 ml RE 3 per kg feed (T1), however, differed significantly (P<0.05) from those treated with coccidiostat (To+). This weight was also higher than that of those fed a higher dose of RE 3 (T2). Similar observations were made by Apgar et al. (1993) and Okai (2010).

Table 5 - Carcass weight of some organs of rabbits fed RE3 for a period of 4 months (g)

Trt	Live Wt	Warm Dressed Wt	Chilled dressed wt	Full stom	Full GIT	Brain	Heart	Lung	Liver	Kidney	testis	Ton & Tra	Carcass length/ cm
To+	2,700	1,697^{b}	1,576^{bc}	91.30	441	7.67	7.33	13.70	67.0	13.00	6.83	11.67	29.69
To-	2,767	1,740^{a}	1,610^{ab}	115.30	411	7.67	8.00	17.70	77.0	12.67	8.58	11.67	29.83
T1	2,833	1,781^{a}	1,650^{a}	121.30	479	6.67	9.67	11.00	77.3	13.67	7.83	12.67	30.05
T2	2,667	1,677^{b}	1,560^{c}	87.70	392	7.33	8.33	14.70	74.7	13.67	7.08	11.33	29.84
L.S.D.	570.0	41.80	41.70	57.99	210.5	2.88	3.81	11.29	14.72	3.21	6.21	2.514	1.999

Means in a column with similar or no superscripts are not significantly different (P>0.05). Trt= Treatment; Full Stom = Full Stomach; Ton & Tra= Tongue and Trachea; GIT= Gastrointestinal Tract; Warm Dress Wt= Warm dressing Weight; Chilled Dress Wt == Chilled Dressing Weight

CONCLUSION

The study revealed that the use of this probiotic, RE 3 could enhance the concentration of white blood cells and lymphocyte particularly at the inclusion rate of 1.0 ml per kg feed. Furthermore, weight gain, feed intake and average daily gain were not influenced by the inclusion of RE 3. However, feed conversion efficiency (FCE) of rabbits supplemented with 1.0 ml per kg feed (T1) tended to be better than those provided 1.5 ml per kg feed (T2) which is suggestive of the fact that treatment T1 was a better and relatively efficient converter of feed to meat. RE 3 did not appear to affect the immune function and response of rabbits.

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