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Include volume of blood collected, container used, and amount of preservative or anticoagulant (e.g., heparin).

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Original Article

The Effect of Natural Pastures Grazing Conditions on Skin\Leather Quality of Sudan Desert Sheep

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ABSTRACT

This study was conducted to estimate the effect of natural pastures grazing conditions on Sudan Desert Sheep Skin\leather quality. Five Sudan desert sheep breeds aged 1-1.2 years old were used in this experiment. One hundred and fifty (150) pieces of fresh skins from Five (5) non-castrated male of Sudan desert sheep breeds which bring from different geographical area from west Sudan (Kordofan state) and east Sudan (Gezira and Butana). Sheep were divided in two groups according to geographical zone. 15 pieces of sheep skins for each breed were selected from animals grazed at poor pasture areas and similar number were obtained from animals grazed in enriched pasture areas, according to pasture measurements records at each breed locations. The results revealed that, fresh skin weight and Leather cracking load were significantly affected ($P \leq 0.05$) by pasture quality. Leather elongation, Tensile strength kg/cm^2, Thickness values and Flexibility values were not statistically ($P \leq 0.05$) affected by pastures quality. Moisture content of Sudan desert sheep leather values were significantly affected by pasture condition, with highest values of leather moisture content on Shugor sheep (group one) either on enriches and poor nutrition samples, and lowest values were in Kabashi and Hamari (group two) on poor pastures level. There were no significant effects of pasture quality on chemical characteristic (fat, ash and chrome oxide contents) on leather quality. The high values on fat content was in Shugor, Watish (group one) and Kabashi (group two) in both enrich and poor pastures levels. While the lowest fat contents were in Dubasi (group one) and Hamari (group two) sub-types on poor levels of pastures.

Keywords: Desert sheep, Leather quality, Natural grazing, Sudan.

INTRODUCTION

In Sudan, skin from Cattle, sheep and goat is valuable animal by products for local use as well for export market. Sheep are very important farm animals in Sudan, especially the Desert breed. One of the major problems facing the Desert sheep is the heat stress and the high ambient temperature. Sudan sheep population was estimated at 50.9 million head (M.A.R.,

2007). Sheep are predominately, about 90%, in the hands of traditional producers who mainly depend on natural pasture to raise their animals (Elrasheed, 2010). More than 80% of the sheep in Sudan are Sudan desert type; they are mainly predominant north of 12º N (Devendra and Mcleroy, 1982), where they were maintained under rangeland conditions for meat production (Idris *et al*., 2010). Animal managed under range land faced many problems including the nutritional limitation, low nutritive value of the range, high ambient temperature, scarcity of feed and water have great effect on the reproduction and production performance of the sheep in semi-arid area of Sudan.

The quality of sheep leather is influenced by the breed and age of the animals (intrinsic quality), by nutrition and by the marks on the skins acquired during the lifetime of the animal (extrinsic quality) (Jacinto *et al*., 2004). Sheep kept under this extensive system, are subjected to a series of environmental stresses during the dry season, mainly inadequate nutrition and inadequate drinking water (Idris *et al*., 2010). There is high variability in the amount and distribution of rainfall, which affects the vegetation and water availability, and in turn the flock movement, watering intervals and general husbandry. Thus this study was aimed to estimate the effect of feeding desert sheep under range conditions and it is impact on skin\leather quality, when compared to SSMO (Sudanese standards and Metrology) standards for leather quality.

MATERIAL AND METHODS

Study area

This study was conducted in Wad-Madani area. Sheep groups were bringing from Kordofan region, Gazira and Butana region. Kordofan region in the western part of the Sudan (latitudes 9°:30" and 16°:30 North and longitudes 24° and 32°:25 East). The mean annual rainfall ranges from 50-850 mm. The rainy season extends from July to October, reaching its peak in August.The natural vegetation consisted mainly of the grass species as *Panicum tugidum, Arisdia spp, Cympopogons spp., Ctenium elegan, Dactyloctenium aegyptium* and *Eragrostis tremula* (Idris *et al*., 2010). Gazira state in the east-central region of the Sudan (latitudes 14°:30 and 33°:30 North and longitudes 14°:5and 33°:5 East). Butana plain is a semiarid clay region (Latitude 13°:40and 17°:50 North and Longitude 32°:40 and 36° East). The rainfall ranges between 600 mm/year. The annual mean temperature ranges from 32°-16° C in January (winter) and from 46°-27°C in May-June (summer). Two vegetation zones are existing in the area, namely semi-desert Acacia shrub and short grasslands of the North Central Sudan and secondly, the low woodland savannah of central Sudan.

Selection of experiment animal skins

One hundred and fifty (150) pieces of fresh skins from Five (5) non-castrated male of Sudan desert sheep breeds aged 1-1.2 years old, which bring from different geographical area from west Sudan (Kordofan state) and east Sudan (Gezira and Butana). Sheep were divided in two groups, group one consistent of Shugor, Watish and Dubasi represents east Sudan sheep**;** second group consistent of Hamari and Kabashi represents the semi-arid area of west Sudan sheep. 15 pieces of fresh skin for each breed were selected from animals raised at poor pasture areas and the other (15 pieces) were obtained good pasture (enrich) with available feeds.

Tanning procedures

Leather was prepared from sheep skin according to the following main steps: Soaking, liming, deliming, bating, degreasing, pickling, tanning, neutralization and re-tanning. Sampling and assessment of chemical and physical characteristics was done according SSMO (Sudanese Standard and Meteorology Organization) methodology. Physomechanical properties that assessed were: Tensile strength and elongation% according to SSMO5 (2003), Flexibility test according to SSMO6 (2001) and Measurement of tearing load and resistance

to grain cracking according to SLTC (Society of Leather Trades Chemists, 1965). Whilst, chemical characteristics were: moisture% according to SSMO1 (2006), total Ash% According to SSMO2 (2006), fats and oils% according to SSMO4 (2006), and chromium% according to SSMO3 (2006) procedures.

Statistical Analysis

The data were statistically analyzed according to complete randomized design using SPSS v.14.0 software package (SPSS, 1996). Duncan's Multiple Range Tests (DMRT) was used for means separation, beside comparing skin and leather measurements results with Sudanese Standard Thresholds for leather quality according to SSMO standards.

RESULT AND DISCUSSION

Sudan desert sheep skin\leather physical properties:

Fresh skin weight was significantly affected ($P \leq 0.05$) by pasture quality and the highest weight values were recorded for sheep on good or enrich pasture. These findings were similar to those obtained by Williams and Thornberry (1992) who found that sheep lamb skins supplemented with higher level of concentrate had higher thickness than low level. This might be due to the better nutritive value of good quality pastures which attributes to better thickness. The effect of pasture quality on Sudan desert sheep leather elongation was not statistically detected ($P \leq 0.05$). The highest values were observed under poor pastures. Tensile strength kg/cm^2 was not significantly ($P \leq 0.05$) affected by pastures quality. These results were not on line with Oliveira *et al.* (2007) and Teklebrhan *et al.* (2012) who found that significant difference in strength and flexibility properties among sheep lamb breeds was not detected. Generally, the high records were detected on skin from sheep in good pastures levels for all breeds (Table 1).

Table 1. The effect of grazing of Sudan Desert Sheep at poor and enrich natural pastures on skin\leather physical properties

Parameters	Pastures	group one			group two	
		Dubasi	Shugor	Watish	Kabashi	Hamari
Weight	Poor	1.16±0.07^{f}	1.39±0.16^{cd}	1.19±0.11^{ef}	1.36±0.12^{cd}	1.26±0.13^{def}
	Enrich	1.31±0.04^{de}	1.57±0.26^{b}	1.47±0.09^{bc}	1.77±0.12^{a}	1.49±0.20^{bc}
Elongation	Poor	61.70±5.26^{cd}	67.17±4.66^{ab}	68.10±3.13^{a}	63.17±3.52^{bc}	70.32±1.74^{a}
	Enrich	54.59±4.15^{e}	58.19±3.73^{de}	60.83±5.60^{cd}	55.94±4.47^{e}	62.69±3.17^{c}
Tensile strength	Poor	174.13±18.54^{b}	159.59±26.89^{b}	155.63±37.85^{bc}	172.82±23.98^{b}	127.30±24.07^{c}
	Enrich	216.72±22.38^{a}	204.40±44.27^{a}	215.17±22.77^{a}	209.93±21.92^{a}	173.49±31.90^{b}
Cracking load	Poor	7.11±0.45^{e}	8.22±1.14^{cd}	8.97±1.63^{abc}	9.19±1.66^{ab}	7.81±1.37^{de}
	Enrich	8.57±1.18^{bcd}	9.37±1.40^{ab}	9.49±1.60^{a}	9.79±2.17^{a}	8.08±1.09^{cd}
Thickness	Poor	1.21±0.41^{abc}	1.13±0.32^{bc}	1.31±0.40^{abc}	1.33±0.30^{abc}	1.07±0.32^{c}
	Enrich	1.50±0.50^{a}	1.43±0.52^{ab}	1.45±0.48^{ab}	1.45±0.34^{ab}	1.35±0.34^{abc}
Tear load	Poor	37.42±3.95^{d}	41.90±5.58^{bc}	31.34±1.95^{f}	40.99±3.71^{c}	32.62±3.64^{ef}
	Enrich	42.20±6.32^{bc}	51.61±5.58^{a}	36.04±1.47^{de}	44.73±5.18^{b}	34.58±2.64^{def}
Flexibility	Poor	3.07±1.03^{abcd}	3.67±0.62^{a}	3.20±0.94^{abc}	3.27±0.80^{abc}	2.80±0.86^{bcd}
	Enrich	2.67±0.72^{cd}	3.60±0.74^{ab}	3.33±0.72^{abc}	3.60±0.83^{ab}	2.33±0.49^{d}

Values in same row with different superscripts differ significantly (P≤0.05)

Leather cracking load was significantly affected ($P \leq 0.05$) by pastures quality levels, where the high values were reported on enrich levels of pastures. These findings were different from those reported by Williams and Thornberry (1992). Thickness values were not significantly affected ($P \leq 0.05$) by pastures quality. However, the lowest leather thickness values were recorded on poor pastures level were and the value. Tear load values were significantly ($P \leq 0.05$) affected by pastures quality. Thus, the highest value of tear load was reported on enrich pastures. These results were different from those reported by Murray (1996) who found that tear strength (N/mm^2) values were not significantly affected ($P \leq 0.05$)

by breeds and nutrition level of sheep lambs. Flexibility values were not significantly ($P \leq 0.05$) affected by pastures quality. These findings were agreed with Teklebrhan *et al.* (2012) who mentioned that no significant difference in strength and flexibility properties among sheep lamb breeds. However, the high valuable degree of flexibility was recorded on enrich pastures (Table 1).

Effect of grazing of Sudan desert sheep on leather chemical characteristics

Moisture content of Sudan desert sheep leather values were significantly affected by pasture condition ($P \leq 0.05$). The highest values of leather moisture content was observed on Shugor sheep (group one) either on enrich and poor nutrition samples. While the lowest values were determined for Kabashi and Hamari (group two) on poor pastures level, same results obtained by Briegel *et al.* (2012). These results might be due to the variation on the skin texture bundles which might be closer to each on Shugor (group one) and holds water within while in Kabashi and Hamari (group two) texture bundles might be not closer or tight to each other's or in occasional order which is helps on temperature losing in hot climate where they are raised. For the same reason Hamri and Kabashi (group two) were generally reported less tensile strength and tear loads than other sub-types of Sudan desert sheep this might be referenced to the texture bundles closeness which has low resistant against load separation force (Table 2).

Table 2. The effect of feeding Sudan Desert Sheep at poor and enrich natural pastures on skin\leather chemical characteristics

Parameters	Pastures	group one			group two	
		Dubasi	Shugor	Watish	Kabashi	Hamari
Moisture%	Poor	8.15 ± 1.35^{de}	11.83 ± 2.15^{a}	9.04 ± 0.76^{bcd}	7.73 ± 1.26^{e}	7.85 ± 1.33^{e}
	Enrich	9.75 ± 1.40^{bc}	11.36 ± 1.82^{a}	10.03 ± 1.25^{b}	8.64 ± 1.68^{cde}	9.38 ± 1.01^{bc}
Ash%	Poor	2.84 ± 0.39^{a}	2.78 ± 0.30^{a}	2.92 ± 0.26^{a}	2.79 ± 0.27^{a}	2.74 ± 0.32^{a}
	Enrich	2.93 ± 0.25^{a}	2.90 ± 0.36^{a}	2.84 ± 0.27^{a}	2.98 ± 0.31^{a}	3.01 ± 0.31^{a}
Fat%	Poor	5.97 ± 1.26^{b}	7.23 ± 2.07^{ab}	6.45 ± 1.27^{ab}	7.49 ± 1.69^{ab}	5.90 ± 1.26^{b}
	Enrich	6.83 ± 1.26^{ab}	8.06 ± 1.61^{a}	7.23 ± 1.06^{ab}	7.43 ± 1.36^{ab}	7.26 ± 1.46^{ab}
Chrome oxide%	Poor	2.89 ± 0.46^{ab}	2.82 ± 0.27^{ab}	2.92 ± 0.21^{ab}	3.05 ± 0.64^{a}	2.67 ± 0.31^{b}
	Enrich	2.97 ± 0.31^{ab}	2.91 ± 0.38^{ab}	2.93 ± 0.26^{ab}	3.04 ± 0.41^{a}	2.94 ± 0.26^{ab}

Values in same row with different superscripts differ significantly (P≤0.05

Effect of pastures quality were not significantly detected among Sudan desert sheep breeds on fat and ash contents ($P \geq 0.05$) .The high values on fat content percentages was recorded for Shugor, Watish (group one) and Kabashi (group two) in both enrich and poor pastures levels. While the lowest fat contents were reported in Dubasi (group one) and Hamari (group two) sub-types on poor levels of pastures, those results not online with the Lyne (1964). These findings were different from Wodzicka (1958).who reported that sheep has numerically higher natural fat in the skin when supplemented with higher level of concentrate when he studied Ethiopian sheep breeds (Table 2). Similarly, chrome oxide contents were not affected by pastures conditions, and no statistically variation were detected among all Sudan desert sheep sub-types either on enrich and poor pastures levels (Table 2).

This result were different from which was reported by Teklebrhan *et al.* (2012) and Stosic (1994) whom found that sheep lambs supplemented with low level of concentrate have numerically higher leather chrome-oxide content than higher level of concentrate (Table 2).

CONCLUSION

Physical properties of Sudan desert sheep leather; Fresh skin weight, thickness, elongation, tensile strength**,** cracking and tear load results; were significantly affected by pastures quality sheep fed on. While flexibility results were not significantly affected by pastures quality

levels, Thereupon, the improvements of pastures quality or sheep feeding generally would lead to an improvement in most parameters of leather quality.

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Original Article

Effect of Feed Restriction on Linear Body Measurements and Weight Changes of Pregnant Rabbit Does

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ABSTRACT

Restricted feeding of growing rabbits has two advantages such that using an adequate feed restriction could help decrease feed intake without reduction of the body weight and also prevent the occurrence of enteritis after weaning. A four- week study was conducted to determine the effect of varying levels and periods of feed restriction during pregnancy on linear body measurements and weight changes of rabbit does. A total of thirty six rabbit does (36) were grouped into three consisting of 12 rabbits does each. These rabbit does were exposed to three levels of quantitative feed restriction (0.15 and 30%) at three different periods of gestation (15-19, 20-24 and 25-29 days). Data collected on performance and linear body measurements were arranged in a 3×3 factorial experimental layout and then subjected to completely randomised design using SAS. The result showed significant differences ($p<0.05$) in final weight and weight gain. While, all other parameters measured for linear body measurement were not significantly ($p>0.05$) affected. In this study, it was revealed that the levels and periods of feed restriction do not have any negative effect on linear body measurement of pregnant rabbit does.

Keywords: Feed restriction, linear body measurement, Pregnant, rabbit does.

INTRODUCTION

Rabbit production is gradually becoming an important source of income and employment generation in Nigeria. It can serve as alternative source of cheap animal protein to mitigate the negative impacts of malnutrition in infants and adults which is prevalent in developing countries. The only limiting factor reported to be affecting growth and productivity of rabbits in tropical and arid climates according to McNitt *et al.,* (2000) is calorie stress associated with high ambient temperature. Rabbit meat provides a cheap source of meat which is

characterized by a high protein and low fat cholesterol content (Aduku and Olukosi, 1990), and it is considered a delicacy and a healthy food product (Dalle Zotte, 2000). One of the pre-requisites for genetic improvement is the knowledge of genetic parameters for important economic traits (Akanno and Ibe, 2006). Rabbit producers are interested in the relationship that exists between bodyweight and physical characteristics, since this information would reflect in their feed efficiency and performance of the rabbits. According to Margherita (2008), because of the size and oral anatomy of rabbits, it is intrinsically difficult to perform a thorough oral examination and measurement on rabbits and rodents. Breeders need to establish the relationship that exists between these parameters and to organize the breeding programmes so as to achieve an optimum combination of bodyweight and good conformation for maximum economic returns (Khalil *et al*., 1987). In livestock production the objective of live body measurement has appealed to many researchers as a means of describing the size and shape of farm animals (Brown *et al* 1956). In line with this, linear body measurements have been used to characterize breeds, evaluate breed performance and predict live body weight of animals (Ibe 1989; 1994, Ozoje and Herbert, 1997). This later report is attributed to high genetic correlations between body weight and linear traits. For instance Adeleke *et al.,* (2004) observed that chickens live weight is positively correlated with other linear body traits and gave breast girth as the best predictor of live weight. In domestic rabbit, Oke *et al.,* (2003) found height at withers as the best prediction of body weight at 20 weeks of age and body length at 16weeks of age.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the Rabbitry Unit, Directorate of University Farms, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State. The site is located in the rain forest vegetation zone of South-Western Nigeria on latitude 7^{o} 13' 49.46'' N, longitude 3^{o} 26 11.98E and altitude 76m above the sea level. The climate is humid with a mean annual rainfall of 1037mm and mean temperature and humidity of 34.7^{0}C and 83%, respectively (Google Earth, 2013).

Experimental Animals and Management

Thirty six (36) rabbits do of 20 weeks old of mixed breeds (Chinchilla, Dutch and New Zealand white) with initial live weight of 1.7-2.0 kg were used for the study. The does were divided into three groups of twelve rabbits each after balancing for weight and housed individually in cells of dimension 0.8×0.5×0.6 m. The hutches were washed and disinfected prior to the commencement of the experiment.

Experimental Design

Animals (36) were grouped into three and allotted to three feed restriction levels (0.15, 30%). Each group was further subdivided into three and three and then randomly divided assigned to three periods of feed restriction (15-19, 20-24, 25-29 days). Thus arranged in a 3×3 factorial experimental layout in a completely randomized design. The table below shows the composition of concentrate mash diet fed to the rabbit does.

DATA COLLECTION

The experiment lasted for 28days (4 weeks) during which data were collected on weight gain and linear body measurement (Head to shoulder, ear length, heart girth, body length and tail length) of the rabbit does.

Weight gain

This was measured on weekly basis for four weeks by subtracting the initial weight from the final weight.

Table 1. Composition of concentrate diet fed to rabbit does

Ingredients	%
Maize	47.50
Fish meal	2.00
Soybean meal	3.00
Wheat offal	23.00
Groundnut cake	12.00
Rice husk	7.00
Bone meal	3.00
Oyster shell	2.00
Salt	0.25
Vitamin and Mineral premix	0.25
Total	100
Determined Analysis	
ME (Kcal/kg)	2578.8
Ash (%)	2.74
Crude fibre %	10.65
Crude protein	16.20
Nitrogen free extract	42.50

Linear body measurement

Linear body measurements that were taken on the rabbit does include: Head to shoulder (HTS), ear length (EL), heart girth (HG), body length (BL)and tail length (TL).This was taken at an interval of 7days for a period of four weeks. All the linear body measurements were taken in centimeter with the aid of tape rule according to the procedures of Akanno and Ibe (2006).

The descriptions of the measurements were as described below:

i) **Head to shoulder**-This was measured from the tip of the nose to the end of the cervical vertebra.
ii) **Ear length –**This was measured from the tip of the ear to the junction of the ear at the level of the skull.
iii) **Heart girth-** This was determined by measuring the circumference of the chest region directly below the fore arms.
iv) **Body Length** – This was the length from the tip of the shoulder to the tip of the pelvic.
v) **Tail length** –This was taken from the junction of the hip to the tip of the tail.

Statistical Analysis

Data collected were arranged in a 3×3 factorial experimental layout and then subjected to one way analysis of variance using (SAS, 1999). Significantly ($p<0.05$) different means were separated using Duncan's Multiple Range Test of SAS (1999) statistical package.

The experimental model:

$Y_{ijk} = \mu + R_i + P_{j+} RP_{ij} + \varepsilon_i j_k$

Where Y_{iJk} = Observed value

μ = Overall mean value

R_i = Effect of ith Restriction

P_j= Effect of jth Periods
RP_{ij}= Effect of interaction between ith Restriction and jth periods
ε_{iJk}= Residual error

RESULTS

Main effect of levels and periods of feed restriction on linear body measurement of pregnant rabbit does

Table 2 shows the main effect of level of feed restriction and period of feed restriction on final weight, weight gain and linear body measurements of rabbit does. The result showed that significant differences ($p<0.05$) were obtained on final weight and weight gain of the rabbit does on different levels and periods of feed restriction. Rabbit does on 15% restriction have the highest final weight (2,414.16 g, and weight gain 530.00g respectively) while rabbit does on 0% restriction have the least values (2,221.33g and 397.67g respectively). Levels of feed restriction significantly ($p<0.05$) influenced head to shoulder length, ear length and tail length. However, heart girth and body length were not significantly affected ($p>0.05$). The means for head to shoulder ranges from 12.67cm to 13.48cm for the levels of feed restriction. Ear length values ranged from 11.27cm (does on 0% restriction) to 11.89cm (does on 15% restriction level) while that of the tail ranges from 7.63 cm for does on 30% restriction and 10.56cm for does on 0% restriction level. Periods of feed restriction had no effect on body weight gain and linear body measurement except for ($p<0.05$) the tail length with rabbit does restricted between 25-29 days recording the longest (9.44cm).

Table 2. Main effect of levels and periods of feed restriction on linear body measurement of pregnant rabbit does

	Levels of feed restriction				Periods of feed restriction(days)			
Parameters	0%	15%	30%	SEM	15-19	20-2 4	25-29	SEM
Initial weight (g)	1823.66	1884.16	1848.33	26.53	1815.83	1912.41	1827.91	27.17
Final weight (g)	2221.33^{c}	2414.16^{a}	2258.33^{b}	54.46	2263.33	2367.41	2263.08	54.94
Weight gain(g)	397.67^{c}	530.00^{a}	410.00^{b}	23.06	447.50	455.00	435.16	42.31
Head to shoulder(cm)	13.48^{a}	13.45^{a}	12.67^{b}	0.15	13.38	13.24	12.97	0.15
Ear length (cm)	11.27^{b}	11.89^{a}	11.51^{ab}	0.18	11.56	11.56	11.55	0.19
Heart girth (cm)	27.39	26.31	26.39	0.37	26.73	26.73	26.62	0.43
Body length (cm)	33.23	34.38	32.50	1.10	32.72	33.44	33.95	1.15
Tail length (cm)	10.56^{a}	8.69^{b}	7.63^{c}	0.30	8.50^{b}	8.93^{ab}	9.44^{a}	0.10

$^{a, b, c}$:Means in the same row with different superscripts differ significantly ($p<0.05$)
SEM: Standard error of mean

Interaction between levels and periods of feed restriction linear body measurement of pregnant rabbit does

Table 3 shows the interaction between levels of feed restriction and period of restriction on weight gain and linear body measurement of gestating does. Significant ($p<0.05$) differences were obtained on the final weight and weight gain. Gestating does on 15% level of feed restriction at 20-24days recorded the highest value (2,567.50 g) for final weight compared to those on 0% level of feed restriction at the different periods which recorded similar statistical values with other treatment group. Similar ($p>0.05$) mean weight gain values (395.00, 400.00 and 398.00 g) were obtained for gestating does on 0% feed restriction across the different restriction periods which differed ($p<0.05$) significantly with similar values (545.00, 555.00 and 490.00 g) observed for those on 15% restriction at various periods of restriction.

The interaction between levels of feed restriction and period of feed restriction had no significant ($p>0.05$) effect on all the parameters measured for linear body measurements.

Table 3. Interaction between levels and periods of feed restriction linear body measurement of pregnant rabbit does

Levels of feed restriction	0%			15%			30%			
Period of feed restriction(days)	15-19	20-24	25-29	15-19	20-24	25-29	15-19	20-24	25-29	SEM
Parameters										
Initial weight (g)	1825.00	1822.25	1823.75	1792.50	2012.50	1847.50	1830.00	1902.50	1812.50	46.06
Final weight (g)	2220.00^{b}	2222.25^{b}	2221.75^{b}	2337.50^{b}	2567.50^{a}	2337.50^{b}	2232.50^{b}	2312.50^{b}	2230.00^{b}	73.63
Weight gain(g)	395.00^{ab}	400.00^{ab}	398.00^{ab}	545.00^{a}	555.00^{a}	490.00^{a}	402.50^{ab}	410.00^{ab}	417.50^{ab}	55.21
Head to shoulder(cm)	13.57	13.40	13.47	13.53	13.46	13.37	13.06	12.86	12.09	0.26
Ear length (cm)	11.37	11.22	11.22	11.56	11.93	12.18	11.77	11.53	11.25	0.31
Heart girth (cm)	27.47	27.34	27.36	26.54	26.51	25.88	26.19	26.35	26.64	0.65
Body length (cm)	33.31	33.20	33.18	32.50	34.78	35.86	32.35	32.36	32.80	1.91
Tail length (cm)	10.65	10.46	10.58	7.54	8.18	10.35	7.33	8.15	7.40	0.52

$^{a, b, c}$:Means in the same row with different superscripts differ significantly ($p<0.05$)
SEM: Standard error of mean

DISCUSSION

In this study, feed restriction had significant effect on the performance (final weight and weight gain) of the gestating does and this is in accordance with the work of Perrier and Ouhayoun (1996) and Tumova *et al*., (2002; 2003) who reported a form of compensatory growth and typical weight gain in restricted group during realimentation period. The mean values obtained for main effect on head to shoulder in this study for the levels and periods of feed restriction is higher than what was reported by Ogbuewu *et al.*, (2010) in mature rabbit bucks. The significant effect ($p<0.05$) obtained on ear length for levels and periods of feed restriction is in agreement with the range of values reported by Olawumi (2014) in rabbit at 16 and 18 weeks of age. The means obtained for heart girth were similar across the levels and periods of feed restriction. The result obtained for heart girth is within the ranges of what was reported by Ajayi and Oseni (2012) in adult female rabbits. Values obtained for body length in this study corroborate with the work of Olawumi (2014) who also reported values that are within the ranges of what was obtained in this study. The significant difference obtained on tail length in this study is higher than what was reported by Ajayi and Oseni (2012) in adult female rabbit.

Interaction between level of feed restriction and period of feed restriction showed significant effect on the final weight and weight gain of gestating does. The result obtained in this study is also in harmony with the work of Tumova *et al*., (2003) that also reported a form of compensatory growth and typical weight gain in the restricted groups. Consequently, when feed was provided *ad libitum* to the previously restricted does, weight gain was significantly higher than that in the *ad libitum* group and this also coincides with what was obtained in this study as reported by Petrere *et al.*, (1993) and Bispham *et al*., (2003).

The result obtained for interaction shows that all linear body measurement parameters measured were not significantly ($p>0.05$) affected. The result obtained on ear length for the level and period of feed restriction in this study is higher than the values reported by Ajayi and Oseni (2012) in female rabbits the higher values obtained cannot be attributed to the treatment effect. Result obtained for heart girth and body length in this study is within the ranges of values reported by Ajayi and Oseni (2012) in female rabbits.

CONCLUSIONS

From this study it can be concluded that feed restriction does not have any adverse effect on linear body measurement of pregnant rabbit does. There were no skeletal malformation and abortions recorded during the period of feed restriction. All pregnant does carried their neonates to term and there were no mortality of kits after kindling. Feed restriction can be applied on pregnant does at 15 % between 20-24 days because it was at this level optimum performance of does was recorded.

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Original Article

Canonical Correlation Analysis Relating Age At First Egg, Bodyweight At First Egg And Weight Of First Egg With Egg Production At Different Periods In A Strain Of Layer Type Chicken

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ABSTRACT

The relationship between age at first egg (AFE), bodyweight at first egg (BWFE), weight of first egg (WFE), with egg numbers recorded at 20–28 weeks (EN1), 28 – 35 weeks (EN2) and 35 – 42 weeks (EN3) was evaluated using canonical correlation analysis. Two hundred layers contributed the data used for the study. Estimated canonical correlations between three pairs of canonical variates were 0.667, 0.247 and 0.047. Only the canonical correlation between the first pair of canonical variates (0.667) was significant ($p<0.001$) based on the likelihood ratio test. Canonical weights and loadings from canonical correlation analysis showed that weight of first egg had the largest contribution to the variation in egg number at the three different periods compared with AFE and BWFE. Therefore, WFE could be used as a selection criterion for selecting good performance layers in terms of egg number.

Keywords: Canonical correlation, layer type chicken, egg production, selection.

INTRODUCTION

Studies have shown that AFE, BWFE and WFE were interrelated in the domestic chicken (Oni *et al*, 1991; Adenowo *et al.*, 1996; Udeh, 2010). Although these interrelated traits are important, the number of eggs produced at different periods in the laying cycle is more important economically. The impact of the aforementioned traits on egg production under the Nigerian environment has not been studied. The relationship between two or more traits is usually measured using correlation analysis. Correlation describes the extent that one variable relates or predict the other variables. Canonical correlation analysis is a multivariate statistical model that establishes the interrelationship between two sets of variables, in addition to quantifying the percentage of variance common to the two groups (Ventura *et al.*, 2011; Jacob

and Ganesan, 2013). The procedure looks for relationship between sets of variables and not causation. One set of variable is referred to as independent variables and the other as the dependent variables (Green, 1978). The canonical correlations are extracted in decreasing size. At each step, they represent the largest correlation possible between linear combinations in the two sets, provided the linear combinations are independent of any previously derived linear combinations.

Few studies utilized canonical correlation analysis to estimate the relationship between two sets of egg production traits. Akbas and Takma (2005) used CCA to estimate the relationship between egg production (set 1) with age at sexual maturity (ASM), bodyweight (BW) and egg weight (EW, set 2). The results of their study showed that ASM had the largest contribution to the variation in egg number of the birds compared with BW and EW. Cankaya *et al.*, (2008) used CCA to estimate the relationship between three different sexual maturity traits and level of nutrient intake as well as egg production traits at two different periods. The authors concluded that bodyweight at sexual maturity can have a higher contribution to variation in egg production in pullets if the contribution of differences in nutrient intake to onset of egg production was eliminated.

This study was aimed at estimating the relationship between AFE, BWFE and WFE (set 1) with egg numbers recorded at three different periods (set 2) in a strain of layer type chicken using canonical correlation analysis.

MATERIALS AND METHODS

The data used for this study came from the egg production records of Isa brown layers housed at the poultry unit of teaching and research farm, Enugu State University of technology, Enugu, Nigeria. The data consists of age at first egg (AFE), bodyweight at first (BWFE), weight of first egg (WFE) and egg numbers produced at 20–28 weeks (EN1), 28 – 35 weeks (EN2) and 35–42 weeks (EN3). AFE was recorded as the number of days from day old to first egg. BWFE was recorded individually for each bird at onset of lay. WFE was recorded as the average weight of first ten eggs per bird. Egg numbers were recorded on daily bases from onset of lay (20 weeks) to 42 weeks of age. Coefficients of correlations among the egg production variables were calculated. In the canonical correlation analysis, AFE, BWFE and WFE were considered as the first set of variables (Xi) while egg numbers at different periods (EN1, EN2 and EN3) were considered as the second set of variables (Yi). CCA focuses on the correlation between a linear combination of the variables in one set and a linear combination of the variables in another set (Akbas and Takma, 2005; Sahin *et al*., 2011).

Thus a linear combination of X variables $U = a_1x_1 + a_2x_2 +.....+a_mx_m$ and a linear combination of Y variables $V = b_1y_1 + b_2y_2 +.....+b_my_m$. The first canonical correlation is the maximum correlation between U and V for all U and V. Subsequent pairs of the correlations between U and V are also maximized subject to the constraint that they are not correlated with any other previous pairs (Johnson and Wichern, 2002). The canonical correlation coefficients were tested if they were significantly different from zero using Wilk's lambda statistics described by Dogan *et al.*, (2012). The redundancy measures how much of the average proportion of variance of the original variables of one set may be predicted from the variance of another set (Mendes and Akkartal, 2007). Canonical correlation analysis was performed using CANCORR procedure of Microsiris version 21 (2013)**.**

RESULTS AND DISCUSSION

Table 1 presents the coefficient of correlations among the egg production traits.The coefficient of correlations among AFE, BWFE and WFE were low and mostly negative. Agaviezor *et al*., (2011) reported positive correlation between age and body weight at first egg in pure exotic chicken. The correlation coefficients among egg number at different

periods were low and positive. The relationship among AFE, BWFE and WFE with egg numbers at different periods were positive and ranged from 0.022 to 0.544. This is contrary to the report of Akbas and Takma (2005) who obtained negative correlations between sexual maturity traits and egg numbers at different periods. Correlation coefficients can be positive or negative and vary from one set of data to another.

Table 1. Correlation matrix among egg production traits

Traits	AFE	BWFE	WFE	EN1	EN2	EN3
AFE	-	-	-	-	-	-
BWFE	-0.056	-	-	-	-	-
WFE	0.303	-0.190	-	-	-	-
EN1	0.216	0.196	0.544	-	-	-
EN2	0.022	0.010	0.195	0.055	-	-
EN3	0.062	0.292	0.036	0.086	0.166	-

Estimated canonical correlations between the pairs of canonical varieties were 0.667, 0.247 and 0.046 and their probabilities of significance from the likelihood ratio test were 0.000, 0.424 and 0.723 respectively (Table 2).

Table 2. Canonical correlations between two sets of variables, eigen values, likelihood ratio and their probabilities

Canonical Variate Pairs	Canonical Correlation	Squared Canonical correlation	Eigen values	Degree of Freedom	Likelihood ratio	Probability Pr > F
U1V1	0.667	0.444	0.799	9	0.521	0.000
U2V2	0.247	0.061	0. 065	4	0.937	0.424
U3V3	0.046	0.002	0.002	1	0.998	0.723

Only the canonical correlation between the first pair of canonical variates were significant ($p<0.001$). This means that AFE, BWFE and WFE were highly related to EN1, EN2 and EN3. Based on this result, this paper will interpret the relationship between the first pair of canonical variates *(*Thompson, 1984*;* Balkaya *et al.*, 2011; Ogah *et al.*, 2012*)*. Table 3 presents the standardized canonical coefficients of variates.

Table 3. Standardized canonical coefficients of variables

X – variable set				Y – variable set			
	AFE	**BWFE**	**WFE**		**EN1**	**EN2**	**EN3**
U1	0.081	0.565	0.911	V1	0.898	0.275	0.272

These are weights assigned to each original variable to construct the new variables. WFE contributed the highest weight to the construction of U_1, followed by BWFE. Similarly, EN1 contributed relatively higher weight to the construction of V_1 compared to EN2 and EN3. The positive sign of the standardized canonical coefficients show that AFE, BWFE and WFE have positive impact on the number of eggs produced at different times in the laying cycle. Similar observation was reported by Akbas *and* Takma *(*2005). The correlations between the original variables and the canonical variables (canonical loadings) is presented in Table 4.

Table 4. Correlations between input variables and canonical variables

X – variable set				Y – variable set		
AFE	**BWFE**	**WFE**		**EN1**	**EN2**	**EN3**

U1	0.325	0.387	0.828	V1	0.936	0.279	0.304

These are similar to factor loading in factor analysis. The first canonical variate of X (U_1) is highly correlated with WFE, followed by BWFE and AFE. Thus U_1 captures most of the shared variance of WFE. Similarly, the first canonical variate of the Y variable (V_1) is highly correlated with EN1. This means that V_1 captures most of the shared variance of EN1. This suggests that WFE was the most influential variable in the formation of U_1 while EN1 was the most important variable in the formation of V_1. Canonical cross loadings are simple correlation between original variables and their opposite canonical variates (Table 5).

Table 5. Cross loading of the original variables with opposite canonical variables

X – variable set				Y – variable set			
	AFE	**BWFE**	**WFE**		**EN1**	**EN2**	**EN3**
U1	0.104	0.081	-0.236	V1	-0.290	-0.203	0.131

There are low cross loadings between X – variable set and V_1 and between Y – variable set and U_1. WFE and EN1 made the highest contribution to the cross loadings of V_1 and U_1 respectively. By squaring the cross loadings (-0.236^2 and -0.290^2), it will be observed that 6% of the variance of WFE is explained by V_1 while 8.4% of the variance of EN1 is explained by U_1. Akbas and Takma (2005) reported high canonical cross loadings for EN1 (-0.579) and EN2 (-0.673) with the canonical variate W_1 and for ASM (0.813) with the canonical variate V_1. By squaring the figures, the authors concluded that 34% of the variance of EN1 and 45% of the variance of EN2 was explained by the variate W_1 while 66% of the variance of ASM and 2% of the variance of BW was explained by the canonical variate V_1. Based on canonical cross loadings, Sobczynska *et al* (2014) reported that an average of longevity and productivity traits (length of productive life, life time productive trait and number of litters) and an average of 6% of efficiency traits (life time litter efficiency, life time efficiency trait) is explained by the first canonical variate of performance traits (average daily gain, back fat thickness, longissimus muscle depth, phenotypic selection index and exterior traits) in Polish landrace sows. The authors concluded that the first canonical variate of the performance test traits has some predictive power for longevity traits but is a poor predictor of efficiency traits in Polish landrace sows. Redundancy coefficient is the percent variance in one set of variables accounted for by the canonical variate of other set. This is shown in Table 6.

Table 6. Redundancy coefficients for the two sets of variables X and Y

X – variable set				Y – variable set			
U1	**U2**	**U3**	**Sum**	**V1**	**V2**	**V3**	**Sum**
0.139	0.019	0.001	0.159	0.155	0.001	0.017	0.173

The redundancy coefficient of 0.139 of the first variable set (U_1) means that 13.9% of the variance of X variable set is explained by V_1 while the redundancy coefficient of 0.155 of the first variable set (V_1) means that 15.5% of the variance of Y variable set is explained by U_1. Tahtali *et al* (2012) reported redundancy measure of 0.208 for the first canonical variate (U_1) of traits measured at birth and 0.193 for the first canonical variate (V_1) of traits measured at weaning in Karayaka lambs. According to the authors, it means that about 20.8% of the variance of Y variable set is accounted for by V_1 while 19.3% of the variance of X variable set is accounted for by U_1. In conclusion, the results of canonical coefficients, loadings and cross loadings had indicated that WFE had the largest contribution to variability of egg numbers at different periods compared to AFE and BWFE. Therefore, WFE could be included as selection criterion for the improvement of egg production in chickens.

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Review Article

Bioactive Properties of Goat Milk: It's Hypoallergenic, Nutritional and Therapeutic Significance: A Review

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ABSTRACT

This paper reviewed researches on bioactive properties of goat milk: it's hypoallergenic, nutritional and therapeutic significance. Dietary proteins of animal or plant foods can provide rich sources of biologically active peptides. Once bioactive peptides are liberated by digestion or proteolysis, they may impart in the body different physiological effects on the gastrointestinal, cardiovascular, endocrine, immune, and nervous systems. However, the original macromolecular proteins such as cow milk caseins and whey proteins can cause allergic responses to certain individuals. Goat milk, on the other hand, has been known for its hypoallergenic and therapeutic properties in human nutrition and health, suggesting that Caprine milk may possess certain bioactive and metabolically active components that may be unique to this species' milk. Considering the bioactive components in milk, the hypoallergenic properties of goat milk are of great importance to human health and medicine. This premise has been of continuous keen interest to goat milk producers and consumers, especially in recent years in developed countries. Goat milk also exhibits significant nutritional and therapeutic functions in abnormal or disease conditions of human nutrition and health, due mainly to some of its biologically active compounds. Goat milk recommended as a "useful alternative to cow milk" because Caprine milk apparently has certain growth factors and bioactive components, which may not be equally available in bovine milk.

Keywords: Bioactive properties, goat milk, hypoallergenic, therapeutic significance.

INTRODUCTION

Dietary proteins of animal or plant foods can provide rich sources of biologically active peptides. Once bioactive peptides are liberated by digestion or proteolysis, they may impart in the body different physiological effects on the gastrointestinal, cardiovascular, endocrine, immune, and nervous systems (Korhonen and Pihlanto, 2007). However, the original macromolecular proteins such as cow milk caseins and whey proteins can cause allergic responses to certain individuals. Goat milk, on the other hand, has been known for its

hypoallergenic and therapeutic properties in human nutrition and health, suggesting that Caprine milk may possess certain bioactive and metabolically active components that may be unique to this species' milk. Cow milk allergy (CMA) is a frequent disease in infants, although its etiologic mechanisms are not clearly defined (Heyman and Desjeux, 1992; Park, 1994; Park and Haenlein, 2006). Caseins as well as beta–lactoglobulin which is the major whey protein cow milk, not found in human breast milk, are mostly responsible for cow milk allergy (Heyman *et al*., 1990 ; Park, 1994). It has been suggested that increased gastrointestinal absorption of antigens followed by adverse local immune reactions may contribute to a major etiological factor in development of food allergies like cow milk allergy (CMA) (Walker, 1987). Infants afflicted with cow milk allergy (CMA) were associated with an inflammatory response in the *lamina propia* of the intestinal membrane by prolonged exposure to cow milk.

Such inflammatory response also can occur by a constant increase in macromolecular permeability and electrogenic activity of the epithelial layer, even in the absence of milk antigen (Robertson *et al*., 1982; Heyman *et al.,* 1988). The clinical symptoms of cow milk allergy (CMA) are transient, since all disease parameters return to normal after several months on cow milk–free diet (Heyman *et al.,* 1990). Goat milk has been recommended as the cow milk substitute for infants and allergic patients who suffer from allergies to cow milk or other food sources (Rosenblum and Rosenblum, 1952; Walker, 1965; Van der Horst, 1976; Taitz and Armitage, 1984; Park, 1994; Haenlein, 2004). There has been much documented and anecdotal evidence for the potential of goat milk as an effective natural, hypoallergenic, and bioactive dairy food source for human nutrition and health. Therefore, this manuscript Endeavour's to present a detailed discussion on bioactive properties of goat milk: it's hypoallergenic, nutritional and therapeutic significance.

Hypoallergenic properties of goat milk

Considering the bioactive components in milk, the hypoallergenic properties of goat milk are of great importance to human health and medicine. This premise has been of continuous keen interest to goat milk producers and consumers, especially in recent years in developed countries (Park and Haenlein, 2006). In a recent study, treatment with goat milk resolved significant numbers of cases of children who had cow milk allergy problems; and in another allergy case study, 49 of 55 treated children benefited from the treatment with goat milk (Bevilacqua *et al*., 2000). Various anecdotal literature has shown that goat milk has been used for hypoallergenic infant food or milk substitute in infants allergic to cow milk and in those patients suffering from various allergies such as eczema, asthma, chronic catarrh, migraine, colitis, hay fever, stomach ulcer, epigastric distress, and abdominal pain due to allergenicity of cow milk protein (Walker, 1965; Wahn and Ganster, 1982; Taitz and Armitage, 1984; Park, 1994; Haenlein, 2004). (Soothill, 1987) reported that children who were reactive or allergic to bovine milk but not to goat milk also reacted to bovine milk cheese but not to goat milk cheese. In another study, administration and feeding of goat milk also improved gastrointestinal allergy in certain infants (Rosenblum and Rosenblum, 1952). In an extensive feeding trial, (Walker, 1965) showed that only 1 in 100 infants who were allergic to cow milk did not thrive well on goat milk of 1,682 patients with allergic migraine, 1,460 were due to food, 98 due to inhalants, 98 due to endogenous (bacterial) substances, and 25 due to drugs (including tobacco). Among the 1,460 patients with food allergy, 92% were due to cow milk or dairy products; 35% wheat; 25% fish; 18% egg; 10% tomato; and 9% chocolate. Some patients were allergic to more than one food. In another experiment, approximately 40% of allergic patients sensitive to cow milk proteins were able to tolerate goat milk proteins (Brenneman, 1978). These patients may be sensitive to cow lactalbumin, which is species specific. Other milk proteins, such as β-lactoglobulin, are also shown to be responsible for cow milk allergy (Zeman, 1982; Heyman and Desjeux, 1992). Many scientists have recommended evaporated goat milk or goat milk powder for infant formula (McLaughlan, *et*

al., 1981; Juntunen and Ali Yrkko, 1983; Taitz and Armitage, 1984; Coveney and Darnton-Hill, 1985), because heat applied to manufacturing processes reduces allergic reactions (Perlman, 1977). Heat denaturation alters basic protein structure by decreasing its allergenicity (Macy *et al.*, 1953) and high heat treatment removes sensitizing capacity of milk (McLaughlan, *et al*., 1981). Because goat milk has relatively low αs_1-casein content, it is logical that children with high sensitivity to αs_1-casein of cow milk should tolerate goat milk quite well (Chandan *et al*., 1992).

Perlman (1977) observed that lactalbumin from goat milk showed a different skin reaction in comparison with its bovine milk counterpart and that there was a variation of skin test reaction to allergenic fractions of bovine milk and goat milk. The data indicate that some proteins of bovine milk gave higher incidences of positive skin test reactions than goat milk. (Podleski, 1992) reported that inconsistency in cross-allergenicity among milk of different species may be qualitative and quantitative. A few reports using gel electrophoretic precipitation analysis also showed that there was a certain immunological cross-reactivity between cow and goat milk proteins (Saperstein, 1960; Parkash and Jenness, 1968; McClenathan and Walker, 1982).

There is a wide variety of genetic polymorphisms of the different caseins and whey proteins (Grosclaude, 1995), which adds to the complexity of the cow milk allergy (CMA) situation and the difficulty of determining which protein is mainly responsible for an allergic reaction. However, Bevilacqua *et al*.,(2000) have shown that this genetic protein diversity may actually help identify which protein is the allergen, if genetic polymorphisms of milk proteins are specifically used for clinical tests. Compared to cow milk, goat milk contains much less or nondetectable amounts of αs_1-casein (Jenness, 1980; Chandan *et al*., 1992; Remeuf, 1993). In French clinical studies over 20 years with cow milk allergy patients, (Sabbah *et al*., 1997) concluded that substitution with goat milk was followed by "undeniable" improvements. In other French extensive clinical studies with CMA children, the treatment with goat milk produced positive results in 93% of the children and was recommended as a valuable aid in child nutrition because goat milk had less allergenicity and better digestibility compared to cow milk (Grzesiak, 199)

Nutritional and therapeutic properties of goat milk

Goat milk also exhibits significant nutritional and therapeutic functions in abnormal or disease conditions of human nutrition and health, due mainly to some of its biologically active compounds. Reports have shown that therapeutic and nutritional advantages of goat milk over cow milk come not from its protein or mineral differences, but from the lipids, more specifically the fatty acids within the lipids (Babayan, 1981; Park, 1994; Park and Haenlein, 2006). Goat milk fat contains significantly greater contents of short and medium chain length fatty acids (C_4:0–C_{12}:0) than the cow counterpart (Babayan, 1981; Chandan *et al.*, 1992; Park, 1994; Park and Haenlein, 2006).

Goat milk has smaller fat globule size compared to cow and other species' milk. Comparative average diameters of fat globule for goat, cow, buffalo and sheep milk were reported as 3.49, 4.55, 5.92, and 3.30 μm, respectively (Fahmi *et al*., 1956). The smaller fat globule size of goat milk would have better digestibility compared to cow milk counterparts (Chandan *et al*., 1992). The short and medium chain fatty acids in goat milk have been shown to possess several bioactive functionalities in digestion and metabolism of lipids as well as treatment of lipid malabsorption syndromes in a variety of patients (Park, 1994; Park and Haenlein, 2006). Goat milk proteins are also believed to be more readily digestible, and their amino acids absorbed more efficiently than those of cow milk. Caprine milk forms a softer, more friable curd when acidified, which may be related to lower contents of αs_1-casein in the milk (Jenness, 1980). It may be logical that smaller, more friable curds of goat milk would be attacked more rapidly by stomach proteases, giving better digestibility (Jenness, 1980).

Caprine milk also has better buffering capacity than bovine milk, which is good for the treatment of ulcers (Devendra and Burns, 1970). In a comparative study of buffering capacity (BC) using Caprine milk, bovine milk, and commercial bovine milk infant formulae, (Park, 1991) reported that Nubian goat milk had the highest BC among all tested milk and that the major buffering entities of milk were influenced by species and breeds within species. Due to the compositional differences, milk of Nubian goat breed showed a higher BC compared with the milk of Alpine breed, Holstein cows, and Jersey cows. Nubian goat milk had highest levels of total N, protein, non protein N (NPN) and phosphate (P_2O_5) among the four breeds of goat and cow milk. Regardless of breed, goat milk contained significantly higher non protein N than cow milk (Park, 1991). The BC is influenced by proteins, primarily casein and phosphate components in milk (Watson, 1931). Soy based infant formulae contained less total N and NPN compared with natural goat and cow milk, and BC of the formulae were also lower than those of natural milk. The higher BC of Nubian goat milk compared to cow milk would be important in human nutrition. (Mack, 1953) conducted a nutrition trial involving 38 children (20 girls and 18 boys) aged 6 to 13 years by feeding one - half of them 0.946 liter of goat milk and the other half 0.946 liter of cow milk daily for 5 months. The study revealed that children in the goat milk group surpassed those on cow milk in weight gain, statue, skeletal mineralization, bone density, blood plasma vitamin A, calcium, thiamine, riboflavin, niacin and hemoglobin concentrations.

Statistical differences were minimal for blood hemoglobin and various other biochemical and structural measurements between the two groups. In another study of a feeding trial of anemic rats, goat milk also showed a greater iron bioavailability than cow milk (Park *et al*., 1986), indicating that the iron compounds in goat milk, such as lactoferrin, may be more bioactive than those in cow milk. In recent Spanish studies, (Barrionuevo *et al*., 2002) removed 50% of distal small intestine of rats by resection, simulating the pathological condition of mal absorption syndrome, and found that the feeding of goat milk instead of cow milk as part of the diet resulted in significantly higher digestibility and absorption of iron and copper, thereby preventing anemia. In a separate trial, they also found that the utilization of fat and weight gain was improved with goat milk in the diet, compared to cow milk, and levels of cholesterol were reduced, while triglyceride, HDL, GOT, and GPT values remained normal (Alferez *et al.,* 2001). It was concluded that the consumption of goat milk reduces total cholesterol levels and the LDL fraction because of the higher presence of medium-chain triglycerides (MCT) (36% in goat milk vs. 21% in cow milk), which decreases the synthesis of endogenous cholesterol.

In an Algerian study, (Hachelaf *et al.,* 1993) also found that 64 infants with mal absorption syndromes, who had the substitution of cow milk with goat milk, resulted in significantly higher rates of intestinal fat absorption. Thus goat milk was again recommended as a "useful alternative to cow milk for rehabilitating undernourished children." Considering the results of these nutritional studies, Caprine milk apparently has certain growth factors and bioactive components, which may not be equally available in bovine milk.

CONCLUSIONS

Caprine milk recommended as a "useful alternative to cow milk" because Caprine milk apparently has certain growth factors and bioactive components, which may not be equally available in bovine milk. Therefore the consumption of Caprine milk and its derived dairy product reduced allergic problem and increased disease resistance mechanism compared to bovine milk consumed by human being.

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Original Article

Effect of Different Levels of A-Cellulose on Growth and Survival of Rohu (*Labeo Rohita*) Fingerlings

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ABSTRACT

Four isonitrogenous and isocaloric diets, with different α-cellulose inclusion levels, were formulated. Diet with 4% α-cellulose in it served as control. Fish ranging from 2.6-3.4 gm each were housed in glass aquaria @10 fish per aquarium. Aquaria were provided with 14L/10D fluorescent light. Trial was conducted for 60 days. No mortality was observed in any group. All diets performed equally well. However, the diet with 12% α-cellulose showed superiority over the rest of the treatments in growth and nutrient digestibility. There was no variation in digestibility of carbohydrates and dry matter contents. Lowest digestibility of fats and protein was observed in 16% α-cellulose containing diet the group which also displayed the lowest growth. The studies have suggested that *Labeo* fingerlings can tolerate complex carbohydrates up to 16% if included in the diet but there is a gradual reduction in performance if inclusion level of this carbohydrate exceeds 12% of the diet.

Keywords: *Labeo* rohita , α-cellulose, Fish growth, Digestibility of nutrients, FCR.

INTRODUCTION

Labeo rohita is the most important fish contributing 35% of the total stocking on the average and 23% of the total aquaculture production in the region (personal observation). It is present in freshwaters of Pakistan, Bangladesh and Burma and has been transplanted in many other countries (Agrawal, 1994). Fish farmers like to stock this fish as their main aquaculture species because it has high consumer preference and fetches high price when marketed. It comes next to *Catla* in growth amongst the Indian major carps. It feeds on phytoplankton, zooplankton, detritus, and vegetable debris. It matures in two years from spawning and breeds from June to July by hypophysation.

Semi-intensive poly fish culture is commonly practiced in Pakistan. Fish heavily depend on natural food produced in pond by frequent applications of organic and inorganic fertilizers. There is no established formula which can totally support the growth and health of this fish.

There are several reasons for non development of effective feed; cost of feed ingredients and their selective digestibility are the major ones. Fish prefer to have animal feed sources which are never cost effective and have drastic implications on the economics of fish farm. Sustainability of fish culture therefore rests with utilization of alternate cheaper protein sources in aqua feeds (Francis *et al*., 2001; Zhou *et al*., 2004) which is really a challenge for scientists.

Lot of efforts has been exhausted to search alternative protein sources and plant protein sources are always at the top. But they have their own limitations. High fiber contents and poor digestibility due to lack of well developed stomach in fish are the major ones (Robinson *et al*., 1981) which is basically cellulose and does not have any nutritional value for fish and need to be restricted to less than 7% of fish diets. McGoogan and Reigh (1996) reported higher digestibility of protein by red drum *Sciaenops ocellatus* for ingredients with less than 2% of fiber but when level exceeded this limit, protein digestibility reduced drastically.

The aim of this research was to assess the effects of increasing dietary doses of αcellulose on growth and feed digestibility juvenile *Labeo rohita*.

MATERIALS AND METHODS

Experimental Fish and its husbandry

The experiment was conducted at the Fisheries and Aquaculture Research Centre (University of Veterinary and Animal Sciences Ravi Campus Pattoki). Fingerlings of *Labeo rohita* ranging from 2.6-3.4 gm each were procured local Fish Seed Production facility and were acclimatized in concrete tanks. A control diet (30% protein) was fed for two weeks prior to the experiment to acclimate the fish to their environment. The same diet was later on divided into four groups to prepare different dietary treatments. Ambient water temperature was maintained by uninterrupted supply of fresh tube well water and the photoperiod of 14 h light: 10 h dark was set by providing artificial lights hanging on aquaria. . Environmental and water quality indicators were closely monitored over the course of the experiment. No major health issues were encountered over the course of this experiment. There were no disease outbreaks, no problems with feed acceptance and there was no mortality.

Experimental design

Trial was designed as Completely Randomized Design (CRD) with three treatments and a control with reportedly the most acceptable fiber level for fish. There were three treatments and a control. Every treatment including control had three replicates. Studies were executed in glass aquaria with water holding capacity of 70 liter each. Aquaria were installed to maintain a flow-through-system with water exchange rate of 5 L min^{-1} $aquarium^{-1}$. Five fish were randomly taken from the e main stock, weighed and measured for baseline data and for comparison of future growth increments in fish. Then three aquaria were randomly allotted to each treatment to avoid possibility of systematic error. After preliminary preparations 10 fish were randomly collected from the main stock and carefully transferred to each properly labeled aquarium.

Experimental diets

Four isonitrogenous and isocaloric diets with different levels of α-cellulose, were formulated. All ingredients were individually finely ground and then mixed in an appropriate ratio to achieve desired protein level (30% protein). One percent Cr_2O_3 was added as marker in dry feed and mixed thoroughly to determine digestibility of different macronutrients. Homogenously mixed feed ingredients were moistened with boiled water (1:0.6 W/V) and pelleted in a laboratory type pellet machine and then dried in oven at 60 ^{0}C to constant weight and then stored in zip lock bags in refrigerator at 4 ^{0}C. Feed mixture was dry pelletized using

molasses as binder. Pellets were oven dried and crumbled to size proportionate to the mouth size of fish. Prepared diet was divided into 4 groups. Diet with 4% α-cellulose in it served as control. Treatment 1 contained 8, treatment 2, 12 and treatment 3 contained 16% α-cellulose (Table 1).

Table 1- Initial and final weight of *Labeo rohita* fingerlings fed on formulated feeds for 57 days

Treatment	Initial Weight	Final Weight
4% Cellulose diet	2.579±2.128E-01[a]	5.0±3.8[a]
8% Cellulose diet	2.779±1.768E-01[a]	3.8±2.0[a]
12% Cellulose diet	2.805±1.860E-01[a]	6.1±4.3[a]
16% Cellulose diet	3.373±3.288E-01[a]	5.2±3.7[a]

Data are presented as X±SE
Note: Values in the columns followed by the same superscript letters are not significantly different from each other at p>0.05.

Experimental protocol and set-up

Fish were fed @ 5% of its body weight daily at 9.00 A.M. and 2.30 P.M. regularly. Fluorescent lights hanged above the aquaria provided 14L/10D photoperiod for maximum feeding. Water quality was checked every day at noon and at night. Normally measured parameters were; temperature, pH, oxygen content and NH_3 which remained within appropriate ranges for fish growth during the experimental period. Feces were collected 4 hours after feeding by sucking with plastic pipe, blotted and then dried in oven at 80 ^{0}C up to constant weight then stored in refrigerator for proximate analysis. On the termination of the feeding trial, water was totally drained off; all the fish were harvested, weighed and measured for growth data analysis.

Chemical analysis of feed and fecal matter

Individual feed ingredients and freeze-dried feces, collected from triplicate groups of corresponding treatment were ground in a coffee grinder and thoroughly homogenized to collect representative sub-samples. All chemical analyses were done in triplicate and made on dry weight basis. Feed and feces were analyzed for dry matter by drying samples to a constant weight (ISO 1983; ISO 1998). Crude protein (N × 6.25) was determined by Kjeldahl method after acid digestion (ISO, 1979). Total lipids were extracted by petroleum ether in a Soxhlet fat extraction apparatus (ISO/DIS 1996).

Determination of apparent digestibility coefficients (ADC %)

ADC (%) of different nutrients was performed by indirect method using Cr_2O_3 as inert marker (De Silva *et al*., 1997).

$ADC_{DM} = 100[1-(Cr_2O_3 \text{ in diet}/Cr_2O_3 \text{ in feces})]$
$ADC_{N} = 100[1-(Cr_2O_3 \text{ in diet}/Cr_2O_3 \text{ in feces})(\text{nutrient in feces}/\text{nutrient in diet}]$

Statistical Analysis

Each aquarium served as an experimental unit. Data collected analyzed as a completely randomized design using the General Linear Model procedure of IBM SPSS Statistics (Version 19.0.0, SPSS Inc., Chicago, IL, USA). Tukey's Multiple Range Test was applied to determine the significance level among treatments. Differences were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

Water quality parameters

Water quality parameters remained within appropriate ranges during the course of experiment. DO levels remained at 4 ppm or higher.

Growth

No mortality was observed in any group. All diets performed equally well. However, the diet with 12% α-cellulose showed superiority over the rest of the treatments in growth (Table 1 and 2). Lowest growth was observed on 16% α-cellulose containing diet though initial fish size was quite bigger in treatment 4 than control group and other two treatments. As other growth parameters like, Feed Conversion Ratio (FCR), specific growth rate are tagged with gain in weight hence they followed the same trend as it was observed in weight increments.

Table 2- Absolute growth rate (increase in weight per day in gm), relative growth rate (%increase in weight over the whole time period), specific growth rate (%increase in weight per day) and feed conversion ratio of fish fed on formulated feeds with different α-cellulose levels

Treatment	AGR	RGR	SGR	FCR
4% cellulose diet	0.025±0.001^{a}	55±10.5^{a}	0.91±0.2^{a}	1.97±0.3
8% cellulose diet	0.02±0.001^{a}	49.4±9.8^{a}	0.76±0.2^{a}	2.45±0.7^{a}
12% cellulose diet	0.03±0.002^{b}	67.6±7.2^{b}	0.77±0.3^{a}	1.8±0.3^{b}
16% cellulose diet	0.01±0.001^{c}	20.2±4.2^{c}	0.33±0.1^{b}	4.67±1.1^{c}

AGR= Absolute Growth Rate, RGR= Relative Growth Rate, SGR= Specific Growth Rate and FCR= Feed Conversion Ratio

Data figures with different superscript letters are different from each other at $p<0.01$

The lowest values were observed in treatment 2 indicating acceptable cellulose requirement of this stage of this fish. Dioundick and Stom (1990) and Shia *et al*., (1988) and Liang (1994) observed growth depression and reduction in feed intake in Tilapia when fed on diet containing 10% cellulose. Similarly inclusion of alginate and guar gum (2.5-10%) in rainbow trout diets lowered protein and lipid digestibility (Storebakken, 1985). Situation was little different in current studies. When *Labeo rohita* was fed on diets containing varying percentages of α-cellulose, fish growth increased up to 12% cellulose inclusion level but declined when cellulose level exceeded 12%. Morita *et al*., (1982) have observed improvements in growth and feed efficiency in red sea bream fed on diet supplemented with 3, 6, 9 or 12 % carboxy methylcellulose level. Previous studies substantiate ours and further verify that Tilapia, red sea bream and *Labeo rohita* have probably similar response and tolerance capability to carboxy methylcellulose.

Digestibility

Dry matter digestibility was uniform among treatments. Protein digestibility declined significantly when we moved from 4% to 16% diet. Protein digestibility was significantly lower in treatment 3 and 4 than treatment 2. When later two diets were compared with each other diet 4 again showed significantly poor digestibilities than diet 3. Lipid digestibility remained same from diet 1 to 3 but it drastically fell down when we moved towards higher cellulose levels. Carbohydrates however did not show any difference. Though there was minor variation in digestibility values of carbohydrates between treatment 3 and 4 but statistically differences were not discernable (Table 3).

Table 3- Apparent digestibility coefficients (%) of the experimental diets

Treatment	Dry Matter	Crude Protein	Crude Fat	Carbohydrates
4% cellulose diet	79.8±7.5[a]	82.5±4.2[a]	90.3±6.1[a]	62.3±4.1[a]
8% cellulose diet	78.8±8.1[a]	80.3±5.1[a]	85.4±7.3[a]	60.4±3.9[a]
12% cellulose diet	78.7±6.2[a]	72.2±3.9[b]	78.4±3.5[a]	60.3±4.5[a]
16% cellulose diet	77.9±5.6[a]	63.5±4.1[c]	67.3±5.2[b]	58.5±4.7[b]

In the current studies fat digestibility was same in control (4% cellulose) and treatment 1(8% cellulose) and 2(12% cellulose) but decreased in 16% cellulose containing diet. Protein digestibility followed the same trend but digestibility started to decline even in 12% cellulose containing diet. Contradictory to our findings Dias *et al*., (1998) showed that addition of two levels of cellulose(10 and 20%) did not affect digestibility of protein, growth and feed utilization in sea bass but higher levels did impart negative effects in current studies on *Labeo rohita* fingerlings. Lekva *et al*., (2010) while working on Atlantic cod*(Gadus morhua* L.) observed decreased digestibility of fat and dry matter when α-cellulose level was increased in diet having no effect on liver index, protein digestibility and protein retention. On the other hand Velortas *et al*., (2011) while working on penaeoid shrimp observed decreased digestibility coefficients from 83.7% to 51.2% (*A. longinaris*) and from 71.9% to 7.6% (*P. muelleris*) as the dietary starch levels increased. It seems that the physiological effects of cellulose in fish are not fully understood and quite inconsistent from specie to species.

Dietary plant ingredients can affect gastrointestinal transit time of feed as a result of presence of fibers and sugars and alter the digestibility of nutrients ingested by fish (Eusebio *et al*., 2004); Zhou *et al*., 2004). According to Eusebio *et al*., (2004) as dietary fiber is part of the carbohydrate component of plant ingredients, most fish can not utilize it. However, low dietary concentrations of fiber (3-5%) may have beneficial effects on fish growth. High dietary fiber (>8%) however may decrease dry matter digestibility of the diet and reduce availability of other nutrients (Altan and Korkut, 2011). Similarly Pavasovic *et al*., (2006) investigated that diet with either 30% α-cellulose or fullers earth significantly reduced apparent dry matter and protein digestibility's in red claw crayfish, *Cherax quadricarinatus*. The same workers in another study on the same animal explored that dietary levels above 12% α-cellulose were correlated with significant reductions in survival rate, specific growth rate and feeding efficiency. These studies are quite in line with ours and further confirm that higher levels of cellulose in fish or crustacean diets have deleterious effects on growth and nutrient digestibility's.

CONCLUSIONS

It can therefore be concluded that *Labeo rohita* fingerlings can tolerate complex carbohydrates up to 16% if included in the diet but there is a gradual reduction in growth performance and nutrient digestibility if level exceeds 12% of the diet.

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Original Article

Determine of Feed Potassium and Calcium by Goats Grazing at Natural Range, West Kordofan, Sudan

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ABSTRACT

This study was conducted at El-khuwei locality, west Kordofan, Sudan, during the flowering and seed setting stages on the natural range land in year 2011. The main objective of this study was to determine the macro minerals in the feed potassium K and calcium Ca at the flowering and seed setting stages on the natural range land. Sampling was done by locating 2 km 2 each stage at the plants maturity (flowering and seed setting stages). A completely randomized design (CRD) was used to selected samples of feed. The results indicated that stages effect on feed macro minerals concentration were significantly ($P<0.001$) higher potassium K (0.22 ppm) concentration at the flowering stage and lower potassium K (0.07 ppm) concentration at the seed setting stage. There was increased calcium Ca (8.02 ppm) concentration at the flowering stage and decreased Ca (6.76 ppm) concentration during the seed setting stage.

Keywords: Stages, feed, potassium, calcium, goat.

INTRODUCTION

Ruminants grazing forages in severely mineral-deficient areas may be more limited by this condition than by lack of energy or protein (McDowell and Conrad, 1977). McDowell *et al.* (1983) stated deficiencies or imbalances of trace elements in soils and forages are responsible for low production and reproduction among grazing livestock. Miles and McDowell (1983) reported that pastures in Ethiopia are deficient in Calcium (Ca), Phosphorus (P), Sodium (Na) , Zinc (Zn) , Copper (Cu), Cobalt (Co), Sulfur (S) and Selenium (Se), but their Iron (Fe) and Magnesium (Mn) levels are too high. The potassium (K) content of plants is high compared with the potassium requirements of sheep and goat. Sadaqat *et al.* (1996) observed low levels of potassium 0.48-1.72 % in forages in Pakistan. On the other hand K concentrations in Kenyan forages were quite high (Abate, 1985). Masters and Feels (1990) reported that during autumn and summer, pasture contained adequate potassium 6-22 g per kg for sheep, the

highest concentrations being recorded in summer. Oil seed meals and green growing forages are excellent sources of K (Rick, 2007). Potassium deficiency for ruminants results in nonspecific symptoms such as slow growth, reduced feed and water intake, lowered feed efficiency, muscular weakness, nervous disorders and degeneration of vital organs (McDowell, 1992). Calcium is the most abundant mineral in the body, 90% of Ca is found in the bones and teeth (Rick, 2007). Calcium is normally one of the primary limiting factors in the diets of sheep and goat and hence need to be provided as supplement (Rick, 2007). Some of the important functions of Ca are blood clotting, membrane permeability, muscle contraction, nerve functions, and cardiac regulation and enzyme activations (Rick, 2007). Moreover, excess of macro elements, such as Ca can reduce clotting ability of blood and cause hemorrhagic conditions (Hall *et al.*, 1991). As dietary Ca intake increases, its absorption is reduced (Rick, 2007). There is evidence that deficiencies of elements such as Ca occur under farming conditions. Nutritional calcium deficiency is associated with weakness, poor animal performance that has swollen joints, lameness, weak bones, and a propensity for broken bones (Puls, 1994). Vitamin D is required for active absorption of calcium. The objective of this study was to determine feed K and Ca concentrations at the natural rangeland, west Kordofan, Sudan.

MATERIALS AND METHODS

Study Area

This study was conducted at El-khuwei locality (Longitudes 28˚:33' to 28˚:30'N and latitudes 12˚:14' to 14˚:12' E). The long term average annual rainfall is about 300-mm, consisting of storms of short duration between July and September with the highest rainfall generally occurring in August. The soil of the site lies within the sand dune area locally known as "Goz" soil. During the rainy season, forage biomass is suitable to provide sufficient feed for animals, but during the dry season forage is scarce and small quantities of grain are also fed to animals. The site is naturally dominated by grasses namely Huskneet (*Cenchrus biflorus),* Shilini (*Zornia glochidiata*), Bigail (*Blepharis linarifolia*) and Aborakhus (*Andropogon gayanus*). The trees included Humied (*Sclerocarya birrea*), Higlig (*Balanites aegyptiaca*) and Sider (*Zizuphus spina- Christi).* The Shrubs include Kursan (*Boscia senegalensis*), Usher (*Calotropis*), Mereikh (*Leptadenia pyrotechnica*) and Arad (*Leptadenia pyrotechnica)* according to MARF (2009).

Sampling and Experimental Study

Sampling was done on two stages of plant maturity at flowering and seed setting in selected locations (2 km^2 each), within each season randomly selected and collected thirty samples of feed.

Samples and Preparation of Macro Potassium and calcium

Feed sampling

Samples of feed were collected from those species that were most frequently grazed by goats at this range. The parameters measured diet botanical composition was estimated using the bite-count techniques, (Fadlalla and Cook, 1985). Within each season 60 goats was kept for this study. The first goat was followed for five times, and then the second one followed for another five minutes and so on for all goats. The procedure was repeated tine times, thus each goats followed for one hour in the first day, was also followed by observer for three days and 600 bites, and species of plant ingested and bite were recorded

Feed preparation

One gram of the dried forage sample was taken in a 50 ml conical flask, and kept overnight after adding 5 ml concentrated HNO_3 and 5 ml perchloric acid ($HClO_4$). Next day, again 5 ml

HNO_3 was added to each sample. All the samples were digested on hot plate at 250° C in fuming hood till the material was clear. After digestion the material was cooled down and the volume was made up to 50 ml with double distilled water and stored in clean airtight bottles for analysis of metal ions (Anon, 1990).

Laboratory analysis

Macro elements in the feed Calcium (Ca) were analyzed using atomic absorption spectrophotometer (Singh *et al*., 2005). Potassium (K) concentration was analyzed using flame photometer (AOAC, 1990).

Statistical Analysis

The data were analyzed using a completely randomized design (CRD) with the effect of stages as the whole plots and effects of sampling as the sub-plots (Steel and Torrie, 1980). SPSS version 10 (Statistical Package for Social Sciences, 1996) was used for the statistical analysis.

RESULTS

Feed Potassium and Calcium

Table 1 shown macro elements in feed during the flowering and seed setting stages at El-khuwei locality, west Kordofan State, Sudan. Stages effect were significantly difference (P<0.001) higher potassium K (0.22-0.07 ppm) at flowering stage than that at seed setting stage respectively. Statistically there was no significant difference (P< 0.05) between calcium during flowering and seed setting, even thought there was increased calcium Ca (8.02-6.76 ppm) at the flowering stage compared to seed setting stage respectively**.**

Table 1. Feed potassium and calcium during the flowering and seed setting stages at El-khuwei locality

Minerals	Stages		Mean	SE±	significant
	Flowering	Seed setting			
Potassium K (ppm)	0.22[a]	0.07[b]	0.15	0.02	**
Calcium Ca (ppm)	8.02	6.76	7.39	0.53	NS

[a,b] Values with the same raw bearing different superscript vary significantly at P <0.05 or P<0.001,
** = high significant (P < 0.001), ns= not significant

DISCUSSION

Feed potassium

Feed potassium showed significant effect of stages, higher K (0.22ppm) concentration were observed at flowering stage and less K (0.07ppm) concentration are found at the seed setting stage. Green growing forages are excellent sources of K (Rick, 2007). Higher forage K+ 2.11% concentrations were observed at rainy period and lower 1.60% values are found at the dry period, however, all mean feed concentrations were higher than the optimal values 0.60 % as suggested by Khan *et al.* (2009), this result is agreement and similar with study. The findings on plant K with a range of (1.58 - 37.1 g/kg) are similar to those recorded by Ramirez *et al*. (2001) who found higher K concentration in shrubs grazed by goats during summer than in other seasons; increased K 1.96 g/kg level during the cold wet season and decreased K 0.52g/kg during the hot dry season. During the hot dry season all the plants had adequate levels of K to meet adult goat requirements. With the exception of Azadirachta indicate (1.75 g/kg), all the plants collected had adequate levels of K in the cold dry season. Variation of K in plants within different seasons may partially be attributed to different stages of plant maturity at the time of sampling. Khan *et al.* (2009) reported variation of K in plants within different seasons may partially be attributed to different stages of plant maturity at the

time of sampling and the translocation of minerals to the root system. Plant species such as Balanites aegyptiaca (37.1 g/kg in the hot dry season) and Amaranth us spinosum (15.9 g/kg) had K concentrations as much as 10 times the required levels, high K concentrations first result in an Mg deficiency; when K is in greater imbalance, they will cause a Ca deficiency.

Feed calcium

Feed calcium was higher (8.02 ppm) concentrations at flowering stage and least (6.76 ppm) during the seed setting stage. Khan *et al.* (2009) reported mineral Ca concentrations and soluble carbohydrates may respectively increase and decrease dietary Mg requirements of livestock, whereas raised dietary P levels appears to lower the requirements for both Ca and Mg. Effect of seasonal differences was increased Ca 19.8 g/kg concentrations at cold season and decreased 8.05 g/kg at hot dry season, all browse plants had adequate levels of Ca (range 0.02 to 58.4 g/kg) to meet adult goat requirements of 1.3 to 3.3 g /kg in the diet (NRC, 2007) except Eleusine coracana which had Ca concentration below the required minimum during the hot dry season (0.02 g/kg) and in the wet season (0.36 g/kg). In another study Ca is not usually deficient, for optimal livestock performance, in foliage from browse plants that grow in tropical regions (Ramirez *et al*, 2001). Ca and P are both important in the development and maintenance of the animal's body; the recommended calcium to phosphorus ratio in the diet is a minimum of 2:1 and a deficiency of either or both in growing animals leads to poorly developed bones. However, in the present, this ratio was not achieved in any of the plants; goats are known to be tolerant to high Ca: P ratios. Forage Ca concentrations observed in our present reported were mostly similar to those study.

CONCLUSIONS

It can be concluded that at the flowering stage higher potassium concentration and least during the seed setting stage, however increased calcium at the flowering stage and decreased during the seed setting stage.

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Original Article

Serological Study on Mucosal Response of Cattle to Haemorrhagic Septicaemia Vaccine

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ABSTRACT

The purpose of this study was to compare the efficacies of systemic immune response to mucosal vaccination against *Pasteurella multocida* infection in cattle. Three groups of ten cattle each were immunized subcutaneously and intranasally with bacterin of *P. multocida* serotype B: 2. Group 1 and Group 2 were immunized subcutaneously and intranasally with 0.5 ml of bacterin mixed with mucosal adjuvant respectively. Group 3 served as a control group was immunized subcutaneously with 1 ml of final vaccine product of bacterin as recommended dose according to Central Veterinary Research Laboratories, two cattle for each group unvaccinated control, all three groups received a booster dose on day 24 post inoculation.The level of the antibody immune response in these three groups was measured by the indirect haemagglutination test. Serum and nasal antibodies of vaccinated animals increased after the second vaccination, and this difference was statistically significant. Concentration of serum antibody against *P. multocida* increased from primary vaccination (6.25 antibody titer) on day 7 to (82.5 antibody titer) on day 31 after boosting animal, similar levels of protection were obtained from group 3. The nasal antibodies were rised from (3.75 antibody titer) at first vaccination on day 7 to (20 antibody titer) on day 31 after the second inoculation. The mucosal level of antibody in the intranasally vaccinated group was less compared to subcutaneously vaccinated group.

Keywords: Immune response, *P. multocida*, vaccine, mucosal adjuvant.

INTRODUCTION

Pasteurella multocida (*P. multocida*) causes heavy losses, particularly in wet areas and when the animals are exposed to humid, chilly weather or are stressed by heavy work (Benkirane and Alwis, 2002). There is ample evidence that buffaloes are more susceptible than cattle, in both species, young and young adult animals are more susceptible than older animals (Alwis, 1990). Also *P. multocida* is etiological agent of fowl cholera in birds, atrophic rhinitis in pigs and rhinitis, pneumonia, otitis media and death in rabbits (Mannheim, 1984; Jarvinen, *et al*., 1998). The two common serotypes of *P. multocida* associated with disease in these species are types B: 2 (in Asia) and E:2 (in Africa). Infection occurs by inhalation or ingestion of *P. multocida* bacteria or by the ingestion of contaminated feed-

stuffs. The infection originates from healthy carriers or clinical cases, or possibly from ticks (Radostits *et al*., 2003) and biting insects. The control of pasteurellosis is depending on vaccination. Haemorrhagic septicaemia vaccine is produced from local strains at Central Veterinary Research Laboratories (CVRL), determinated by (Elbashir, 1993).
Based on the previously mentioned facts, the present study was delineated (i) to investigate the effectiveness of vaccination in cattle with (HS) bacterin, and to test the pea-nut oil and freund´s incomplete adjuvant as mucosal adjuvant for delivery of vaccine (ii) to evaluate the efficacy of intranasal (I/N) versus subcutaneous (S/C) administration of the vaccine in stimulating protective immunity against *P. multocida*.

MATERIALS AND METHODS

Bacteria

The freeze-dried strains of *P. multocida* (B and E) which were used in this study were obtained from the Department of Microbiology, faculty of Veterinary Science, University of Khartoum they had been isolated from outbreak of haemorrhagic septicaemia (Shigidi and Mustafa, 1979). Freeze-dried strains were reconstituted in nutrient broth and incubated at 37^{o}C for 24 hours, then checked for purity.

Antigen

Formalin treated whole cells 0f *P. multocida*, serotypes B:2, and E:2, were prepared according to the protocol of vaccine production in the Central Veterinary Research Laboratories, Khartoum (Elbashir,1993). The bacteria were propagated in the Gottingen bioreactor (Bio-Chem-Spezialgerate GmbH, Göttingen, Germany).

Mucosal adjuvant

Pea-nut oil mixed (I: 1 v/v) with Freund´s incomplete adjuvant was experimented as mucosal adjuvant to deliver the vaccine.

Experimental animals

Thirty head of local breed of cattle which were used in this study were located in a traditional farm in White Nile state, with no previous vaccination history. The calves were 6-9 months old; the calves were divided into 3 groups each of ten cattle. Pre-immunization sera and nasal swabs were collected.

Immunization of cattle

The antigen bacterin was mixed with the mucosal adjuvant and the mixture was placed in a water bath at 37^{o}C for 15 minutes. A dose of 0.5 ml of the antigen described above was injected subcutaneously in group (I) and the same dose inoculated intranasally in group (II), cattle in two both groups received a second dose of vaccine on day 24 post initial immunization. Control group of two cattle of two groups were received the normal saline via the same route. The group (III) was served as control group, received 1 ml of the bacterin subcutaneously as recommended dose according to Central Veterinary Research Laboratories. The group was vaccinated with the bacterin without the mucosal adjuvant. 1ml of the bacterin was administered subcutaneously; the cattle received a booster dose at day 24 post inoculation. A control group of two cattle received normal saline through the same route of treated group.

Laboratory Assay

Antibodies against the *Pasteurella multocida* were measured by using indirect haemagglutination test (IHA) using human blood "O" (RBC's Bain *et al*., 1982) , but sheep red blood cells have been used according to (Sawada et al., 1982).

Test Procedure

The test was carried out in microtitre plates of Flow Laboratories, each having 96 U shaped wells, arranged in 8 rows and 12 columns designated as A-H and 1-12, respectively. Two fold dilutions of the test sera starting from 1: 5 to 1: 640 were made in normal saline solution and added in 25µl amounts to all the wells of plate except those of column 11 and 12 which were maintained as controls. First four wells (A-D) of column 11 were added with known negative serum and last four wells (E-H) with the known positive serum. All the wells of the column 12 were added with normal saline solution. Sensitized RBC's (1%) were added in equal amounts (25µl) to all the wells of the plate, so that column 12 served as control for the RBC's. The plates were incubated at room temperature for two hours and the observations were recorded. Thereafter the plates were kept under refrigeration for overnight shake lightly, allowed to resettle and read again. Results were interpreted as under:

- **Positive:** No button formation, clumping occurring in an unordered and ragged pattern.
- **Negative:** Button formation, RBC's clumping in an organized and regular pattern.

Interpretation

Both IgM and secretary IgA classes of antibody are produced in response to any of vaccinated animals. IgM and IgA antibody is first detectable within 1 week after immunized animals and peaks at 4 weeks.Titers of 1: 5 are considered borderline and follow-up samples should be tested for serology.

RESULTS

Mucosal adjuvant

Pea-nut oil mixed with Freund´s incomplete adjuvant experimented as mucosal adjuvant in cattle proved to be safe and hence it was used to deliver the vaccine**.**

Immune response of cattle

Results of samples of vaccinated and control animals, the serum and nasal swabs collected from cattle in all groups were tested for pasteurellosis antibodies by indirect haemagglutination test IHA, no results recorded on day 0, the small levels observed on day 7, 14, 21 and 24 before the booster dose, the peak of antibodies level was recorded in all groups after the second dose of vaccine. The results of pasteurellosis antibodies of all animals in the three groups are shown in table 1.

Table 1. Mean average of antibody titers in three cattle groups vaccinated intranasal and subcutaneous with bacterin HS vaccine by IHA (n=8)

Route of administration	No. Cattle	day0	Day7	Day14	Day21	Day24	Day31
I/N (0.5 ml)	8	0	6025	12.5	17.5	28.75	82.5
S/C (0.5 ml)	8	0	3.75	5	7.5	11.25	20
S/C (1 ml)	8	0	8.75	12.5	21.25	36.25	92.5

DISCUSSION

P. multocida causes heavy losses, particularly in low-lying areas and when the animals are exposed to wet, chilly weather or are stressed by heavy work (Benkirane and Alwis, 2002). There is ample evidence that buffaloes are more susceptible than cattle and that, in both species, young and young adult animals are more susceptible than older animals (Alwis,1990b). The two common serotypes of *P. multocida* associated with disease in these species are types B:2 (in Asia) and E:2 (in Africa). All age groups are affected with *P. multocida*, but in cattle the most susceptible age group is between 6 months and 2 years.

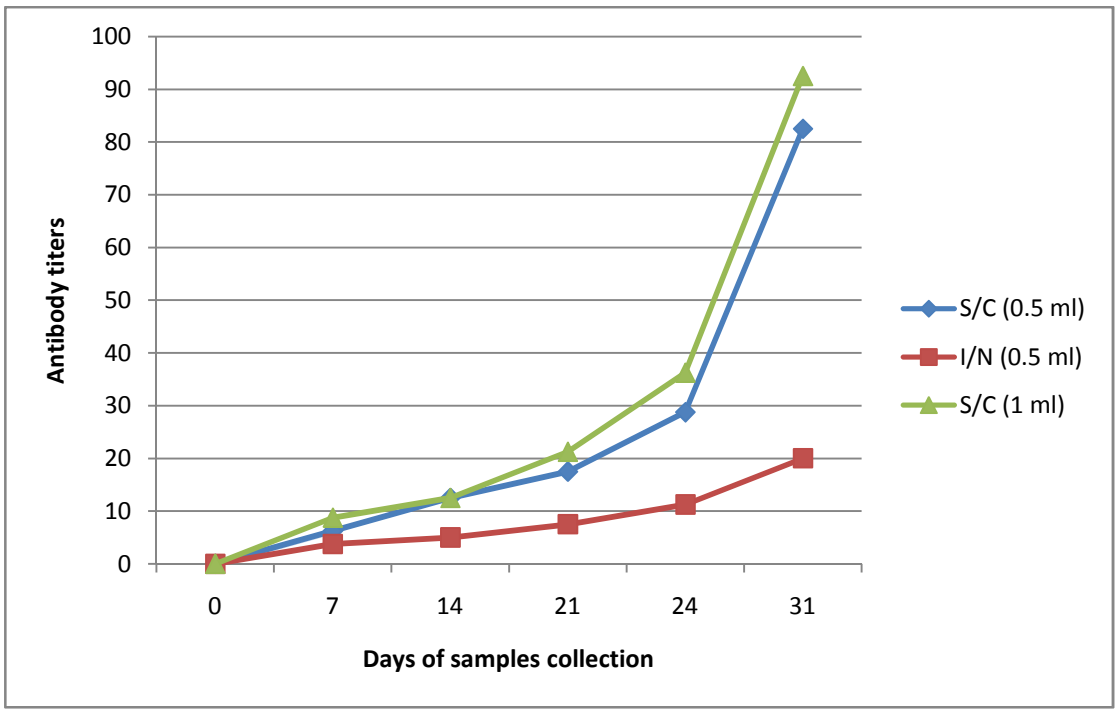

Figure 1. Antibody titers at 0, 7, 14, 21, 24 and 31 days post immunization

The present study was conducted to compare the subcutaneous vaccination to the intranasally inoculated in protecting cattle against pasteurellosis with haemorrhagic septicaemia vaccine. In this study the Freund´s incomplete adjuvant was mixed with the pea-nut oil (1:1 v/v) was used as mucosal adjuvant to vaccinate groups of cattle via the subcutaneous and intranasal route. The results of indirect haemagglutination in group 1 and group 3 were vaccinated subcutaneously were greater, these two groups were developed a serum anti-pasteurellosis response that dependent on dose volume and mucosal adjuvant when compared with the titer of group 2 was immunized intranasally, this group also developed secretory IgA antibody against *P. multocida* that was due to the dose volume is not cover all the nasal area or may be the mucosal adjuvant is not effective on nasal route. The finding of the bacterin vaccine gave a better protection when injected subcutaneously is in consistency with work of (Elbashir, 1993), who used a bacterin vaccine produced in a continuous cultivation system. In this study mucosal response to *P. multocida* resulted by vaccination with a bacterin, the average results of laboratory assay the IHA, the low titer levels were recorded on day 7 (3.75 antibody titer), and high level was obtained on day 31 (20 antibody titer) post booster dose this results were less protective than subcutaneous route, but bearing in mind that we used adjuvant might necessitate the experimentation of other mucosal adjuvant which might confer higher protection than the pea-nut freund´s incomplete adjuvant used in the present study. Even though intranasal immunization with bacterin is not an effective way to control infection, the method of vaccine delivery is not necessarily practical, especially when vaccinating a large number of animals. However, the efficacy of mucosal vaccination suggests that, it may eventually by possible to deliver vaccine by alternative routes, such as orally, to induce mucosal immunity in respiratory tracts.

The titration of nasal swabs samples in cattle represents only small level titers (0 on day 0, 3.75 on day 7, 5 on day 14, 7.5 on day 21, 11.25 on day 24 and 20 on day 31) because the titers of the nasal samples may not reflect the total of respiratory tract surfaces. Nasal swabs are not suitable technique for measuring secretary IgA, because the collection of nasal samples limited in nasal mucosa area of respiratory tracts.

CONCLUSION

A bacterin HS vaccine stimulates antibody activity to and protective immunity against *P. multocida* in cattle. The efficacy of mucosal vaccination suggests that, it may eventually by possible to deliver vaccine by alternative routes, such as orally, to induce mucosal immunity in respiratory tracts. The peak level of antibody titers against *P. multocida* was obtained after boosting animals.

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Original Article

Effects of Feeding Rumen-Protected Choline and Vitamin E on Serum Protein Fractions, Total Thiol Molecules and Total Antioxidant Capacity in Early Lactating Dairy Cows

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ABSTRACT

Twenty four primiparous and multiparous Holstein cows on early lactation, beginning five weeks postpartum, were used for four weeks to investigate the effects of supplementation of rumen-protected choline (RPC) or vitamin E on blood serum protein fractions, plasma total thiol molecules (TTM), and plasma total antioxidant capacity (TAC). Cows were randomly assigned to one of the following treatments: I - no supplement (control), II - 90 g/d of RPC, and III - 4400 IU/d of vitamin E. Serum protein electrophoresis of samples exhibited four main fractions in the blood serum of the cows including: albumin, α, β, and γ. The electrophoresis was carried out by capillary zone electrophoresis (CZE). In this study, feeding RPC or vitamin E affected the blood serum albumin fraction as well as blood plasma TTM ($P<0.05$) but the treatments did not affect the different fractions of globulin as well as plasma TAC ($P>0.05$). The results showed that the increases in serum albumin fractions and TTM which observed in this study, pointed towards a beneficial role of RPC and vitamin E in early lactating dairy cows.

Keywords: Electrophoresis, Serum Proteins, Choline, Vitamin E, Dairy cow.

INTRODUCTION

Normal plasma or serum protein electrophoresis leads to identification of two major protein fractions: albumin and globulin. In humans, sheep, goats, rabbits, dogs, guinea pigs and rats, albumin predominates over globulin while in horses and cows the ratio of albumin and globulin is nearly equal, or globulin predominates (Swenson, 1993). In addition to such species characteristics, there are evidences that some physiological factors, namely: hormones, sexual influences, pregnancy, lactation (Nath *et al.*, 2005; Pourouchottamane *et al.*,

2005; Richard Jagatheesan *et al.*, 2005), nutritional state and many other conditions (dehydration, hemorrhage, liver and kidney dysfunctions, and inflammatory processes) affect serum protein level (Doxey, 1983; Coles, 1986).

Albumin is essential due to its contribution in the maintenance of osmotic pressure of plasma, because it is carrier of many vital substances like steroid hormones, hemin and fatty acids. The albumin value frequently and markedly declines during different diseases. Globulin fraction contains enzymes, hormones and antibodies, which are synthesized at various places in the body (Nicholson *et al.*, 2000). The α-globulin value increases mainly in traumas, and some alterations of the lipoprotein metabolism induce changes in the β-globulin fraction. γ-globulin concentration is a reliable indicator of humoral immunity. Its principal component is IgG but other isotypes of antibodies are also present in this fraction (Goldsby *et al.*, 2001). Blood proteins, with the exception of the γ-globulin fraction, are synthesized in liver (Diehl and Delincee., 1986).

To measure classical protein fractions in serum several electrophoretic techniques are available, like separation on cellulose acetate membrane, agarose gel, etc. but capillary zone electrophoresis (CZE) has been suggested as a useful technique for separation and quantification of serum proteins (Henskens *et al.*, 1998).

Total thiol molecules (TTM) are powerful reducing agents capable of acting antioxidants (Ueland *et al.*, 1996). TTM status is important for normal physiological function. Changes in TTM status have been linked to induction of apoptosis (programmed cell death) (Marchetti *et al.*, 1997), and have been observed in a number of diseases including vascular disease and renal failure (Ueland *et al.*, 1996).

Free radicals can be produced during the respiratory oxidation of different cells. Since free radicals can damage various macromolecules as protein, fat, nucleic acids, etc. they are harmful for body (Jamro and Beltwoski, 2002). The natural defense system, which can prevent the damage of free radicals and neutralize them, has been referred to as total antioxidant capacity (TAC) (Kankfer and Lipko, 2006).

Choline is in the structure of lipoproteins which transport lipids in the blood, thus it is an important factor in preventing fatty liver and ketosis in lactating cows (Cooke *et al.*, 2007). Unfortunately most of dietary choline is degraded by microbial populations in the rumen (Sharma and Erdman, 1989), and not much is available for absorption; therefore, choline must be in rumen-protected form when fed.

Choline can also be used as an antioxidant (Elsawy *et al.*, 2014) because it has significant antioxidant properties that protects cells (Jansen, 2014). In a research, dietary choline decreased the oxidant damage and regulated the antioxidant system in immune organs of fish (Wua *et al.*, 2014).

Vitamin E (*α*-tocopherol) is a powerful antioxidant for body defense against oxidative stress (Burton and Traber, 1990; Ibrahim *et al.*, 1997) and is not degraded in the anaerobic ruminal environment (Burton and Traber, 1990; Leedle *et al.*, 1993).

In peripartum and early lactating cows, lipid peroxidation increases (Castillo *et al.*, 2005) while serum *a*-tocopherol decreases (LeBlanc *et al.*, 2004) indicating a higher level of oxidative stress which subsequently can lead to reduced health in dairy cows (Miller *et al.*, 1993).

The role of vitamin E in recovering from postpartum-related oxidative stress and decrease in lipid peroxidation in liver has been reported in cattle, mice and rats (Ferre *et al.*, 2001; Bouwstra *et al.*, 2008). In a study, supplemental vitamin E could improve liver antioxidant status in mice with fatty liver (Soltys *et al.*, 2001).

The present study was carried out to compare the oxidative status of dairy cows on early lactation which received either supplemental RPC or vitamin E or those unsupplemented, and also to assess the changes in serum protein fractions.

MATERIALS AND METHODS

Cows, treatments and experimental design

Twenty four early lactating primiparous and multiparous Holstein cows beginning five weeks postpartum (BCS = 2.82 ± 0.12; mean ± S.D. and number of lactation = 2.56; mean) were used for four weeks from October 2011 to November 2011. The cows were free from any diseases, with a normal healthy appearance, and were housed in individual tie stalls. All experimental procedures were in accordance with the guidelines for the use and care of experimental animals and approved by the animal ethical committee of Tehran University. Selection of the cows was based on parity, milk yield of previous lactation (milk yield of dams for the cows in their first lactation) and BCS. In this study, there were 3 blocks based on lactation numbers 1, 2, and 3 or greater. Lactation number was indication of age. Eight cows per treatment were randomly assigned to receive one of the following treatments, using block randomization based on parity: I- no supplement (control), II- 90 g/d of RPC and III- 4400 IU/d of vitamin E. The RPC (Reashure Choline, Balchem, USA; 25%) was a rumen protected source of choline chloride, and the vitamin E was the product of Roche Company (Vitamins Ltd; Switzerland). The cows were fed total mixed rations (TMR) *ad libitum*. The diet (Table 1) was formulated to meet the nutritional requirements of dairy cows (NRC, 2001). The RPC and vitamin E were top dressed onto the TMR.

Table 1 - Ingredients and nutrient composition of the diet

Ingredient (g/kg of DM)		(Analyzed or Calculated) Chemical Composition [3]	
Alfalfa hay (medium chopped)	204.7	DM (g/kg) [4]	590
Corn silage	175.8	CP (g/kg) [4]	171.7
Beet pulp	41.3	Ash (g/kg) [4]	57.6
Ground barley grain	198.8	Total fat (g/kg) [4]	43.8
Ground corn grain	58.7	NDF (g/kg) [4]	304.8
Ground wheat grain	28.5	ADF (g/kg) [4]	183.8
Solvent extracted soybean meal	79.9	NFC (g/kg) [4, 6]	382.1
Wheat bran	7.1	Ca (g/kg) [4]	8.1
High lint whole cottonseed	29.5	P (g/kg) [4]	5.0
Canola meal	100.2	NEL (Mcal/kg) [5]	1.66
Corn gluten meal	11.5	RUP (g/kg of CP) [5]	314.5
Minerals and vitamins supplement [1]	6.3	RDP (g/kg of CP) [5]	685.5
Fat supplement (energy booster) [2]	15.9	Met (g/kg MP) [5]	22.1
Salt	2.5	Lys (g/kg MP) [5]	76.9
Calcium carbonate	3.2	Vitamin E (IU/kg) [5]	18.9
Sodium bicarbonate	10.2		
Di calcium phosphate	3.7		
Magnesium oxide	1.9		
Mycosorb	0.6		
Biotin premix	0.7		
Zeolit	19.0		

1 - Contained 190 g Ca/kg, 90 g P/kg, 30 g Mg/kg, 4 g Fe/kg, 0·5 g Cu/kg, 5 g Mn/kg, 4 g Zn/kg, 0·1 g Co/kg, 0·1 g I/kg, 0·03 g Se/kg, 0·4 g antioxidant/kg, 5×10^5 IU vitamin A/kg, 10^5 IU vitamin D/kg and 3×10^3 IU vitamin E/kg.
2 - Rumen protected fat - Energizer RP10.
3 - Analysis conducted with four TMR samples.
4 - The nutrients which were determined by laboratory.
5 - The nutrients which were calculated using the standards (NRC, 2001).
6 - NFC=1000− (CP+ash+total fat+NDF).

Blood Sampling

Blood samples were obtained before morning meal from the coccygeal vein (tail vein) on the last day of the experiment, by using heparinized and non-heparinized Vacutainers tubes (Becton Dickinson, Franklin Lakes, NJ). Blood samples were placed on ice immediately following collection. Then plasma and serum were harvested after centrifugation of the blood at 3000 g for 15 min and were stored at -20 °C until subsequent analyses. The indices of oxidative status including TTM and TAC concentration were analyzed in plasma samples, and the different fractions of blood serum protein were analyzed in serum by CZE.

Capillary Zone Electrophoresis

The Capillary system (Sebia, Issy-les-Moulineaux, France) was operated according to the manufacturer's instructions under software version 1.4.1. The instrument has eight fused silica capillaries (17 cm in length and 25 µm ID). The alkaline buffer (borate and additives) is pH 10 and sample is diluted 1:10. Detection voltage is 9 kV. Separation is carried out at 35°C and takes 2.5 min. Ultraviolet detection at 200 nm is used for direct quantification of the peptide bonds. When the samples are analyzed in batch, capillary has a throughput of 100 samples/h. A typical electrophoretic pattern for blood serum of a cow is shown in Figure. 1. The proteins were measured at 200 nm wavelength. Protein values were expressed as percentages.

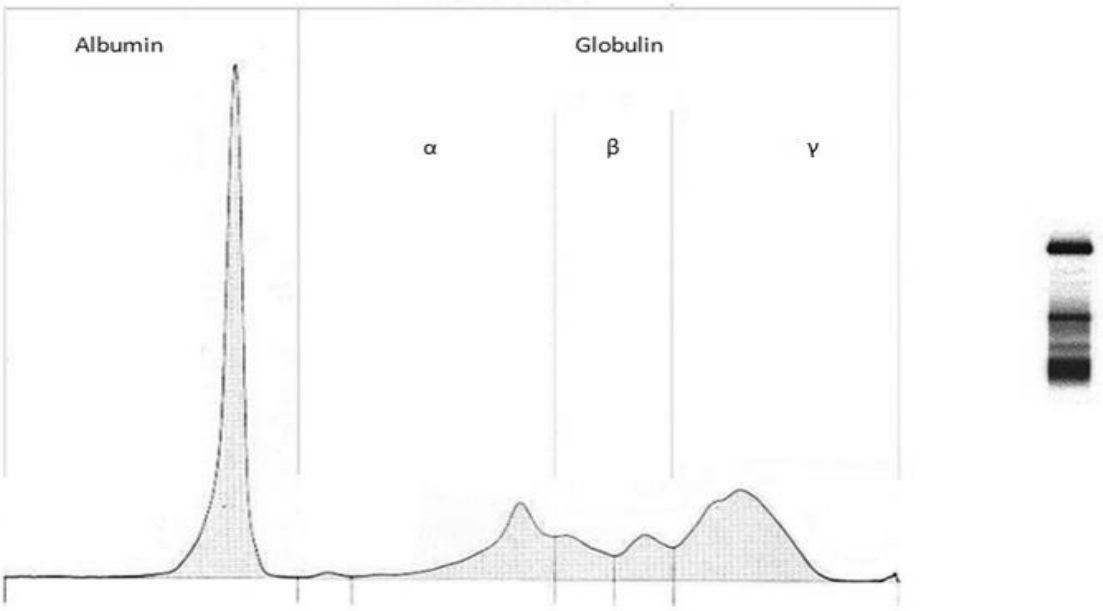

Figure 1- Capillary zone electrophoresis for blood serum of a cow

Assessment of plasma total antioxidant capacity (TAC)

TAC of plasma was evaluated by applying the FRAP assay (ferric reducing antioxidant power or ferric reducing ability of plasma) (Benzie and Strain, 1999). The method is based on the reduction of ferric (Fe^{3+}) to ferrous (Fe^{2+}) ion at low pH. This causes a formation of blue colored ferroustripyridyltriazine (Fe^{2+}-TPTZ) complex, which absorbs at 593nm. Absorbance changes are linear over a wide concentration range with antioxidant mixtures, including plasma (Liu *et al.*, 1982; Benzie and Strain, 1999). Results were expressed as mmol/l (mM). The method could be described in brief as the following: the working FRAP reagent was prepared ex tempore by mixing 300 mmol/l acetate buffer, pH 3.6 with 2,4,6-tripyridyl-striazine (TPTZ) solution (10 mM in 40 mM HCl) and 20 mmol/l $FeCl_3$ solution in ratio10:1:1 respectively, and was pre-tempered at 37°C. The reaction was performed by adding of 100 µl plasma, previously diluted 1:1 with distilled water, to 900 µl FRAP working

reagent and the mixture was incubated for 25 min at 37°C. The absorbance was measured on 593nm compare to a blank mixture where 100 µl water was added to the working FRAP reagent instead of plasma. Aqueous solutions of known Fe^{2+} concentration, in range 0.2 to 1 mmol/l (FeSO4. 7H2O) were used for creating of the standard curve. The results were expressed in mmol/l (mM) Fe^{2+}.

Measurement of Plasma Total Thiol Molecules (TTM)

Total sulfhydryl content was determined in plasma by the method of Hu (Hu and Dillared, 1994). A volume of plasma (0.20 ml) was mixed in a 10 ml test tube with 0.6 ml of Tris–EDTA buffer (Tris base 0.25 M, EDTA 20 mM, pH 8.2) followed by the addition of 40 ml of 10 mM of DTNB (Dithiobis-2-nitrobenzoic acid) in methanol. The final volume of the reaction mixture was made up to 4.0 ml by adding 3.16 ml of methanol. The test tube was capped, and the color was developed for 15–20 min, followed by centrifugation at 3000 g for 10 min at ambient temperature. The absorbance of the supernatant was measured at 412 nm. The TTM capacity was expressed as nmol per mg of protein in samples.

Statistical Analyses

Raw data were transformed to their natural logarithm to achieve a normal distribution for analysis. All transformed data were back-transformed for reporting least squares means. Statistical analyses were performed with SAS (SAS, 2002) using GLM procedure in SAS by inspection of standardized residuals plotted against the predicted residuals. Standardized residuals were also inspected graphically to assess fit to a normal distribution. Differences among means were separated with Duncan multiple range test. Each metabolite was considered as an outcome in separate models over the whole experimental period. Significant levels were declared at $P<0.05$.

RESULTS AND DISCUSSION

Cows undergo a variety of physiological changes during lactation. These occur with respect to the cows' blood composition due to metabolic changes. In fact, the cows make adjustments to provide an adequate supply of nutrients for producing milk while lactation (Drackley, 1999).

In our study, we fed the experimental cows 90 g/d of RPC, because according to some researches feeding 90 g/d of choline would be optimal dose in lactating dairy cows (Sharma and Erdman, 1989; Xu *et al.*, 2006). In an experiment, oral administration of 800 IU/d of vitamin E resulted in significant improvements in liver function in people with non-alcoholic fatty liver disease (Sanyal *et al.*, 2010), thus we decided to feed 4400 IU/d of vitamin E because a cow's body weight is approximately 5.5 times heavier than a human's body weight.

In this research, serum protein electrophoresis of the samples separated into four major fractions: albumin, α-globulin, β-globulin, and γ-globulin (Table 2). The treatments affected albumin fraction ($P<0.05$), but not different fractions of globulin ($P>0.05$).

Albumin is associated with postpartum diseases and can be used to predict disease risks in early lactation period (Saun, 2004). In spite of concerns about variables confounding albumin interpretation, it seems to be a good disease risk indicator possibly reflecting availability of amino acids from the labile protein pool. In our study, feeding RPC or vitamin E affected albumin fractions ($P<0.05$). Therefore, due to increases in albumin fractions of the treated cows we could speculate that the treated cows might be more resistant against various diseases compared with the control group.

Generally at the beginning of lactation cycle, the blood level of NEFA, are elevated mainly due to negative energy balance which would result in a reduced performance of the liver (Overton and Waldron, 2004). Choline reduces NEFA in blood stream due to donation of methyl groups which may lead to improving liver function (Cooke *et al.*, 2007; Soltan *et al.*,

2012). Some researchers have reported that the blood metabolites, like total protein, albumin and globulin, in cows and goats were not affected by choline supplementation (Ambrosio *et al.*, 2007; Toghdory *et al.*, 2007; Mohsen *et al.*, 2011).

Table 2: percentages of serum protein fractions through CZE, and the amount of TTM and TAC in supplemented cows with RPC or vitamin E

Item	Control	Choline	Vitamin E	P- Value
Albumin	36.69±0.98[b]	39.70±0.83[a]	40.21±1.09[a]	0.0486
α-globulin	16.21±1.16	15.34±1.45	14.60±1.30	0.7413
β-globulin	11.45±0.75	9.10±0.76	8.55±0.65	0.4252
γ-globulin	35.65±1.68	35.86±0.67	36.64±0.80	0.8343
TTM (nmol/mg)	1.44±0.07[b]	1.66±0.06[a]	1.64±0.04[a]	0.0362
TAC (mmol/l)	0.12±0.01	0.13±0.01	0.14±0.01	0.5519

[ab] different superscripts are indicating significant differences (*P<0.05*) between the various study groups

In an experiment on ewes, the data demonstrated that receiving vitamin E, starting two weeks before mating and extending through pregnancy till occurrence of lambing, improved levels of albumin, globulin and total serum protein in treated ewes (El-Shahat and Monem, 2011). Similar finding was obtained by other researches in buffaloes (Helal *et al.*, 2009). In a study on vitamin E deficient rabbits, total plasma protein concentration was not significantly affected by vitamin E deficiency, but albumin levels were lower and globulin levels were higher in deficient animals (Diehl and Delincee., 1986).

In this research, supplementation of RPC or vitamin E affected the concentrations of TTM (*P<0.05*), but the treatments did not affect TAC (*P>0.05*; Table 2).

TTM are organic compounds that contain a sulphydryl group. Among all the antioxidants that are available in the body, thiols constitute the major portion of the total body antioxidants and play a significant role in defense against reactive oxygen species. Albumin is exclusively synthesized by the liver, and it is the main source of plasma thiols. Glutathione is mainly synthesized *de novo* within the liver (Jefferies *et al.*, 2003). The reduction of liver function that is usually observed in the early lactating cows might explain lower plasma thiol levels (Bernabucci *et al.*, 2005).

Considering additional data from literature (Goff and Stabel, 1990; Goff and Horst, 1997), the reduction of vitamins E and A in plasma might help to explain the alteration of the oxidative status after calving. In this regard, some studies have demonstrated that, besides enhancing plasma level of fast-acting antioxidants, the supplementation of vitamin E can be useful against oxidative stress in early lactating dairy cows (Weiss *et al.*, 1990; Brzezinska-Slebodzinka *et al.*, 1994).

CONCLUSION

From the results of the present study, we can conclude that the increases in serum albumin fraction and TTM which observed in both RPC and vitamin E groups pointed towards a beneficial role of RPC and vitamin E.

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Original Article

Effects of Replacing Maize with Graded Levels of Boiled Mango Kernel Meal on the Carcass and Sensory Characteristics of Indigenous Guinea Fowl (*Numida meleagris*) Meat

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ABSTRACT

A study was conducted to evaluate the effect of Boiled Mango Kernel Meal (BMKM) on the carcass characteristics and sensory qualities of guinea fowl meat. Dietary maize was substituted with four levels of inclusion of BMKM at 0% (T1), 10% (T2), 15% (T3) and 20% (T4). Forty-eight, 16 week old birds; 12 birds per treatment were randomly selected from a total of 120 birds used for the study. The birds were weighed, slaughtered, and viscera separated from the carcass. Carcass was chilled at -1°C for 24hours, and sectioned into the primal wholesale cuts i.e. breast, wings, thighs and drumstick and each part was weighed. Hot dressing and cold dressing percentages were also taken. Breast and thigh muscles were used for sensory evaluation to assess the sensory attributes i.e. colour, off-odour, juiciness, tenderness, flavour and flavour-liking of the meat. Data obtained were analyzed using the General Linear Model (GLM) of ANOVA component of Minitab. Where significant differences were found, means were separated using Tukey Pair-Wise comparison, at 5% level of significance. The results indicated that the use of BMKM in place of maize in guinea fowl diets had no significant effects on carcass (P>0.05) and sensory characteristics (P>0.05) of the meat. Cost of acquiring 100kg BMKM was GH ¢60.00 ($20.00) whiles 100kg maize was GH ¢150.00 ($50.00). It was concluded that the use of BMKM up to 20 % in guinea fowl diets has no adverse effect on the carcass and sensory characteristics of the meat.

Keywords: Mango kernel meal, carcass characteristics, sensory evaluation, guinea fowl, boiled.

INTRODUCTION

The domestic guinea fowl (*Numida meleagris*) is indigenous to Africa, and are kept in almost every household in Northern Ghana where their production has assumed socio-economic importance. They exist in different strains such as pearl, lavender and white (Dei and Karbo, 2004). The guinea fowl is important in providing good quality meat, eggs and security remedy for unprepared circumstances such as ready cash to buy other agricultural inputs or pay school fees. There has been a significant shift in the consumer preference for guinea fowl meat due to its peculiar taste.

Meat from guinea fowl has high levels of crude protein, lower in fat and cholesterol compared with chicken (Koney, 1993). Guinea fowl rearing is however plagued by high cost of feed, bringing about a high production cost of Guinea fowls in Ghana. Maize, which constitutes the main energy source, is inadequate in supply and expensive when available. This necessitates a study into locally available, less expensive and nutritionally adequate substitutes for maize in poultry feeding. One of such ingredients with potential for use is mango seed kernel.

Mango (*Mangifera indica*) is a tree crop which is well adapted to all ecological zones of Ghana, and the trees are found in almost every part of the country. Mango kernel, a by-product of mango pulp is reported to be a good source of starch (Saadanry *et al*., 1980). In India, mango kernel is used to prepare porridge for human consumption (Saadanry *et al*., 1980; Opeke, 1982), but in Ghana it is regarded as waste, thus contributing to environmental pollution.

There are few reports on the use of mango kernel in livestock feeding, but levels of inclusion in poultry diets has been low because of the presence of tannins which have been reported to reduce chick growth (Jansman *et al*., 1995; Teguia, 1995). Teguia (1995) reported that body weight gains and feed consumption of broilers were adversely affected when 20% of dietary maize was substituted with raw mango kernel meal. However, boiling has been reported by several researchers to be an effective method of reducing the levels of tannin in feed ingredients (Gyabaah, 2011). Mbajunwa (1995) reported a reduction of tannins up to 52% when African oil bean was boiled in water. This study was therefore aimed at determining the effects of feeding graded levels of boiled mango kernel meal to guinea fowls on the carcass and sensory characteristics of the birds.

MATERIALS AND METHODS

Experimental Site

The study was conducted at the Poultry Section of the Department of Animal Science, University for Development Studies, Nyankpala Campus, Tamale.

Processing of mango kernel meal for use

Mango seeds were collected during the month of May (peak mango season in the study area). The seeds were opened up with a knife to obtain the fresh kernels which were chopped into smaller units and boiled in fresh water at 100^{o}C for 30 minutes. The boiled product was then spread on a clean concrete floor and sun-dried for 72 hours. The dried mango kernel was milled using a conventional grinding mill, packaged in polythene bags and stored at room temperature for later use.

Experimental diets and birds

Four dietary treatments were formulated and fed to birds from five weeks old till maturity (16 weeks). T1 was the control diet with 0% BMKM. In treatments 2, 3 and 4, BMKM was used to replace dietary maize at 10%, 15% and 20% respectively. A total of forty-eight (48) indigenous guinea fowls (16 weeks old) with sex ratio of 1:1 were selected with twelve birds each randomly selected from each of the four treatment groups.

Slaughtering of birds

Each bird was weighed (live weight) with an electronic scale (Sartorius, CP 245S) after a 24-hour feed withdrawal, and tagged to differentiate them. The birds were then stuck with a sharp knife to cut the jugular veins and were allowed to bleed for approximately 60 seconds, after which they were scalded in warm water (60°C). The feathers were plucked manually and head and shanks removed. An incision was then made around the vent to remove the viscera. The hot carcass weight was then taken.

Carcass yield and sectioning

The viscera were separated into intestines, gizzard, liver and spleen. The dressed carcass was chilled for 24 hours and cold weight taken. Primal cuttings were made from the chilled carcass and weighed. The breast and thigh muscles were used for sensory evaluations.

Carcass and Sensory Evaluations

Measurement of carcass characteristics

The carcass was chilled and weighed to get the chilled carcass weight. Dressing percentages were obtained as follows;

$$\textit{Hot carcass} = \frac{eviscerated\ weight}{live\ weight} \times 100$$

The cold dressing percentage was calculated by:

$$\textit{Cold carcass} = \frac{weight\ after\ chilling}{live\ weight} \times 100$$

Sensory evaluation of carcass

A total of fifteen (15) panelists aged between 18-25 years were randomly selected and trained according to the British Standard Institution guidelines to evaluate the products (BSI, 1993). Sensory evaluation was carried out on days 1 and 7 of product storage (-18°C). The breast muscles were thawed and grilled to a core temperature of 70°C in an electric oven (Turbofan, Blue seal, UK). The products were sliced into uniform sizes (about $2cm^3$) and wrapped with coded aluminum foils and presented to the panelists. Each panelist was provided with water and pieces of bread to serve as neutralizers between the products.

A five-point category scale was used to evaluate the sensory characteristics of the products as follows: Colour: Very pale red (1), Pale red (2), Intermediate (3), Dark red (4), very dark red (5); Off-odour: Very weak (1), weak (2), intermediate (3), strong (4), very strong (5); Juiciness: Very dry (1), dry (2), intermediate (3), juicy (4), very juicy (5); Tenderness: Very tough (1), tough (2), intermediate (3), tender (4), very tender (5); Guinea fowl flavour: Very weak (1), weak (2), moderate (3), strong (4), very strong (5) ; Flavour-liking: Dislike very much (1), Dislike (2), intermediate (3), Like (4), Like very much (5).

Data analysis

The data obtained was analyzed using the General Linear Model (GLM) of Analysis of Variance (ANOVA) of Minitab statistical package (Minitab, 2007). Where significant differences were found, means were separated using Tukey Pair-Wise comparison, at 5% level of significance

RESULTS AND DISCUSSION

Dressing percentage and primal cuts of the birds

The dressing percentage and primal cuts of the birds are presented in Table 1.There were no significant (P> 0.05) differences in the dressing percentages and primal cuts of the birds.

Hot dressing percentage indicates the carcass yield, while cold dressing percentage indicates the ability of the carcass to retain moisture during chilling.

Table 1: Dressing percentage and primal cuts of the birds

Parameter (%)	T1	T2	T3	T4	SED	Sig
Hot dressing	79.19	78.09	77.74	79.54	1.88	NS
Cold dressing	70.35	69.69	68.29	70.48	2.09	NS
Drumstick	36.73	32.98	30.60	33.06	4.03	NS
Wings	49.37	43.39	42.12	44.56	4.97	NS
Breast	140.1	124.7	131.0	123.5	14.33	NS
Thigh	47.11	44.31	39.62	42.78	6.65	NS

SED= Standard Error of Difference; Sig.=significance; ns = not significant (P>0.05)

The primal cuts are the most marketable parts of poultry, and therefore higher weights of primal cuts are desirable for high profitability. Teye *et al.* (2011) reported significantly lower ($P < 0.05$) dressing percentage and primal cuts of birds fed raw false yam seed meal (RFYSM). This observation was assigned to the anti-nutritional factors in the false yam seed meal that hindered growth and development of the birds. The anti-nutritional factors in the feed might have made the feed unpalatable and poorly digestible and consequent difficulty in proper utilization by animals (Okine *et al.,* 2009). Gyabaah (2011) however, used boiled false yam seed meal to feed broiler chicken and reported no significant differences ($P>0.05$) in the dressing percentages. The results from this study confirm the assertion that boiling is an efficient means of minimizing anti-nutritional factors in feed materials. Jourdain (1980); Oluyemi and Roberts (1988) reported that protein utilization in feed is important in muscle deposition, but this is hindered by anti-nutritional factors in feed. Therefore, the insignificant differences in the carcass yield and primal cuts indicate that dietary nutrient utilization was not affected by the inclusion of BMKM to Guinea fowl diets.

There was no significant ($P>0.05$) difference in the contents of the intestine and gizzard. This indicates that the rate at which the feed passes through the gastro- intestinal tract is similar among the birds on the different diets. This might have resulted in the insignificant differences in the carcass yield of the birds.

Sensory evaluation of the meat

The sensory characteristics of the meat are indicated in Table 2. There was no significant ($P>0.05$) difference in the colour, off-odour, juiciness, flavour and flavour-liking of the guinea fowl breast muscles. These sensory parameters are the most important qualities consumers look out for when buying meat.

Table 2: Sensory characteristics of the meat

Parameter	T1	T2	T3	T4	SED	Sig
Colour	2.27	2.33	2.33	2.40	0.54	NS
Off-odour	1.80	1.60	2.07	1.87	0.85	NS
Juiciness	3.07	3.00	2.87	3.20	0.87	NS
Tenderness	3.27	3.60	3.87	3.53	0.64	NS
Flavour	3.53	3.87	3.73	3.47	0.98	NS
Flavour-liking	3.73	4.07	4.00	3.47	0.75	NS

SED= Standard Error of Difference; Sig.=significance; NS = not significant (P>0.05)

Colour and general appearance of meat are important criteria consumers look out for when making buying decisions (Feiner, 2006). Colour is an important factor used by most consumers to determine freshness of meat and meat products (Van Oeckel *et al*., 1999). This implies that a product with an unusual colour will not be accepted by consumers. The similar

colour appearance of the meats indicates that the use of BMKM had no effect on the appearance of the meat.

According to McWilliams (1997), pleasant odour of a product invites people, while a strong irritating odour discourages consumer patronage. A product with an odour that differs from the known will deter consumers from patronizing such products.

Juiciness of meat is directly related to inter and intra-muscular lipids and moisture content of the meat (Cross *et al*., 1986). Juiciness of a product is very important to a consumer and since there was no significant difference between treatments, it can be said that the experimental diet had no adverse effect on the meat. Guinea fowl meat has a characteristic aroma, which is cherished by most consumers in Ghana. The result from this study indicates that the experimental diet had adverse effect on the aroma of the meat. Flavour is the outcome of combining the senses of smell; taste and mouth feel by a consumer, and is determined subjectively by taste panellists. Sulphur compounds like hydrogen sulphide provides the meat flavour of meats (Bell and Weaver, 2002). Therefore any meat product which does not have the taste of its source is said to be contaminated and will likely be rejected by consumers. From the results, there was no significant difference in the flavour-liking of the products, meaning consumers will not hesitate buying such products.

Costs of acquiring maize and Boiled Mango Kernel Meal

The costs of acquiring 100kg each of maize and boiled mango kernel meal are shown in Table 3. The cost of acquiring 100kg of BMKM was GH ¢60.00 ($20.00) whiles that of 100kg maize was GH¢150.00 ($50.00). It can be realised that using BMKM in place of dietary maize was cheaper, although there were no significant differences in the carcass parameters. The adoption of BMKM in Guinea fowl production will reduce production cost and boost profitability of Guinea fowl production. The use of BMKM in place of maize will also minimize competition between livestock and humans over maize, which is now very expensive due to inadequate supply of the commodity.

Table 3: Costs of acquiring 100kg maize and BMKM

Ingredient	Cost of acquiring 100kg (GH¢)	Cost of processing (GH¢)	Total Cost (GH¢)
Maize	140.00	10.00	150.00
Mango kernel	10.00	50.00*	60.00

* Cost includes boiling, drying, milling and transportation

CONCLUSION AND RECOMMENDATION

The use of boiled mango kernel meal up to 20% inclusion in Guinea fowl diets has no adverse effects on the carcass and sensory characteristics of the meat. However, the use of BMKM in place of maize in guinea fowl diets reduces production costs. It is recommended that further studies should be conducted to determine the effects of feeding boiled mango kernel meal to guinea fowls, on the haematological characteristics and nutritional composition of the birds.

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Review Article

Pathophysiology of the Intestinal Ischemic Reperfusion Injury

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ABSTRACT

The objective of this review is to approach current information about the ischemic reperfusion injury that affects the gastrointestinal system in animals, because it is classified as a complex event that can cause local and systemic injuries, leading to multiple organ failure. The deleterious events caused by the reperfusion process are greater when compared with the ischemia, due to the circulation of toxins released secondary to hypoxia, loss of cellular membrane integrity, release of free radical and endothelial injuries during reperfusion. It is known that in Veterinary Medicine most of the abdominal emergencies (acute abdomen) cause gastrointestinal microcirculatory dysfunctions and its diagnostic is still a challenge, because the clinical signs are similar to other diseases. The reperfusion injury is one of the reasons for the morbidity and mortality associated with intestinal ischemia, a common affection, especially in equines. The injuries on intestinal ischemia/reperfusion (I/R) are considerate of extreme importance due to its severity and the comprehension of the pathophysiological mechanism of these injuries is necessary to determine therapeutic strategies in the main domestic species.

Keywords: hypoxia, cellular apoptosis, free radicals, acute abdomen, microcirculatory dysfunction.

INTRODUCTION

Ischemic and reperfusion injury (R/I) is characterized by the reduction and interruption of the blood flow followed by a sequence of vascular alterations that leads to the production of free radicals during the reestablishment of the blood flow to the ischemic tissue (Matos *et al*., 2000). The sudden reintroduction of oxygen, also called reperfusion, increases the tissue and vascular injury, hastening the process of cellular necrosis (Tong *et al*., 2012). Despite all the existing studies about ischemic and reperfusion injuries, only in 1986 it was demonstrated that reperfusion would cause a greater systemic and tissue injury than the ischemic injury itself (Parks and Granger, 1986; Santos *et al*., 2008).

The intestine is irrigated by the mesenteric circulation, receiving about 20 to 25 % of the body total blood volume (Vollmar and Menger, 2011). From this volume, approximately 70 % is directed to the mucosa and sub mucosa keeping the homeostasis and the functionality of the crypts and intestinal villi. The organ is very sensitive to any kind of decrease in blood

flow, especially the small intestine (Yasuhara, 2005). Because of that, mechanisms of auto regulation that aim to mainten the flow are constantly triggered in situations of systemic blood pressure decrease or stimulation of the sympathetic tone (Vollmar and Menger, 2011).

Any injury that is capable of causing intestinal ischemia has high potential of progression, causing tissue damage (Yasuhara, 2005), such as sub mucosa edema followed by loosening of the superficial mucosa epithelium and the occurrence of ulcers and/or bleeding of the intestinal villi (Brasileiro *et al*., 2013). Consequent to the ischemic damage, the reperfusion leads to alteration of the vascular permeability and loss of the integrity of the intestinal barrier caused by the reactive oxygen species and inflammatory mediators causing damage as hemorrhages and bacterial translocation (Yasuhara, 2005; Kostopanagiotou *et al*., 2007; Vollmar and Menger, 2011; Brasileiro *et al*., 2013).

The intestinal disorders that cause the acute abdomen syndrome in animal patients, such as strangulation obstructions (torsion, volvulus, intussusceptions, strangulated hernia) and non strangulation obstruction (Rowe and White, 2002) have the potential to develop ischemic injuries and reperfusion that is associated with high mortality rates, between 60 to 70 % of the cases (Ritz *et al*., 2005; Boybeyi *et al*., 2014). Clinically, it is observed diarrhea, vomit and/or intense abdominal pain, signs that can be associated with the occurrence of acute intestinal ischemia (Ravipati *et al*., 2011).

The intestinal ischemic/reperfusion injuries (I/R) are considerate of extreme importance due to its severity (Gao *et al*., 2006; Jiang *et al*., 2011; Vollmar and Menger, 2011) and the comprehension of the pathophysiological mechanisms of these injuries are necessary to determine therapeutic strategies for the majority of the domestic species.

PATHOPHYSIOLOGY OF THE ISCHEMIC INJURY

In the moment that the tissue blood flow is interrupted, a series of metabolic and enzymatic compensatory events are triggered (Evora *et al*., 1996). The low cellular oxygen offer causes a decrease in the production of adenosine triphosphate (ATP) by the mitochondria, decreasing intracellular concentration of this molecule. Alongside an increase in adenosine monophosphate (AMP) will occur.

Attempting to keep tissue function and in response to the increase in AMP, the cells will initiate the production of energy through an anaerobic mechanism (glycolisis), producing lactic acid and H^+ ions (Moore *et al*., 1995). The accumulated lactic acid decreases the intracellular pH which hinders the maintenance of the cellular function, due to the exhaustion of cellular energy resources. Without energy, the membrane pumps that are responsible for the flux of ions cease their functions, causing an influx of fluid and calcium ions to the intracellular space (calcium paradox), initiating the mitochondria and sarcolemma lesion, resulting in edemas (Farber *et al*., 1981; Evora *et al*., 1996; Silva-JR *et al*., 2002; Slone and Fleming, 2014).

The mitochondrial lesion will contribute to the decrease in the activity of the adenine nicotinamine dinocleotide coupled to the hydrogen (NADH) desidrogenase, the diphosphate adenosine carrier/ triphosphate adenosine (ADP/ATP) and the ATP synthase, and to the increase in the activity of phospholipase A2, creating a ionic gradient in the cellular membrane, altering the rearrangement of calcium in the citosol (Kono *et al*., 1982; Silva-JR *et al*., 2002).

This process will potentiate the increase in cytoplasmic calcium, activating a protease that can convert xantine desidrogenase (XDH) in xantine oxidase (XO) (McCord, 1985; Nilsson *et al*., 1994; Greca *et al*., 2008). At the same time there will be a depletion of ATP, accumulating AMP that will be catabolized into adenosine and inosine, ending with hipoxantine (Greca *et al*., 2008).

Among the most common causes of intestinal ischemia there are acute mesenteric obstruction and ischemic colitis, which will lead to a decrease of tissue blood supply and a

decrease in the intestinal oxygen (Yasuhara, 2005; Rowe and White, 2002). The intestinal ischemia progress rapidly causing tissue damage, especially necrosis of the tissue cells, production of toxins, loss of membrane integrity and bacterial translocation (Yasuhara, 2005; Vollmar and Menger, 2011; Brasileiro *et al*., 2013), which may cause secondary lesion in the lungs and result in multiple organs failure (Slone and Fleming, 2014).

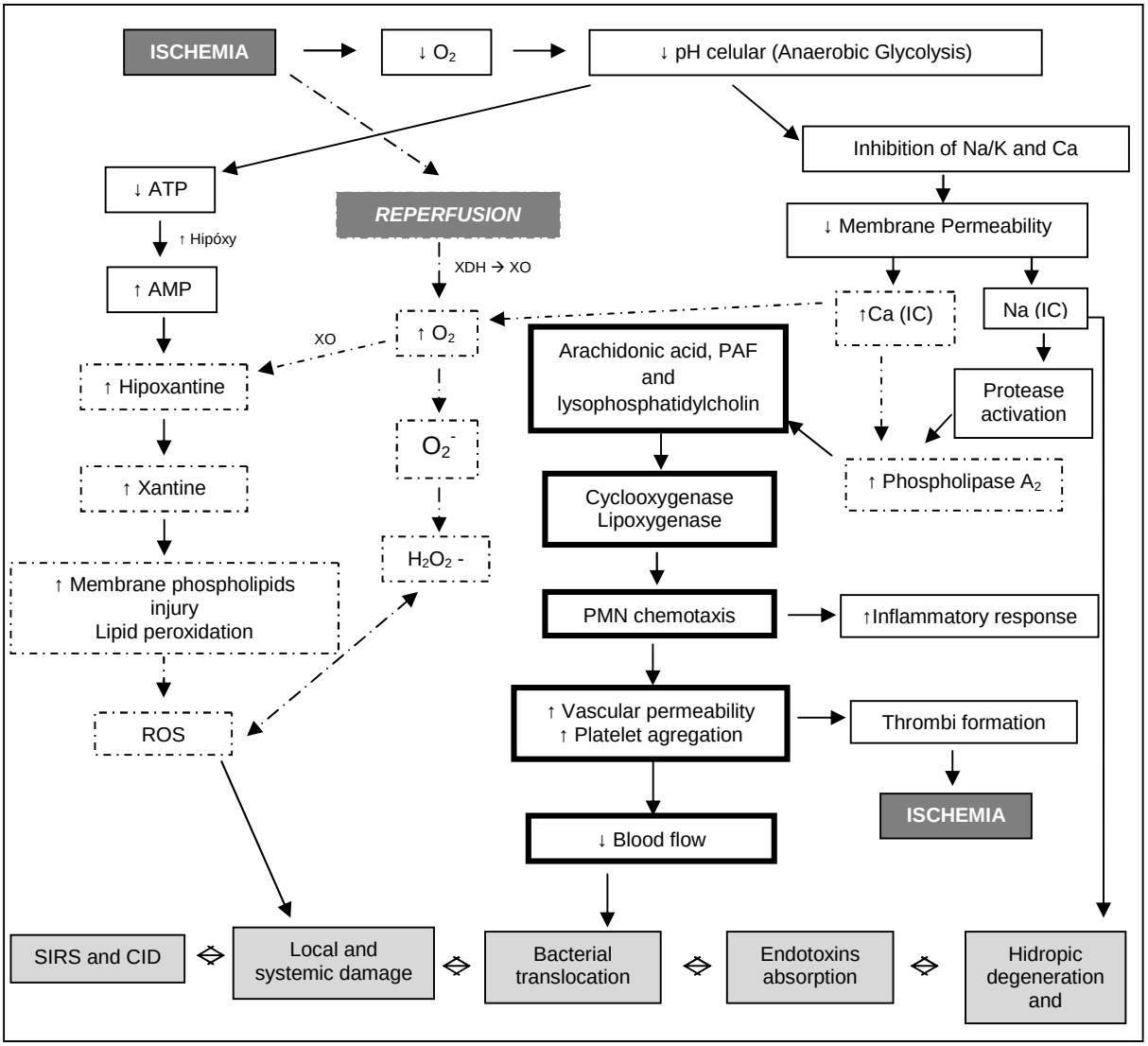

Figure 1. Representative scheme of the pathophysiological events in the intestinal ischemia reperfusion injury. After an ischemic event there will be a decrease the in supply of oxygen (O_2), a decrease in the production of adenosine triphospate (ATP), membrane permeability altering causing electrolyte imbalance and the inhibition of the body physiologic pumps, promoving influxe of intracellular calcium (Ca – IC), proteases and lipases activation, especially phospholipase A2. This enzyme will promote membrane phospholipids injury, Arachidonic acid, platelet activating factor (PAF) and lysophosphatidylcholine release. Yet, will be an increase in the production of hipoxantine. With the reintroduction of O_2, during reperfusion, it will occur activation and break of xantine desidrogenase (XDH) in xantine oxidase (XO), that will act in the hipoxantine increasing the production of reactive oxygen species (ROS), such as, superoxide anions (O_2^-) and hydrogen peroxide ($H_2O_2^-$). The sum of these events and the secondary products to the I/R can lead to or enhance the systemic inflammatory response (SIRS), disseminate intravascular coagulation (CID), bacterial translocation, endotoxins absorption, cellular apoptosis and other local and systemic damage in the body.

PATHOPHYSIOLOGY OF THE REPERFUSION INJURY

The consequences of ischemia in the different tissues and organs are dependent upon the duration of the event and many of the lesions will develop during the reoxygenation stage resulted from the tissue reperfusion (Silva-JR. *et al*., 2002). The reperfusion mechanism became much discussed because it can cause local and systemic injuries, predisposing the

formation of reactive oxygen molecules that will result in injuries throughout the body (Parks and Granger, 1986; Greca *et al*., 2001; Lock, 2002; Edward *et al*., 2003; Greca *et al*., 2008; Santos *et al*., 2010; Slone and Fleming, 2014). The deleterious effects caused by the reperfusion process will be even greater than the ischemia due to the accumulation of toxins during this event and its posterior distribution throughout the body during reperfusion (Greca *et al*., 2008).

The reperfusion stage is characterized by the feedback of the blood flow to the ischemic area. Hence, the anaerobic metabolites from the damaged tissue gain the bloodstream, causing more local and systemic tissue damage being compared with the damage caused by the ischemia (Granger and Korthuis, 1995; Greca *et al*., 2001; Lock, 2002; Edward *et al*., 2003; Chen *et al*., 2003; Greca *et al*, 2008; Köhler *et al*., 2011; Ben *et al*., 2012; Brasileiro *et al*., 2013).

The whole I/R process will cause a series of injuries **(Figure 1)**, mediated by oxygen free radicals produced by the parenchymal cells and/or by inflammatory cells. These radicals will migrate to the local and distant tissues causing damage (Ferro *et al*., 2010; Rocha *et al*., 2012).

The hipoxantine, produced in consequence of hypoxia and accumulated during ischemia, will suffer the action of xantine oxidase (XO), with the presence of molecular oxygen (tissue reoxygenation), becoming oxygen free radicals, also called superoxide or reactive oxygen species (ROS), such as, the superoxide anions (O_2^-) and the hydrogen peroxide ($H_2O_2^-$). These can suffer reduction and transform into reactive hydroxyl that will initiate lipid peroxidation (McCord, 1985; Pitt *et al*., 1991; Moore *et al*., 1995; Hirata *et al*., 1996; Greca *et al*., 2008; Battelli *et al*., 2014).

The reperfusion event associated with the calcium influx to the intracellular space (Evora *et al*., 1996) will increase the activation of enzymes such as fosfolipase, which acts degrading the plasmatic membrane and altering the structural function of the cells. The proteases and lipases will also be activated and act degrading the organelles (Moore *et al*., 1995). These event will alter structurally and functionally the lipids present in the cellular membrane, originating an exacerbated systemic inflammatory response (SIRS), an increase in the endothelial to fluids, macromolecules and inflammatory cells, furthermore, it can aggravates the injury caused by ischemia (McCord, 1985; Moore *et al*., 1995; McQuaid and Keenan, 1997; Cohen *et al*., 1997; Greca *et al*., 2008; Belknap *et al*., 2009; Laskoski *et al*., 2012).

FINAL CONSIDERATIONS

The pathophysiology of the intestinal I/R happens in a brief and gradual manner, becoming an event highly complex due to its systemic proportion. Because it is an organ that depends on a health vascular function, in situations that culminate with I/R injuries, there will be failure in the cellular nutrition, triggering of the inflammatory mediators cascade, a response to the inflammatory process and loss of the intestinal epithelial barrier. Summed to the fact that will happen injuries in the vascular intestinal endothelium, the bacterias from the intestine can gain the system leading to bacterial translocation. The presence of bacteria in the bloodstream, as well as the systemic inflammatory response due to the endotoxin shock can directly interfere in the prognostic of the injuries associated with the acute I/R, being considered a bad prognostic.

The events are considered multifactorial and interdependent. So the comprehension of the pathophysiology is considered of great importance to improve the prognostic of patients affected by this injury.

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Review Article

Application of Biotechnology for Augmentation of Productivity in Mithun (*Bos frontalis*)

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ABSTRACT

Mithun, also known as 'Cattle of Mountain" is an important bovine species of north-eastern hill region of India and also of China, Myanmar, Bhutan and Bangladesh. This magnificent massive bovine is presently reared under free-range condition in the hill forests at an altitude of 1000 to 3000 m above mean sea level. Mithun plays an important role in the socio-economic and cultural life of the local tribal population. Due to dwindling population of mithun over the years and gradual denudation of free range forest areas for mithun grazing along with the biotic and abiotic stress, there is urgent need of scientific intervention for proper management as well as conservation of this species. Application of various biotechnological tools like artificial insemination, estrus synchronization for timed-AI, multiple ovulation and embryo transfer, rumen microbial manipulation and modern breeding techniques may be of great use for faster multiplication and propagation of this species in near future.

Keywords: mithun productivity, biotechnology, conservation, meat, milk, rare species

INTRODUCTION

Livestock improvement is a continuous process. This can be achieved through application of various scientific methods of breeding, feeding and management. In the recent times, due to tremendous development in the field of biotechnology, especially in the areas such as functional genomics, pharmacogenomics, proteomics, nutrigenomics, stem cell etc., we are being able to cope up ourselves with the modern techniques in those fields for improvement of our livestock species. These technologies are of great use for augmenting the productivity of our livestock.

Mithun *(Bos frontalis)*, a pride animal of Northeastern hills of India, is a rare species of semi-domesticated bovine (Simoons, 1984; Mondal and Pal, 1999; Mondal *et al.*, 2004; 2005a-e; 2006a-f; 2008; 2010; 2014). This animal is mainly confined in the North Eastern Hill region of India and also found in lesser numbers of few selected tracts of Myanmar, Bhutan, and Bangladesh as well as Yunan province of China (Mondal *et al.*, 2014). Mithun is well adapted in steep jungles at an elevation ranged from 1000 to 3000 meter above mean sea

level and has got important place in economic, social, cultural and religious life of tribal people (Simoons, 1984; Mondal and Pal, 1999; Mondal *et al.*, 2004; 2005a-e; 2006a-f; 2008; 2010; 2014). This is an underutilized animal and has got a great potential for quality meat, milk and leather production. Mithun meat, milk as well as leather are of very good quality and there is a great scope to promote this species as an organic meat and milk producer (Mondal *et al.*, 2014). At present, farmers rear this animal under free grazing condition without much emphasis on scientific rearing methods. At this perspective, there is an immediate need to implement the scientific mithun rearing system as well as to utilize the optimum production capabilities in terms of meat, milk and other related value added products.

Distribution and Habitat

Mithun (*Bos frontalis*), is considered as the domesticated form of wild gaur (Mondal *et al.*, 2014). This species has a limited geographical distribution. It is mainly found in the rain forests of Arunachal Pradesh, Nagaland, Manipur and Mizoram States of the Northeastern Hill Regions of India. It is also found in small numbers in Myanmar, China, Bangladesh and Bhutan (Simoons, 1984; Mondal and Pal, 1999; Mondal *et al.*, 2004; 2005a-e; 2006a-f; 2008; 2010; 2014). At present, the population of mithun in India is approximately 0.26 million. As per the quinquennial All India Livestock Census (1997), India had a total population of 1, 76, 893 mithuns. Of the total population, the Arunachal State alone had 70.25% (1, 24, 194 heads). The Nagaland State had 18.86% (33,445 heads) followed by Manipur (9.42%; 16,660 heads) and Mizoram States (1.47%; 2,594 heads). It was seen from the census of the year 2003 that the country possessed 2, 46, 315 numbers of mithun, which registered a growth rate of only 6.5% per year over the population reported in 1997 census and this growth rate is far below than those recorded during last census in 1997 over 1991 (growth rate: 24.56%) indicating declining trend of population of mithun growth rates over the decades. In the recent census (2007), it has been noted that except Arunachal Pradesh, in all other three mithun-inhabited States, percent contribution declined very drastically, particularly in Mizoram State, where the total number of mithuns are less than 2000 heads (Table 1; Mondal *et al.*, 2014). These data suggest an immediate developmental and research attention to this species of animal through proper scientific rearing.

Table 1. Recent trend of Mithun population in India (Mondal *et al.*, 2014)

State	Year		
	1997	2003	2007
Arunachal	1,24,194	1,84,343	2,18,931
Nagaland	33,445	40,452	33,385
Manipur	16,660	19,737	10,024
Mizoram	2,594	1,783	1,939
Total	1,76,893	2,46,315	2,64,279

Currently there are four defined mithun strains, namely Arunachal, Nagaland, Manipur and Mizoram strains (Mondal *et al.*, 2014). These strains are named after the North Eastern states, where they belong to. The contributions of different mithun strains to the total mithun population of India are 75%, 16%, 8% and 1% for Arunachal, Nagaland, Manipur and Mizoram strains, respectively. Among these four different strains, Arunachal strain is the biggest in size, while Mizoram strain is the smallest in size.

Economic Utility

Mithuns are mainly reared for meat purpose. This animal is popularly used as marriage gift and sacrificial animal for different social, cultural and religious ceremonies. At present

farmers do not consume its milk but the milk of this animal is highly nutritious (Mondal *et al.,* 2014).

Being a beef animal, the growth rate of mithun is the prime concern to the farmers. The birth weight of Mithun calves varies from 17 to 22kg. With adequate feeding the growth rate of this animal varies from 266 to 733 g per day, which is comparable with cattle and buffalo. However, the plasma growth hormone concentration (30-90 ng/ ml) is much higher in mithun than any other domesticated animals (Mondal *et al.,* 2006d, 2014). There is a heavy demand for this meat and tribal consumers consider this meat as more tender and superior over the meat of any other species except pork. The dressing percentage in mithun varies from 48 to 54% in different age groups. To achieve an optimum dressing percentage, it is suggested that the Mithun should be slaughtered at the age of 4 to 5 years. This animal produces around 1 to 1.5 kg milk per day (Mondal *et al.,* 2014). However, mithun milk is nutritionally superior to any other domesticated species as it contains high fat (8 to 13%), solid-not-fat (18 to 24%) and protein (5 to 7%). Hence, mithun has a great scope to be exploited as moderately good milk animal for home consumption in these hilly areas. As milk contains high fat and protein, there is great scope for the preparation of different value added products like paneer, various sweet products, ghee, cream, curd etc. Due to high protein content in mithun milk, there is scope to utilize this milk for cheese production also.

As that of milk, the quality of mithun meat is also very good as the protein content in muscle and organs varies from 14 to 19 percent and crude fat and carbohydrate in mithun carcass have been found within the range of 0.4 to 3.58 percent and 0.06 to 4.97 percent, respectively (Das *et al.,* 2011). As mithun is grown organically, it can be promoted as organic meat in the international market. Moreover, various value added meat product can also be promoted in the international market. Some value added meat product like meat powder, nuggets, patties and meat block has already been prepared. There is ample scope to utilize some of the modern biotechnological procedure available in the field of food technology for producing quality value added meat and milk products.

The quality of mithun hide is found to be superior in comparison to the traditional cow hides (Das *et al*., 2011). Mithun hide has been found to be very good for the production of shoe leather, bag leather as well as garment leather. Bag leather has been found to be much superior quality than cow leather (Das *et al.,* 2011). Besides, mithun hide with hairs could be promoted as exotic stuff as sofa cover as well as carpet material (Das *et al*., 2011). The finished product like shoes, jacket, ladies bag etc., which have been prepared from mithun leather, got a very good acclaim.

Genetic Improvement of Mithun

Traditional breeding approaches like selection of mithun for desired trait and nominated mating has been the only method for improvement of livestock so far. However, advancement of science particularly in the field of molecular genetics has given a number of powerful tools in the hand of breeders and scientists for faster genetic improvement. Markers assisted selection approach is one these powerful techniques that is currently being utilized for this purpose. Marker assisted selection is based on the genetic polymorphism at the DNA level, which is identified and utilized for selection of animals having desired genotype. The various applications of molecular markers can be parentage determination, estimation of genetic distance, embryo and semen sexing, gene mapping and selection of animals for disease resistance, and traits with very low heritability.

Marker-assisted selection provides accurate selection of specific DNA variations that are associated with a measurable difference or effect on complex traits of animals. However, marker assisted selection should be considered as a powerful technique to assist with conventional selection techniques and not as its total replacement. Potential benefits from marker assisted selection may be achieved for traits that are: a) simply inherited traits (coat

color, genetic defects), b) carcass quality and palatability traits, c)fertility and reproductive traits, d)carcass quantity and yield, e) milk production and maternal ability, and f) growth performance.

Even if the potential benefit is enormous, still there is long way to go to reap the rich benefit of marker assisted selection in livestock improvement including mithun and yak, as the technology is complex and their applications are widely variable under existing situations. However, marker assisted selection technique has completely revolutionized the system of genetic improvement of livestock, which was thought to be impossible even a decade before. DNA-based technologies are developing at a rapid pace. It is likely that these technologies will play a progressively more important role in animal improvement. However, future application of marker assisted selection technique will depend on how much they are profitable, their economics of use and the rate of genetic gains and their sustainability in long run.

Biotechnological Interventions for Better Production

Though at present the farmers are rearing mithun under free grazing system without any additional managemental inputs, but to utilize this animal with optimum production potential, there is urgent need to adopt this animal with the scientific rearing systems. The various components of scientific mithun rearing are discussed below.

Nutritional Biotechniques

Antibiotic compounds have been employed as feed additive for livestock and poultry for nearly 50 years. There has been a general believe that use of low concentration of antibiotics may favour proliferation of antibiotic resistant microorganisms, which in turn may have serious consequences for disease control in human and animals. Probiotics or feeding of microbial feed additive is the alternative to antibiotics, which benefit the animal by establishing a favorable intestinal microbial balance, nutrition, growth and health. These are nonpathogenic and non toxic to animals and human being. The probiotics like yeast (*Sacharomyces cerevisiae*) and lactic acid bacteria (*Lactobacillus acidophilus*) have successfully been tried in cattle for increasing growth and production. The same type of probiotics can also be used in Mithun for increasing the growth rate and feed conversion efficiency as a consequence of economizing the Mithun production. The overall health condition like rumen fermentation pattern of Mithun was also improved after feeding yeast.

Genetic manipulation of rumen in Mithun can also be initiated for increasing the Mithun production. The population of fiber degrading microbes in the Mithun rumen can be increased for degradation of lignocellulosic feeds by genetic manipulation. These lignocellulosic by-products contain 60-70% of gross energy in the form of either cellulose or hemicellulose, which is otherwise good sources of energy for the ruminants. Due to presence of anti-nutritional factors like lignin, tannin, silica etc. the animals are able to extract only up to 50 to 60% of potential energy from such feeds. So, enhancement of extraction of this energy by genetic manipulation techniques may result in increasing livestock productivity with the available feed resource in the country.

Another area of interest for biotechnological intervention is the microbial diversity of Mithun. The microorganisms playing key role in degradation of lignocellulosic feed in the rumen of Mithun must be identified and different chemicals/plant secondary metabolites must be tried for their potential to stimulate the activity of identified microbes and improvement in fiber degradation. The work on genetic characterization of the mithun rumen microbes should also be carried out. These microbes can also be maintained and refined for quality and fast production for meeting the demand of the market.

Breeding management

Mithun is a polyestrus animal. A healthy adult female mithun shows repeated estrous cycle at an interval of 19 to 24 days unless it is pregnant (Mondal *et al.*, 2004; 2005a-e; 2006a-f; 2008; 2010; 2014). The mithun bred throughout the year and no definite breeding season is observed in this species. The length of gestation period, service period and calving interval in mithun varies from 270 to 290 days, 50 to 100 days and 350 to 400 days, respectively. Whereas, the age at puberty and age at first calving varies form 18 to 24 months and 35 to 40 months, respectively (Mondal *et al.;* 2004; 2005a-e; 2006a-f; 2008; 2010; 2014). The mithun bulls become matured to breed at 3 to 4 years of age. Under free-range system, a practical approach to rear a good stock of animal will be selection breeding through introduction of superior and tested bulls (1 bull for 10 breedable females) in the herd and simultaneous culling of the unwanted bulls from the herd. There should be simultaneous effort to replace breeding bulls preferably once in five years to avoid inbreeding depression. Under semi intensive system, the detection of heat in female is another important step as this animal very often expresses silent heat so that breeding can be done with superior bull either through natural service or through artificial insemination (Mondal *et al.*, 2014).

Reproductive Biotechniques

Artificial Insemination

Artificial insemination is a very efficient method to propagate this animal and also a tool to give the farmers a way of increasing quality animals through using quality semen collected from proven mithun bull for artificial insemination. Semen collection and preservation of commercially important livestock may be a viable venture in the field of biotechnology for young entrepreneurs for augmenting the productivity status of livestock.

Unlike other bovine, mithun bulls do not mount cows that are not in estrus (heat) thereby problem to get semen regularly using artificial vagina (AV) method (Mondal *et al.,* 2010). Here, we tried to use urine from estrus cows stored at refrigerated temperature to attract bull to mount. This urine samples were sprinkled over the perineal region of mithun cow not in estrus and bull reacted as an estrus cow and semen was collected successfully. Urine collected from estrus cows and stored at refrigerated temperature was effective till day 7 post-collection (Mondal *et al.,* 2010).

To get more quantity of semen, we stimulated the bull (which were not capable of mounting the mithun cow properly) with artificial vagina in presence of an estrus/urine sprinkled cow. Massage followed by stimulation produced more quantity semen and there was no need of centrifuge the semen samples to get more concentrated semen for cryopreservation. After suitable evaluation of mithun semen, we have successfully cryopreserved mithun semen for AI and in situ conservation of this valuable germplasm (Mondal *et al.,* 2010).

Estrus synchronization

Estrus synchronization is the manipulation of reproductive process so that female can be bred with normal fertility during a short, predefined interval. It facilitates breeding in two important ways: it reduces and in some cases eliminates labour of detecting estrus, and it allows the producers to schedule the breeding. Considering the importance of synchronization of estrus in mithun, estrus synchronization protocols for timed-AI in mithun has been developed using $PGF_{2\alpha}$, GnRH-$PGF_{2\alpha}$-GnRH (Ovsynch) and controlled intravaginal drug (progesterone) releasing device (CIDR).

a) Estrus synchronization using $PGF_{2\alpha}$

Two injections of $PGF_{2\alpha}$ were given at 11 days apart in cyclic mithun cows. Animals were observed for signs of estrus after second injection of $PGF_{2\alpha}$ and found that mithun cows responded to this treatment. The time from onset of estrus to ovulation was 27.7±0.61 hr with

a range of 26 to 31 hour in $PGF_{2\alpha}$ treated group compared to 26.9 ± 0.31 hour with a range of 26 to 29 hr in control group (Mondal *et al.,* 2014; unpublished data).

b) Estrus synchronization using Ovsynch protocol

Cyclic mithun cows irrespective of any day of estrous cycle were subjected to Ovsynch protocol of estrus synchronization. All mithun cows responded to this treatment. The ovulation time and its relation with LH characteristics were recorded. After developing this protocol in mithun, in the next step we went for fixed time artificial insemination following synchronization. Initially, a total of 16 animals were inseminated artificially (AI) with the cryopreserved mithun semen, 12 cows were conceived (Mondal *et al.,* 2014; unpublished data).

c) Estrus synchronization using CIDR

Experiments were conducted to synchronize estrus using CIDR in cyclic and post-partum mithun cows. In both categories of animal, synchronized estrus using CIDR showed more prominent behavioural signs of estrus than spontaneous heat. More interestingly, application of CIDR on day 45-50 after parturition induced first postpartum estrus immediately after uterine involution (day 53-58 post parturition). Unlike other bovine, mithun cows exhibit first postpartum estrus at around day 102±19.6 postpartum. Use of CIDR is therefore advantageous in terms of a) prominent behavioural signs of estrus thus ease detection of estrus and b) increased productive life span of around 50 days (Mondal *et al.,* 2014; unpublished data).

Multiple ovulation and embryo transfer (MOET)

Superovulatory treatments are widely used in embryo transfer programs to increase the supply of embryos from animals of superior genetic merit. Mithuns suffer from many inherent reproductive problems and these problems coupled with poor production potential due to high inbreeding depression are making mithun husbandry less profitable and accounting for rapid dwindling of mithun population. Through successful application of multiple ovulation and embryo transfer program many problems of mithun reproduction could be solved by faster multiplication of superior germplasm, reducing inbreeding depression by disseminating superior quality male germplasm to mithun pockets and by conserving mithun germplasm pertaining to ex-situ conservation procedure.

Superovulation and embryo transfer technology (ETT) has been standardized for mithun. The first mithun calf, Bharat, was born through embryo transfer technology in 2012 at National Research Centre on Mithun, Nagaland, India. Cryopreservation of mithun embryos has also been standardized. Mohan, the first mithun calf was born from transfer of a 100-day old cryopreserved embryo in 2012 at National Research Centre on Mithun, Nagaland, India (Mondal *et al.,* 2014; unpublished data).

CONCLUSIONS

International Union for Conservation of Nature and Natural species (IUCN, 2000) has categorized mithun (*Bos frontalis*) as the most “vulnerable” facing extinction. It is therefore, the responsibility of the scientific community to save this precious species of Asian origin before being extinct from the nature. As the concept of mithun husbandry is still in developing stage in almost all the mithun rearing areas of our country, more emphasis should be given on scientific rearing of mithun using modern biotechnological tools beginning with application of reproductive biotechniques, feed technology to use of modern technologies of diagnosis of disease at very early stage to exploit the production potential of this unique

species, which can ultimately cater the nutritional needs of poor tribal people of hilly areas of mithun inhabited countries in a sustainable way. Modern biotechnological tools as described herein may be used extensively to increase productivity of livestock in general and mithun in particular.

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Original Article

Evaluation of Carcass Characteristics and Meat Quality of Indigenous Fowl Ecotypes and Exotic Broiler Strains Raised Under Hot Climate

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ABSTRACT

This study was conducted to investigate the influence of genotype on growth performance, carcass characteristics and meat chemical composition traits of chickens under hot climatic conditions. Two exotic meat strains (Hybro and Hubbard) and three Sudanese native chicken ecotypes (Bare- neck, Large Baladi and Betwil) were used for this purpose. Data were analyzed using General linear model (GLM) of SAS (2007). Results revealed that genotype had significant (P<0.01) effect on traits studied, with the exotic strains exhibited higher average values for live body weight, eviscerated carcass, dressing percentage and carcass cuts percentages. On the other hand the native chicken ecotypes showed higher relative values for back, wings, visceral organs and feather. Chemical composition results were variable, with the highest levels of Protein and ether extract recorded for the exotic meat strain, Hybro and the lowest were recorded for the native chicken, Bare-neck. Moreover, significant differences (P< 0.01) among genotypes were observed for shank weight and shank length, with Hubbard being the highest and Large Beladi and Betwil being the lowest for shank weight and shank length respectively. Among the native chicken ecotypes, Bare-neck had the lowest relative feather weight indicating the effect of Na gene in reducing feather coverage around the body.

Keywords: Carcass Characteristics, Exotic Strain, Indigenous Chicken, Meat Quality, Hot Climate.

INTRODUCTION

Chicken comprises the major constituent of poultry species in Africa. Despite the wide spread of exotic strains, local chickens are known to be predominant in developing countries (FAO, 2004; Do, 2005; Bett *et al*., 2012). They play an important role in the economic development of rural communities and they are known to be relatively resistant to some infectious diseases, good converters of poor quality feeds and have products that are preferred by consumers (Mengesha, 2012). In villages and rural communities of the Sudan almost every

family owns a few numbers of chickens to satisfy their needs for eggs and meat. Desai **(**1962**)** described and classified local chickens of Sudan into main three ecotypes, Large Beladi, Bare neck and Betwil (dwarf). Large Beladi is considered as the most common ecotype which found almost everywhere in villages and town dwellings, with body weight at 8 weeks of age ranges from, 476 to 271.8 g **(**Yousif and Osman, 1994; Yousif *et al*., 2006; Yousif *et al*., 2010).

Several studies had been carried out to investigate the effect of high ambient temperature on the performance of exotic commercial broiler strains and to compare them with the indigenous breeds under tropical conditions (Tibin and Mohamed, 1990; Timothy *et al.,* 2003; Hassan *et al*., 2006; Munira *et al*., 2006). The results confirmed that exotic strains had superior performance when compared with indigenous breeds despite the negative impact of hot climate on exotic strains. However, Jaturasitha *et al*. (2008) found no clear differences in dressing percentage and in retail cuts obtained for Thialand local breed and exotic chickens. On the other hand, Castellini *et al*. (2002) reported that dressing percentage of the Italian breed (Padovana) was slightly lower than that reported for commercial broiler. In Sudan the history of importing the exotic temperate chicken breeds dates back to 1926 when a British Veterinarian introduced Wyandotte breed and distributed its fertilized eggs for incubation aiming at improving poultry production. Recently several new commercial strains are introduced to the country and consequently large scale poultry projects have been established to satisfy the increasing demand for poultry products. However, more research efforts are needed to evaluate genotype × environment interactions and to compare these modern strains with the native breeds under different managerial conditions. Therefore, the objective of this study was to evaluate the performance, carcass characteristics and meat quality of the exotic broiler strains in comparison with the local chicken ecotypes under hot climate of the Sudan.

MATERIALS AND METHODS

Experimental Site

This experiment was conducted at the poultry house of the Faculty of Animal Production, University of Khartoum, Sudan. The lowest and the highest average ambient temperature during the experimental period were 22° C and 44° C respectively.

Collection and Incubation of Experimental Eggs

Fertile eggs of the native chicken ecotypes, Bare- neck (BN) and Betwil (BT) were collected from the Indigenous Chicken Research Unit (ICRU) at the Faculty of Animal Production, University of Khartoum, whereas the Large Beladi ecotype eggs were obtained from an experimental stock at the Faculty of Agriculture, Omdurman Islamic University. The exotic strains (Hybro and Hubbard) eggs were obtained from Arab Poultry Breeders Company (OMMAT) farm which located 40 miles west Omdurman city. Eggs were transported to the Hatchery Unit at the Faculty of Animal Production, University of Khartoum by a car with cooling system. An automatic turning device incubator (Funki model) with capacity of 4608 eggs was used for eggs incubation. Throughout the incubation period, temperature inside the incubator was adjusted to 99-100^0 F and the relative humidity was kept at 60-65% using moisture trays allocated at the bottom of the hatchery. In the 15th day of incubation candling of the incubated eggs was practiced to determine fertility and early and late embryonic deaths. Later in the 18th day of incubation eggs of each strain or ecotype were set separately in hatchery trays, fumigated using 30g. potassium permanganate and 90 ml. formaldehyde solutions and then transferred to the hatching unit below the same incubator. Humidity was raised substantially to facilitate eggs hatching. In the morning of the 22nd day of incubation the hatched chicks were released, graded, weighed, wing banded, and transferred to brooders. A total of 516 one -day old chicks (105 Hybro, 105 Hubbard, 102 Bare- necks, 129 Large Baladi and 75 Betwil) were obtained and reared up to eight weeks of age.

Brooding and Rearing Management

Before chick's arrival, brooders were cleaned, incinerated and disinfected using potassium permanganate and formaldehyde solution in a ratio of 1g: 2ml. Each brooder (3.5 ×3.0×3.0 m dimensions) was divided internally into 8 brooder units and covered with 5 inches depth wooden shaving litter. Chicks were placed randomly in brooders (10-15 chicks/genotype/ brooder unit), thus representing a complete randomized design (CRD) with 9 replicates. A starter ration containing 24.1% CP and 3123 K cal/kg ME was provided *ad- libitum* (table 1). Vitamins and minerals were added to drinking water at weekly interval. Chicks were vaccinated against New Castle disease at first and third weeks of age, whereas Gumboro vaccine was administered at the second weeks of age. At the end of the 4th week of age, chicks were transferred to an open sided poultry house (10×4×3 m dimensions) which divided internally into 15 pen units. Each pen unit was covered with 5 inches depth wooden shaving litter and equipped with cleaned and disinfected feeders and drinkers. Finisher ration containing 21.4% CP and 3180 K cal /kg ME was provided *ad-libitum* during the second 4 weeks of age. Artificial light was provided continuously throughout the experimental period using 100- watt bulbs lams. Experimental birds were reared and treated in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Table 1: formulation of starter and finisher ration

Ingredients	Starter %	Finisher %
Sorghum	58	63.23
Groundnut meal	19	15
Sesame meal	14.03	12.3
Super concentrate	5	5
Dcal	1	1
Oyster shell	1.5	1.5
Nacl	0.3	0.3
Lysine	0.1	0.1
Meth.	0.07	0.07
V. oil	1	1.5
Total	100	100

Chemical Composition of starter and finisher ration

Constituents	Starter ration Amounts	Finisher ration Amounts
Crude protein %	24.12	21.35
ME (K cal/ kg)	3123	3180
Dry matter %	93.14	93.46
Ether extract	7.40	7.39
Ash %	7.29	8.35

*Broiler concentrate 5 % Hendrix contains : crude protein 40%; crude fiber,4.52%; fat 5.20%; Ash, 3.20%; M.E. 2200; kcal/kg lysine 8.75%; Methionine, 1.6% spp. Methionine + cystine 2.0%; calcium 7.6%; phosphorus (av.) 4.8%.
Source: AOAC 1990
*ME = Metabolizable energy.

Carcass Processing and Data Recording

At the end of the 8th week birds were weighed individually after an overnight fasting (except from water), slaughtered, scalded in hot water at temperature of 53^{o} C for 2 minutes and de-feathered by hand picking. For each bird feather was weighed after being dried for 24 hours using sun ray during the day. Head and shanks were removed close to the scull and at the hock joints respectively and weighted whereas shanks lengths were measured using robber

metric. Evisceration was accomplished by posterior ventral cut, thus a complete removal and weighing of the visceral organs. Abdominal fat including fat surrounding the gizzard and leaf fat was carefully removed using forceps and weighted. Hot carcass (HC) weight (without neck) was recorded individually and then all carcasses were chilled in chilling refrigerator at 4^oC for 24 hours. In the morning of the next day the carcasses were taken out from the refrigerator, allowed 4 hours thawing at room temperature and weighed individually to determine the cold carcass (CC) weight. Each carcass was dissected into different cuts including breast (BR), drumstick (DR), thigh (TH), and back (BK). The sum of the drumstick and thigh comprised the leg (LG). Carcass cuts were recorded as percentages of CC whereas HC, feather, shank and visceral organs were expressed as proportions of live body weight. Carcass cuts were kept in a freezer under -10^o C for one day before processing.

Chemical Composition Analysis

In the next day the frozen meat from breast and thigh of each strain or ecotype was thawed in a refrigerator at temperature of 4^o C for 24 hours, minced, mixed, and then random samples were taken for chemical analysis. Moisture, protein, ash and fat contents were determined according to AOAC (1990)**.** Six replicates were done for each parameter. The moisture was determined by weighing meat sample, dried in an oven at 100^o C for 18 hours, and then moisture percentage was calculated as: **(Loss in weight ÷sample weight)×100**

Protein percentage was determined by Kjeldahl method. For ash determination, 5 g. of meat sample was dried in a weighed crucible and placed inside muffle furnace at 150^o C, thereafter temperature was increased gradually up to 600^o C. The sample was heated at this temperature for 3 hours before the crucible was taken out, cooled and weighted. Percentage ash was calculated as :**(Crucible weight with incinerated ash - empty crucible weight) ÷ Sample weight × 100**

Crude fat was determined by extracting fat serum from a meat sample for 6 hours using petroleum ether. After extraction the ether petroleum was evaporated in an extraction flask by using a rotary evaporator, the flask was then dried at 100^o C for 30 minutes, cooled and weighted. Crude fat percentage was determined as**: (Fat weight ÷ sample weight) × 100**

Statistical Analysis

Data sets consisted of 498 observations were subjected to statistical analysis using the General Linear Model (GLM) of the Statistical Analysis System (SAS, 2007**)**. Differences among genotype means were compared by Duncan's Multiple Range (DMR) test.

RESULTS AND DISCUSSIONS

In this experiment, the results showed that exotic meat strains, Hybro and Hubbard had significantly ($P<0.01$) higher average values for growth, carcass weight, dressing percentage and carcass cuts percentages (breast, thigh and drumstick) in comparison with the local chicken ecotypes, Bare-neck, Large Beladi and Betwil (Table 2). These are in agreement with the previous studies conducted by Chhabrad and Sapra (1973); Sharma *et al*. (1971); Tibin and Mohamed (1990) ; Hassan *et al*. (2006)**.** However in contrast with the present result, Franco *et al*. (2012) in their work with the native Mos rooster and the hybrid Sasso T-44 concluded that although live weight and carcass weight were higher in the hybrid line, Mos breed had a significantly higher percentage of edible products than Sasso T-44. This was also confirmed by Rizzi *et al*. (2007) who found that at 44 week of age, 2 Italian dual-purpose breed had significantly heavier breasts, thighs, and drumsticks than hybrid hens. In this study, although Hubbard exhibited higher dressing percentage than Hybro, the two strains showed similar results for breast, drumstick and leg. As proportion of hot carcass, abdominal fat of the exotic strains was significantly higher than the local chicken ecotypes. Excessive fat deposition in commercial broiler strains is undesirable for consumers because it is considered as waste and tedious in processing in addition to the fact that it is associated with heart

problems. Furthermore, the native chicken ecotypes showed higher wing, back and visceral organs percentages than the exotic strains. The higher percentages of the less valued carcass parts (wings, back and neck) and the non edible portions (visceral organs, feather, heads and shanks) may reflect the fact that native chickens are genetically unimproved, therefore the proportion of the highly valued edible carcass cuts (breast, thigh and leg) is relatively low. On the other hand, significant differences ($P < 0.01$) were observed among the local ecotypes, Bare-neck, Large Beladi and Betwil for live weight, drumstick and back percentages. This variation indicates that selection for increased body weight and carcass characteristics among the indigenous chickens is possible.

Table 2: Average hot and cold carcass weights, dressing percentage and carcass cuts percentages of the exotic strains and native chicken ecotypes

Trait	Hybro Means ± SD	Hubbard Means ±SD	Bare- neck Means ± SD	Large Beladi Means ± SD	Betwil Means ± SD
BW	1273^{a} ± 232	1268 ^{a}± 244	349 ^{b}±57.6	287^{c} ± 59.3	301^{bc} ±70.6
HCW	910^{a} ± 243	970^{a} ± 279	189^{b}± 57.6	153^{b} ± 35.0	163^{b} ±40.1
HC%	71.5	76.5	54.1	53.2	54.1
CCW	852^{a}± 166	842^{a}± 173	175^{b}± 38.9	144^{b}± 37.2	152^{b}± 36.7
CC %	66.9	66.4	50.3	50.3	50.6
Breast %	27.3^{a} ± 3.60	27.2^{a} ± 3.80	22.7^{b} ± 3.4	23.7^{b} ± 3.2	23.1^{b} ± 3.6
Drumstick%	16.1 ^{a}± 1.40	16.1^{a} ± 2.90	16.1^{a} ± 1.3	15.4 ^{b}± 1.1	15.4^{b}± 1.6
Thigh %	18.9^{a} ± 2.20	18.6 ^{a}± 2.60	16.9^{b} ± 1.4	17.4^{b} ± 1.3	17.0^{b} ± 1.8
Leg %	35.0	34.7	33.0	32.8	32.4
Back %	23.5^{c} ± 2.20	23.8^{c} ± 3.20	26.8 ^{ab}± 3.3	25.2^{b} ± 3.9	27.3^{a} ± 3.6
AF %	2.30	2.40	1.30	1.10	2.00
Wings %	14.1 ^{b}± 1.30	13.7 ^{b}± 1.20	17.5^{a} ± 1.90	17.5 ^{a}± 1.80	17.1^{a} ± 1.60

*Means with the same super script letter in a row are not significantly different; while means with different super script letter in a row are significantly different (P< 0.01).
BW= Live body weight, HCW= Hot carcass weight, CCW= Cold carcass weight
HC and CC % are calculated as proportion of BW, Carcass cuts % are calculated as proportion of CCW, AF % is calculated as proportion of HCW.

The average weights of visceral organs, shank and feather weights and shank length of the exotic and local birds are presented in table 3. The results showed that there were significant differences ($P < 0.01$) among genotypes.

Table 3: Carcass evisceration, shank and feather weights (g) and shank length (cm) of exotic strains and native chicken ecotypes

Trait	Hybro Means ± SD	Hubbard Means ±SD	Bare- neck Means ± SD	Large Beladi Means ± SD	Betwil Means ± SD
LW	1273^{a} ± 232	1268^{a}± 244	349^{b}±57.6	287^{c} ± 59.3	301^{bc} ± 70.6
Head	36.5^{a} ± 5.50	36.2^{a} ±7.70	17.7^{b} ± 2.50	15.9^{c} ± 2.50	16.2^{bc} ± 2.60
Neck	70.3^{a} ± 13.2	69.6^{a} ± 18.3	18.9^{b} ± 4.50	16.9^{b} ± 4.7	17.9^{b} ± 5.10
SW	62.2^{a} ± 12.0	63.2 ^{a}± 15.2	18.8^{b} ± 4.90	14.4^{c} ± 3.60	14.9^{c} ± 3.90
Spleen	1.10^{a} ± 0.60	1.10 ^{a} ± 0.70	0.80^{ab} ± 0.40	0.60^{b}±0.30	0.70^{ab} ± 0.30
Liver	26.3^{a} ± 6.60	27.2^{a} ± 6.80	8.90 ^{b} ± 1.80	7.40^{c} ±1.06	7.40^{c} ± 1.90
Heart	6.80 ^{a} ± 3.30	7.60 ^{a} ± 6.40	1.90^{b} ± 0.80	1.60^{b} ± 0.50	1.70 ^{b} ± 0.50
Gizzard	27.9^{a} ± 6.40	26.5^{a} ± 8.60	16.7^{b} ± 5.20	12.2^{c} ± 2.30	13.5^{c} ± 3.10
Intestine	67.3 ^{a}± 14.5	65.6^{a} ±13.8	28.7^{b} ±5.60	23.2^{c} ± 5.0	21.6 ^{c} ± 4.40
AF	21.1^{a} ± 12.0	23.0 ^{a}± 9.92	2.4$^{\mathbf{b}}$ ±2.30	1.7^{b} ± 1.5	3.20 ^{b} ±1.90
Feather	30.7^{a} ± 8.10	29.7^{a} ± 8.70	14.3^{b} ±3.30	13.5^{b} ±3.2	15.1$^{\mathbf{b}}$ ± 4.60
SL	5.50^{a} ± 0.60	5.30^{b} ± 0.60	4.30^{c} ± 0.50	3.90^{d} ±0.6	3.50^{e} ± 0.60

*Means with the same super script letter in a row are not significantly different; while means with different super script letter in a row are significantly different (P< 0.01).
LW= Live Weight, SW= Shank Weight, AF= Abdominal Fat, SL = Shank Length

Feather weight expressed as percentage of body weight was significantly higher in the native chickens compared to the exotic strains. In tropical area low feather density is favorable because it helps in heat dissipation. Among the native chicken ecotypes, the lowest feather percentage was recorded for the Bare-neck chicken; this may express the effect of the Na gene which tends to reduce the whole feather coverage weight percentage in the neck and breast areas by about 20-40% as compared to normal feather chicken (Yalcin *et al*., 1997). Comparing the exotic strains, there were no significant differences between Hybro and Hubbard for all visceral organs examined. Similar results were also obtained for the native chickens.

Table 4 shows the meat chemical composition of the exotic and native chickens. Significant differences ($P < 0.01$) among genotypes were reported. The highest crude protein and ether percentages were reported for the exotic, Hybro and lowest were found for the native Betwel and Large Beladi chickens respectively. These results are in accordance with those found by Tibin and Mohamed (1990) and Ganabadi *et al*. (2009)**.** Moreover, the highest and the lowest moisture content was found in the native Betwil and Bare-neck respectively. However Zhao *et al*. (2009) reported higher moisture and protein contents in Beijing-You, a Chinese non improved line than in Arbor Acores, a distinct commercial line.

Table 4: Chemical composition traits of the exotic strains and native chicken ecotypes

Trait (%)	Hybro Means ± SD	Hubbard Means ±SD	Bare- neck Means ± SD	Large Baladi Means ± SD	Betwil Means ± SD
Moisture	75.5^{b} ± 0.60	75.6^{b} ± 0.40	74.5^{c} ± 0.70	75.6^{b}±0.70	76.5^{a} ± 0.20
Ash	1.20^{b}± 0.60	1.30^{a} ± 0.10	1.10^{b} ± 0.10	1.30^{a} ±0.10	1.10^{b} ± 0.80
C.P	22.7^{a} ± 0.10	22.5^{ab}±0.20	21.3^{c} ± 0.20	21.5^{c}±0.30	22.2^{b} ± 0.50
E.E.	2.30^{a} ± 0.10	2.00^{b} ±0.40	2.00^{b} ± 0.20	1.50^{c} ±0.10	2.00^{b} ± 0.10

*Means with the same super script letter in a row are not significantly different; while means with different super script letter in a row are significantly different (P< 0.01).
CP = Crud Protein
EE = Ether Extract

CONCLUSIONS

In conclusion genotype affected significantly the performance, carcass characteristics and meat quality of chickens reared under hot climate. Exotic commercial strains seemed to be affected negatively by high ambient temperature even though their performance was higher than that of the native chickens which are more tolerant to harsh management. Phenotypic variations among the native ecotypes indicate that selection procedures can be applied to improve their performance and meat quality.

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Original Article

Growth Performance of Indigenous Guinea Fowls Fed Varied Levels of Boiled Mango Kernel Meal

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ABSTRACT

A study was conducted to determine effects of varied levels of boiled mango kernel meal (BMKM) as a replacement for maize on growth performance of local guinea fowls. The BMKM was obtained by cutting the seed open with knife and the mango kernel chopped into pieces, boiled at 100^{o}C for 30 minutes and sun-dried for 72 hours. One hundred and twenty, 28-day old local guinea keets of similar live weights (118g ± 2g/bird) were randomly allotted to 4 dietary treatments containing 3 replicates of 10 birds each. The BMKM replaced maize at inclusion levels of 0% (control), 10%, 15% and 20%, respectively. Clean water was provided *ad-libitum*. Data were collected on mean feed intake, final live weight, daily weight gain, feed conversion efficiency (FCE), feed cost per kg gain and analyzed using ANOVA by GENSTATS (3rd Edition). There were no significant differences (P>0.05) in mean feed intake, final live-weight, daily weight gain, FCE, feed cost per kg and feed cost per gain between birds fed the control diets and diets containing BMKM. There was no significant differences (P>0.05) in mortality of birds on the various treatments. It was concluded that boiled mango kernel meal could replace maize up to 20% in the diet of local guinea fowls without any adverse effects on growth.

Keywords: Indigenous guinea fowl, growth performance, mango kernel meal, boiled, replacement.

INTRODUCTION

Poultry production is an important part of the daily life of man, especially of the rural farmers where poultry are raised for several purposes such as offering considerable dietary animal protein supply for human growth (Kondombo *et al.,* 2003). Some of these poultry species include turkey, domestic fowl, duck, peafowl, Japanese quill, pigeon, ostrich and guinea fowl (Payne, 1990). One of the greatest challenges facing the livestock industry in developing countries is the provision of nutritionally balanced and cost-effective rations, since feed constitutes about 65%-80% of the total cost of production (Durunna *et al*., 2000). Hence it is necessary to look for locally available, cheap, safe and nutritionally adequate substitutes for maize in poultry feeding. Lots of feeding trials involving cheap locally available feed

ingredients have been conducted with the aim of solving or reducing high feed costs. Such feeds include blood meal (Donkoh *et al.*, 1999), oilseed cakes (Kocher, 2002),mucuna beans (Sarfo, 2004), false yam tuber (Dei *et al., 2011)* and mango seed kernel (Diarra and Usman, 2008).

Mango kernel, a by-product of mango pulp is reported to be a good source of soluble carbohydrates (Diarra and Usman, 2008). The protein of the kernel (7.8 – 8.0%) is comparable to that of maize but it has higher fat (7.8 - 9.0%) than maize (Jadhav and Siddiqui, 2010). In India, mango kernel is consumed by human beings in the form of porridge (Saadany, 1980) but in Ghana, it is regarded as waste thus contributing to environmental pollution. The high carbohydrate content (Ravindran and Blair, 1991) and high-quality proteins of the seed kernels (Augustine and Ling, 1987) could therefore be exploited using poultry, which are the most efficient converters of raw ingredients such as starches, sugars and proteins into meat and egg products (Adegbola, 1990). There are few reports on the use of mango kernel in livestock feeding but the level of inclusion in poultry diets has been low because of the presence of tannins which exerts anti-nutritive effects that reduce chick growth (Teguia, 1995).

However, boiling has been reported to be an effective method of tannin reduction. Boiling reduced up to 53% tannin in African oil bean (Ugherughe and Ekedolun, 1986) and about 55% tannin in mango kernel (Diarra and Usman, 2008). Because of the abundant accessibility and cheap cost of mango kernel, it would be interesting to investigate the effect of inclusion of mango kernel in poultry diets. This study was therefore undertaken to determine the effect of dietary boiled mango kernel meal (BMKM) on local guinea fowl growth performance and to assess the cost effectiveness of using BMKM as a feed ingredient.

MATERIALS AND METHODS

Location of experimental site

The trial was undertaken at the Poultry Section of the Department of Animal Science, University for Development Studies, Nyankpala Campus, and Tamale between August 2011 to November 2011. Nyankpala is located about 16km West of Tamale and lies on latitude 9^{o} $25^{'}$ $41^{''}$North and longitude 0^{o} $58^{'}$ 42'' West in the Guinea Savanna zone. It has an average annual rainfall of 1034.4mm. Mean annual daytime humidity is 54% with relative humidity usually high in the morning and low at night. Annual temperature is 28.3^{o}C (SARI, 2004). The study area is characterized by low, seasonal, uni-modal and poorly distributed rainfall. The dry season lasts for about six to seven months.

Sources and processing of Boiled Mango Kernel meal

Mango seeds were collected by both women and children during the month of May (peak of the mango season in Nyankpala). The kernel was obtained by cutting the seed open with knife. The fresh kernel was chopped to reduce the particle size andthen boiled in a metal pot with tap water at 100^{o}C for 30 minutes, followed by sun-drying on a clean cemented floorfor 72 hours. The dried kernel was ground in a grinding mill and labeled as BMKM (i.e. Boiled Mango Kernel meal).

Experimental diets

Four dietary treatments were formulated for the experiment (Table 1) with reference to Diarra *et al*. (2010). Diet 1 which was the control contained no BMKM (i.e. 0%). In diets 2, 3 and 4, BMKM replaced maize at 10, 15 and 20% respectively. The BMKM replaced maize on weight by weight basis on the assumption that they have similar nutrient composition, since the BMKM was not analyzed for its nutrient composition due to logistic constraints.

Table 1: Percentage composition of experimental diets

Ingredients	Replacement level of boiled mango meal for maize (%)			
	0.00	**10.00**	**15.00**	**20.00**
Maize	54.70	49.23	46.49	43.76
Boiled mango kernel meal	0.00	5.47	8.21	10.94
Broiler starter concentrate	11.00	11.00	11.00	11.00
Soybean meal	22.30	22.30	22.30	22.30
Wheat bran	10.00	10.00	10.00	10.00
Di-calcium PO_4	0.50	0.50	0.50	0.50
Oyster shell	1.00	1.00	1.00	1.00
Vitamin/ Trace mineral premix*	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Calculated Nutrients Analysis				
Crude protein %	19.63	19.56	19.52	19.48
Gross energy (MJ/kg)	11.19	11.22	11.23	11.25

*Composition of vitamin and trace mineral premix per kg diet; vitamin A,8000000IU; vitamin D3,1500000; vitamin E, 2500mg; K3, 1000mg; vitamin B2, 2000mg; vitamin B12, 5mg; Folic acid, 500mg; Nicotinic Acid, 8000mg; Calcium panthotenate, 2000mg; choline cloruro, 50000mg; Zn, 40000mg; Cu, 4500mg; Co, 100mg; I, 1100mg; Se, 100mg.

Experimental birds, design and their management

A total of 120, 28 day-old guinea keets of similar weight (mean live weight was 116g per bird) were weighed and randomly allotted to 4 treatments containing 3 replicates each, with 10 birds per replicate. The birds were housedin a raised floor pen with wire mesh. Birds in each replicate were confined in a cage of size 2.3m×1.25m×1.8m with a floor space of $0.287m^2$ per bird. Rice husk was used as a bedding material which was spread to a depth of about 0.6cm.Feed for birds were provided in wooden feeding troughs in the morning and evening. Clean fresh water was provided *ad-libitum* in plastic watering troughs throughout the experiment. Coccidiostat (Amprolin-300 ws powder) was administered orally at 5g/10L of water for 3 consecutive days as well as antibiotics (Aliserylws powder) at 5g/10L of water for 4-5 days respectively as and when necessary. Birds were also dewormed once every month with *Piperazine* at 5g/10L water. Biosecurity measures in the poultry house were ensured by using disinfectant (Izal) for cleaning and as footbath. Six (100w) white incandescent electric bulbs were provided as a source of light throughout the experiment to promote feeding particularly during the night. Data was taken every week from the 5^{th} to 15^{th} week of age.

Parameters measured

The parameters measured were feed intake, weight gain, final live weight, FCE (gain/feed), mortality and feed cost. Feed intake were measured weekly using an electronic weighing scale (Jadever JPS-1050). Feed consumption per replicate per week was obtained by subtracting feed left over at the end of every week from the total feed supplied for the week. Mean feed consumption per bird per day was obtained by dividing feed consumed by the number of birds in each replicate and number of days in a week. Weight gain was taken on weekly basis using an electronic weighing scale (Jadever JPS-1050). The calculation of mean weight gain per bird per day was done by dividing the weight gained by the number of birds in each replicate and number of days in a week. Final live-weight was measured at the end of the 11th week of age. The mean final live weight per bird was obtained by total weight of birds by the number of birds per replicate. Feed conversion efficiency (Gain/ Feed ratio) was calculated by dividing the weight gain in the week per bird per day, by the feed intake in the week per bird per day for each replicate. Deaths were recorded as they occurred. Dead birds were sent for post mortem examination by the veterinary technical officer of the school.

Feed cost was obtained as follows:

The quantity of each ingredient needed to formulate a 100 kg feed was multiplied by their unit prices to give the cost of a 100 kg feed. This was divided by 100 kg to give the unit cost of each diet. The unit cost of each diet was multiplied by the total feed consumed per bird to

obtain feed cost per bird. Feed cost per kg gain was determined by dividing the feed consumed per bird by the total live weight gain. This total live weight gain was determined by subtracting the initial live weight of the bird from its final live weight.

RESULTS

Growth Performance

A summary of the performance data of local guinea fowls fed varied levels of BMKM is shown in Table 2.The average daily feed intake was not significantly different (P>0.05) for birds on the control diet (0%BMKM) and the other diets.

Table 2: Effect of varying levels of BMKM on feed intake, weight gain, gain/feed ratio, final live-weight and mortality of local guinea fowls during the growth phase (5-15weeks of age)

Parameters	Levels of BMKM				ANOVA	
	0%	10%	15%	20%	±S.E.D	P- value
Average daily feed intake (g/bird)	52.6	51.0	55.3	54.2	3.88	0.709
Average daily live- weight gain (g/bird)	9.47	9.00	8.41	7.52	0.685	0.081
Gain/Feed	0.180	0.177	0.147	0.140	0.0167	0.095
Final live-weight at 15 weeks (kg/bird)	0.870	0.830	0.777	0.713	0.049	0.059
Mortality	1.67	1.33	2.00	1.67	0.408	0.487

S.E.D = Standard Error of Difference; P = Probability

Numerically, mean feed intake increased for birds on BMKM-based diets increased from 10 to 20% as compared to birds fed with 0% BMKM. Mean weight gain did not vary significantly (P>0.05) between the control fed birds and the birds on test diets and within the treatment groups. Average weight gain of the birds on control diet was numerically similar to birds fed 10% BMKM test diet but slightly lower in birds fed 15% and 20% BMKM. There was no significant difference (P>0.05) in FCE, although less feed intake but better feed conversion efficiency were recorded for birds in fed 10%BMKM as compared to their counterparts fed the other diets. There was no significant difference (P>0.05) between control and the other treatments groups. Final live-weight of birds on control diet tended to be similar to that of birds fed 10% BMKM test diet but slightly lower in birds fed 15% and 20% BMKM.As shown in Table 3, feed cost per kg in all treatment diets was similar with slight increase in feed cost per bird of the BMKM-based diets except for those on 10% which was equivalent to those on 0% BMKM. From the experiments a total of 20 birds (5, 4, 6 and 5 birds in T0, T1, T2 and T3 respectively) died.

Table 3: Cost-benefit analysis of BMKM-based and control diets on guinea fowls performance

Parameters	Levels of BMKM				ANOVA	
	0%	10%	15%	20%	±S.E.D	P- value
Feed cost per kg (GH/kg)	0.99	0.98	0.97	0.96	-	-
Total feed consumed (kg/bird)	4.05	3.9	4.26	4.17	0.299	0.709
Total feed cost (GH/bird)	4.03	3.84	4.14	4.02	0.293	0.796
Feed cost per kg weight gain (GH)	4.63	4.63	5.35	5.70	0.511	0.162

S.E.D = Standard Error of Difference; P = Probability

DISCUSSION

Feed intake

The present report on feed intake, agrees with the observation of Diarra *et al.* (2010) who observed no significant differences (P>0.05) in daily feed intake in broiler chickens fed graded levels of boiled mango kernel meal as a replacement for maize. This suggests that the combination of boiling and sun drying could be suitably employed to prepare mango kernel

meal for inclusion in diets for guinea fowls. The similarity in the consumption of the feed between birds fed control diet and the BMKM indicated that, boiling might have reduced the anti-nutritional factors in the kernel thereby making the feed palatable.

Growth Performance

Weight gain

Although the birds on the different dietary treatments consumed similar amounts of feed, live-weight gains of guinea fowls fed 0% and 10% BMKM in absolute term were slightly higher than those fed the diets containing 15% and20% BMKM. It was expected that consumption of similar amount of feed by the birds would have yielded similar live-weight gains. The lower live-weight gain of birds on the 15% and 20% replacement diets could be due to the fact that, the tannin content in the mango kernel of these diets may be above the threshold of 0.30% that can be tolerated by chicks as reported by Jansman *et al.* (1989). This might be associated with the residual tannins present in the BMKM since boiling did not completely remove the tannins. The findings of this experiment on weight gain agrees with Douglas *et al*., (1993) who reported that, increasing dietary tannins significantly reduced weight gain in young turkeys while there were no adverse of tannins on performance once the turkeys were 57 days old or older. Jansman (1993) reported that addition of tannins to the diet can lead to a lower apparent digestibility of crude protein and to a lesser extent, energy. Thus the lower growth rate, though insignificant, observed for birds on 15% and 20% BMKM diets might be caused by a reduced amount of protein and other nutrients available for growth.

Feed conversion efficiency and mortality

In numerical terms, feed conversion efficiency value obtained for birds fed the control diet was higher compared to those obtained for birds on the BMKM diets. This was expected as the BMKM diets contain some tannin as reported earlier on (Jansman, 1993) impairs feed conversion efficiency. Mortalities were not traceable to any dietary effect but were reported to be internal hemorrhage in the skull of the birds due to an electric shock that occurred during repair of some electrical fittings in the pen.

Economic evaluation

The costs per kilogram of feed for the formulated diets are shown in Table 3. Even though the Mango Seed Kernels were (MSK) obtained free of charge from the market grounds of Nyankpala, it was assigned a value of GH 0.30 (i.e. $0.078) per kg being the cost incurred in collecting the mango seed kernel plus cost incurred in producing the meal. The reduction in the cost of the feed with the increase in the level of mango kernel was due to the relatively cheaper price of MSK compared to maize (GH 0.70 per kg) (i. e. $ 0.182) at the time of the experiment. However, the cost of feed to produce a kg of bird on the 10% was equivalent to those on 0% BMKM and lower than those on 15% and 20% BMKM. Hence the use of the BMKM was economical.

CONCLUSION AND RECOMMENDATION

Based on the results of the present study, BMKM could be included in the diets of local guinea fowls up to 20% during the growth phase without any adverse effects on performance. The use of the BMKM-based diet was economical in guinea fowl production. Further study should be conducted to determine the effect of soaking the mango kernel prior to boiling since soaking has been shown to reduce concentrations of tannins.

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Original Article

Determine of Some Macro Minerals Potassium and Phosphors in the Blood Serum of Goats Grazing At El-Khuwei Locality, West Kordofan State, Sudan

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ABSTRACT

The main objective was to determine macro minerals of potassium and phosphors in the blood serum of goats grazing at flowering and seed setting stage during 2011 in El-khuwei locality, west Kordofan, Sudan. A completely randomized design was used (CRD). Sampling was done on two stages at flowering and seed setting in selected locations (2 km^2). Within each stage 60 goats randomly selected, randomly collected samples of blood serum. Stages had significant ($P< 0.0001$) effect on blood serum of goats was highly K (5.10-3.88 mmol/L) concentration at flowering stage and least during the seed setting stage respectively**.** Concentration of P (2.96-3.94mg/dl) were decreased at flowering stage and increased at seed setting stage respectively. It can be concluded that at the flowering stage highly potassium concentration and decreased phosphors concentration. However during the seed setting stage least potassium concentration and increased phosphors concentration.

Key words: Stages, serum, potassium and phosphors.

INTRODUCTION

Minerals are very important in animal feed, Phosphorus, calcium and potassium play a major role in the life of animals (Abdelhameed, 2000). The physiological role of phosphorus is very important in bones and teeth formation 80% of the phosphorus presented in bones. Moreover phosphorus is very essential for glucose and glycerol absorption, urine formation, metabolism of carbohydrates and protein and molecular fodder crops protein (DNA) which includes (ATP). In addition phosphorus helps in (pH) regulation of the body (Tukrori, 1989). Sabir (2005) mentioned that, deficiency of potassium leads to weak muscles and bones and hormonal defects which appeared in extra secretion of adrenal gland, loss of appetite and

botulism, also the animals eats bones and stones. Furthermore hypopottasia leads to general debility weakness and infertility, that hypo potassium leads to renal shrinkage, blocking heart muscles, hypo blood pressure, acute diarrhea, reduction of gastric juice, Anorexia, delays growth, poor production, calcification of posterior muscles and hypopottasia lead to animal mortality. There is limited information in the mineral nutrition of goats in the natural range of Kordofan. The objective of the study was to determine the levels of macro elements K and P in the blood serum of goats as indicators of their status in the low-rainfall areas of Africa and Asia, small ruminant production represents the principal economic output, contributing a large share of the income of farmers (Ben Salem and Smith, 2008). Sheep and goats are integral component of food production and livelihood systems of many pastoral and agro-pastoral farmers.

MATERIALS AND METHODS

Study Area

This study was conducted at El-khuwei locality. It lies between longitudes 28˚:33' to 28˚:30'N and latitudes 12˚:14' to 14˚:12'E, about 105 Km west of El Obeid town, west Kordofan State, Sudan. El-khuwei locality own large export market of animals (Hammer sheep) in west Sudan. The long term average annual rainfall is about 300-mm, consisting of storms of short duration between July and September with the highest rainfall generally occurring in August. The soil of the site lies within the sand dune area locally known as "Goz" soil. During the rainy season, forage biomass is suitable to provide sufficient feed for animals, but during the dry season forage is scarce and small quantities of grain are also fed to animals (MARF, 2009).

Sampling and Experimental Study

Sampling was done on two stages at flowering and seed setting in selected locations (2 km^2 each). Within each stage 60 goats randomly selected randomly collected samples of blood serums.

Samples Estimating

Blood: Blood serum were collected from 60 goats that were randomly selected from pasture, using 5 ml syringes tubes to be used which filled with anti coagulant; the blood samples were centrifuge at 3000 rpm for 20 minutes to separate the plasma. The plasma samples were stored at –20° C till further analysis**.**

Sample Preparation

Serum: Random blood samples were taken, using 5 ml syringes Tubes to be used which filled with anti coagulant. A quantity of 5 ml of blood plasma was digested with a 4 ml mixture of perchloric acid and nitric acid (1:1). After digestion, the volume was made to 25 ml with distilled de-ionized water. Further dilution was prepared for macro mineral determination following Kamada *et al.* (2000).

Serum calculated by following equation: T/ S×10

Where: T = titration, S = stander according to (Daly *et al.,* 1972).

Laboratory Analysis

Serum concentrations of phosphorus (P) were analyzed using atomic absorption spectrophotometer, (Singh *et al*, 2005). However potassium (K) was analyzed using flame photometer (AOAC, 1990).

Statistical Analysis

The data were analyzed using a completely randomized design (CRD) with the effect of stages as the whole plots and effects of sampling as the sub-plots (Steel and Torrie, 1980). SPSS (Statistical Package for Social Sciences) was used for the statistical analysis. Statistical significance was tested at 0.05, 0.001 and 0.0001 level of probability using the software.

RESULTS

Blood Serum of Potassium and Phosphorus

Stages had significant (P< 0.0001) effect in blood serum of goats was highly K (5.10-3.88 mmol/L) concentration at flowering stage and least during the seed setting stage respectively**.** Concentration of P (2.96-3.94 mg/dl) were decreased at flowering stage and increased at seed setting stage respectively Table 1.

Table 1. Blood serum K and P during the flowering and seed setting stages at El-khuwei locality, West K0rdofn, Sudan

Minerals	Stages		Means	± SE	Significant
	Flowering	Seed setting			
Potassium K (mm/l)	5.10	3.88	4.49	0.09	***
Phosphorus P (mg/dl)	2.96	3.94	3.45	0.11	***

Means in the same column under the same factor with different letters are significantly different.
* = significant (P < 0.05), ** = high significant (P < 0.001) and *** = highly significant (P < 0.0001).

DISCUSSION

Serum Potassium

Significant differences were highly K (5.10 mmol/L) concentration at flowering stage and least K (3.88 mmol/L) concentration at seed setting stage. Grunwaldt *et al.* (2005) who reported season has significant effect on blood minerals of mean mineral concentrations in the blood of the goats are within the normal range of K (6.00mml/l) concentration; this result is agreement with study. The normal of K 14-100 mg/100ml concentration in the blood serum of goats was observed by Sabir (2005). Albarran *et al*. (2012) reported the K concentration differed during the dry season with highest K (29.50 mg/dl) value and lowest (17.31 mg/dl); this is in agreement with study. NRC (2007) reported the K 15 to 20 mg/dl, goats from our region would not likely be deficient in this mineral. Dominguez and Huerta (2007) reported higher plasma K content ranged from 10.76 mg/L during the rainy season and least 7.94 mg/L at the wet season. Higher Plasma K+ concentration was observed during the flowering stage than those found already by Grunwaldt *et al*. (2005) in Argentina and Khan *et al*. (2009) in different ruminants in Pakistan. Similar concentration of plasma K+ has been observed by Gizachew *et al*. (2002) in Western Ethiopia. This is agreement with study. These differences in plasma K+ may be attributed to the physiological state of animal and different climatic conditions. This is despite K being deficient in some plants during the wet and the cold dry seasons. This may be as a result of different individual preferences for plants as the goats were feeding which may have resulted in goats selecting only those plant that were high in K. Plasma K was significantly higher 18.5 mg/liter in the cold season than in the least 16.3 mg/liter at hot seasons. These findings were in accordance with the Khan *et al.* (2003) who found that plasma K was low in goats as compared to other classes which might be due to the secretion of the K through the milk. The seasonal difference in milk K might also be related to the stage of the lactation.

Serum Phosphorus

During the seed setting stage was increased P (3.94 mg/dl) concentration and decreased P (2.96 mg/dl) level at flowering stage. Albarran *et al*. (2012) determine the P level in blood serum of goats in the south of the State of Mexico during the rainy season highest P (4.79

mg/dl) value and least P (3.05 mg/dl) at dry seasons; this range is in agreement which result. Another studied the average concentration of the P in the goat serum is 2.96 mg/dl (Abdelati, 2005); these levels is similar which result. The animals had blood serum P within the normal range in spite of low forage P concentration. NRC (2007) reported of the P in grazing ruminants 3 to 8 mg/dl. Dominguez and Huerta (2007) reported similar levels, which ranged from 10.7 to 12.1 mg/dl, in animals in an extensive grazing system, which were considered adequate. In our study, there were lower P levels than reported in the literature and it is suggested that the goats could experience productive and reproductive deficiencies caused by the lack of P which could compromise many hormonal, metabolic and structural functions, as well as reduced appetite, which could compromise efficient utilization of the diet. Plasma P levels are partly influenced by dietary selection and the variable uptake and availability of the element in the diet. Plasma P was increased 6.16mg/liter at dry hot season and decreased 3.13mg/liter at cold wet season. The observed deficiency may be attributed to low plant P levels observed during the same season Khan *et al*. (2008).

CONCLUSIONS

It can be concluded that at the flowering stage highly potassium concentration and decreased phosphors concentration. However during the seed setting stage least potassium concentration and increased phosphors concentration.

RECOMMENDATIONS

It can be recommended that need goats supplementation phosphors concentration at the flowering stage, however potassium concentration needed at the seed setting stage of grazing goats with the mixture mineral deficient in the blood serum.

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Original Article

Ginger (*Zingiber Officinale*) Root Powder as Natural Feed Additive for Broiler Chicks

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ABSTRACT

The study targeted effect of addition of ginger root powder as natural feed additive on growth performance and blood constituents of broiler chicks. One hundred and sixty unsexed one day-old broiler chicks strain (Ross) were divided randomly into four groups. Each represented a treatment (40 birds/treatment) with 4 replicates in a completely randomized design. In addition to the control diet (0.0% ginger root powder), three diets were formulated to meet the nutritional requirements of broiler chicks according to NRC (1994), with graded levels of ginger root powder 0.5%, 0.75% and 1%. Weekly average feed intake, body weight gain and feed conversion ratio were recorded blood samples were taken to determine the content of glucose, cholesterol and triglyceride. The results showed no significant differences (P>0.05) in the final body weight (1103.3g, 1140.2g, 1141.2g and 1146.9g) between the four treatments. Also, there were no significant differences in total feed intake (2266.1g, 2432.6g, 2396.3g and 2443.6g), total body weight gain (1064.3g, 1101.2g, 1102.2g and 1107.8g), and feed conversion ratio among all dietary treatments. Moreover, no significant differences were obtained in serum glucose, cholesterol and triglyceride among the four treatments. Mortality rate was 2.5%, 3.75%, 3.12%, and 0.62% for the four treatments (0.0% 0.5%, 0.75% and 1%.ginger) respectively. Chicks tolerated up to 1% ginger without adverse effect on growth performance and blood parameters.

Key words: broilers, ginger, glucose, cholesterol, triglyceride, performance.

INTRODUCTION

Food is a major component, affecting net return from the poultry business, because 80% of the total expenditure is in term of cash spent on feed purchase (Asghar *et al*., 2000; Farooq *et al*., 2001). To ensure more net return and to minimize `high expenditure on feed are the main challenges, for which many research strategies have been practiced such as introducing feed supplements and feed additives (Perves, 1992). However the current research is looking for natural alternative to antibiotics because of their residue and subsequent resistance to bacteria

(Lee *et al*., 2004).Growth promoters as feed additives are primarily included to improve the efficiency of the bird's growth and/or laying capacity, prevent disease and improve feed utilization. Among all growth promoters, the most commonly used are antibiotics, although nowadays their use is decreasing towards total extinction (Biovet, 2005). Some growth promoters act as pro-nutrients because of the role they play in enhancing the physiology and microbiology of the animal. Many active ingredients from plant are considered as pro-nutrients and recently been tried in animal feeds (Biovet, 2005).Pro-nutrients are also sometimes referred to as phytogenic feed additives. Phytogenic feed additives are plant-derived products used in animal feeding to improve their performance. This class of feed additives has recently gained increasing interest, especially for use in swine and poultry. This appears to be strongly driven by a complete ban on most of the antibiotic feed additives within the European Union in 2006 (Windisch *et al*., 2008).Many types of feed additives are being used in broiler Rations to improve its performance. Spices are very common to be useful as additives in broilers diets (Zhang *et al*., 2009).Plant active principles are chemical Compounds present in the entire plant or in specific parts of the plant that confers their therapeutic activity or Beneficial effects (Martins *et al*., 2001). The supplementation of spices and herbs could have many benefits to broilers health and performance such as having ant oxidative potential (Hui, 1996), antimicrobial activity (Dorman and Deans, 2000), enhancing digestion by stimulating endogenous enzymes (Brugalli, 2003).Ginger (*Zingiber Officinale*) is widely used in many countries as a food condiment and as a medicinal herb (Chrubasik *et al*., 2005). The main important compounds in Ginger are gingerol, gingerdiol and gingerdionewhich have the ability to stimulate digestive enzymes, affect the microbial activityand having antioxidative activity (Dieumou *et al*., 2009). When used in broiler diets, *Zingiber Officinale* Supplementation improved antioxidant and broiler Chickens blood serum (Zhang *et al*., 2009). The objective of this study is to determine the effect of ginger roots powder supplementation as a natural feed additive with various levels on growth performance of broiler chicks and some blood constituents, and to confirm of the previous studies.

Statement of the Problem

The fast growing nature of broilers and their short generation intervals has been associated over the years with the use of antibiotic growth promoters as sub-therapeutic doses in the feeds in order to improve the quality of the product but these were associated with residues in the meat by consumers and have been banned or limited in many countries, as a result, natural alternatives to antibiotics such as herbs and medicinal plants have attracted attention due to their wide range of potential beneficial effects. The essential compounds of ginger evaluated as natural alternatives to feed antibiotics in broiler diets.

MATERIALS AND METHODS

Experimental Diets

The diets were formulated to evaluate the nutritive value of ginger root powder for broiler chicks performance, Three kilo of ginger root were purchased from local market and ground well. In addition to the control diet (0%) ginger root powder, three diets were formulated to contain 0.5%, 0.75% and 1% ginger root powder per 100 kg diet, respectively. The ingredient composition and calculated analysis of the experimental diets are shown in Table 1 and Table2 respectively.

Experimental Birds

A total of one hundred and sixty one-day old unsexed commercial broiler chicks (ROSS) were obtained. The chicks were weighed and then randomly divided into four groups; each group contains 40 birds with four sub-groups as replicates with 10 birds per pen.

Adaptation Period

The first week of experiment was used as adaptation period, all chicks were fed the control diet and the same procedures of management were applied for all groups.

Table 1. The composition of experimental rations

Feed Ingredients	Treatments Ginger levels			
Ginger root powder	0.0	0.5	0.75	1
Feterita grain	65.47	65.97	65.72	65.47
Ground nut Cake	23	22	22	22
Sesame cake	5	5	5	5
Super concentrate *	5	5	5	5
Di Calcium	0.755	0.755	0.755	0.755
Limestone	0.172	0.172	0.172	0.172
Premix	0.1	0.1	0.1	0.1
Lysine	0.1	0.1	0.1	0.1
Methionine	0.05	0.05	0.05	0.05
Antitoxin	0.1	0.1	0.1	0.1
Salt	0.25	0.25	0.25	0.25

*super concentrate (per kg): Na 2.4%, Methionin 3.70%, Lysin 12%, Available Phosphorus 5%, Ca 6.50%, CP 35%, CF 3%, EE 2.50%, ME/Kcal/Kg 2050

Table2. Calculated analysis of the experimental rations

Items	Ginger levels			
	0%	0.5%	0.75%	1%
ME (kcal/kg)	3197	3196	3195	3195
Crude protein%	22.83	22.53	22.52	22.53
Crude fiber%	4.35	4.32	4.35	4.37
Calcium%	1	0.99	0.99	0.99
A Phosphorus%*	0.59	0.59	0.59	0.59
Methionine%	0.05	0.05	0.05	0.05
Lysine%	0.1	0.1	0.1	0.1

* A: available phosphorus

Management Procedures

All procedures of management were applied for all groups during the experimental period. The chicks were allocated randomly as (10 chicks /pen) with 4 treatments. The birds were brooded for the first three weeks of age. Sugar and multivitamin were administrated in drinking water at the first week of experiment to avoid the expected stress, the multivitamin repeated after each vaccination process. The birds were vaccinated against Newcastle disease (ND) and infectious bronchitis (IB) at 7 days of age and at the second week of age the birds were vaccinated against gumboro and repeated at fourth week of age.Newcastle disease vaccine (*Lasota strain*) was administered at the third week of age. Anticoccidia treatment also given in water at fifth week of age. Renewal Water and clean feed were provided *ad libitum* during the experimental period.

Data Collection

Weekly average feed intake, body weight gain and feed conversion ratio was recorded. At the end of the sixth week of experiment, (the duration period of the experiment) 2 birds from each pen were selected randomly and slaughtered, blood samples were taken from jugular vein during slaughtering and collected into tubes and allowed to clot and sera separated by centrifugation at 3000 rpm for 5 minutes for analysis to determine the content of glucose, cholesterol and triglyceride. Birds were scalded in boiling water, handpicked then all the internal organs were removed out.

Chemical Analysis

Sample of ginger powder taken for approximate analysis on dry matter basis for chemical components Table 3. (Dry matter, crude protein, crude fiber, ether extract, ME, nitrogen free extract, and Ash) were determined according to AOAC (1980). Plasma glucose and cholesterol were determined by enzymatic calorimetric methods using Kit GOD-PAP (Randox Labratoty Ltd. London). Plasma triglyceride was determined by the methods described by Buccolo *et al*., (1973).

Table 3: Proximate analysis of ginger root powder (%)

DM	CP	CF	EE	ASH	NFE	ME/MJ/kg*
89.32	13.84	12.12	2.28	7.68	53.40	11.07

* Metabolizable energy was calculated according to the formula derived by Lodhi *et al*., (1976).
ME = 1.549 + 0.0102 CP+ 0.0275 EE + 0.0148 NFE – 0.0034 CF

Experimental Design and Statistical Analysis

The experiment was conducted by using complete randomized design (CRD). All the data of this experiment were collected and subjected to analysis of variance (ANOVA) by using SPSS program (statistical packages for social science). The differences between treatments were tested by the method of Duncan's Multiple Range Test (DMRT) at ($P < 0.05$) level of significance.

RESULTS AND DISCUSSION

Feed Intake

The effect of feeding graded levels of ginger root powder (*Zingiber Officinale*) on weekly feed intake is presented in Table 4. The results showed that the dietary treatment had no significant difference (P>0.05) on feed intake. The highest feed intake was obtained by the birds fed 1% ginger root powder during second, third, fourth and fifth weeks compared with other levels of ginger (0%, 5% and 75%). Also the results in Table8.Showed that there was an increase in total feed intake in level 1%but with no significant difference (P>0.05) between all levels during the experiment duration this result was comparable with the findings of Doley *et al*., (2009) who revealed that no differences in feed intake for broilers fed with ginger extract for 6 weeks period.

Table 4. Feed intake of broiler chicks (g/bird/week) as affected by addition of ginger root powder

Items	Ginger levels				
	0%	0.5	0.75%	1%	Sig
1st week	103.5±3.1	102.4±1.9	103.9±2.4	102.5±2.9	Ns
2nd week	231.2±5.9	240.3±9.7	231.9±14.3	247.4±8.3	Ns
3rd week	291.4±16.2	300.6±12.7	298.6±23.9	303.1±15.5	Ns
4th week	414.4±14.9	422.3±12.1	422±29.4	437.9±29.6	Ns
5th week	619.4±5	698.5±30.4	695.6±59.6	699.7±29.8	Ns
6th week	606.6±11.9	669.1±33.3	644.2±44.1	652.9±36.5	Ns

Values are means ± standard error of the mean for (4) replicates of (10) birds/pen.
NS = no significant difference (P>0.05).

The increment in feed consumption which was illustrated in this study may be due to pungent test or aroma and flavor of ginger. also compared with the work of Ademola *et al*., (2009) who reported higher feed intake of broilers on diet supplemented with ginger and agrees with Kulka (1967) the effect of pungent test in feed intake cause by number of components predominated by gingerols followed by shogaols and zinger one. And also agree with Purseglove *et al*., (1981).Aroma and flavor of ginger caused by more than 70 constituents present in steam volatile oil obtained from dry ginger. However not in agreement with the report of Herawati (2010) who stated that broilers fed 2% dried supplementary red

ginger meal had significantly lower feed intake than those on the control diet. The insignificant effect of addition of ginger root powder to the basal diet may be due to the fact that the sun drying employed in the processing of the experimental ginger. Eze and Agbo (2011) reported that ginger is best preserved in its natural form under open-air sun drying conditions. However Ebewele and Jimoh (1981) reported that sun drying of ginger results in loss of some volatile oils by evaporation and destruction of some heat sensitive properties. The declining of feed intake in the 6th week may be due to stress of raining autumn season.

Body weight

Results of body weight gain are given in Table5.The data showing significant difference (P<0.05) in weekly body weight gain during the 5th week, the highest body weight gain was obtained in the 5th week by the birds fed 1% ginger root powder. In spite of the results of total body weight gain in Table 8. Showed that there was no significant difference (P>0.05) between all treatments during the experiment duration, but also the highest total body weight gain was obtained by the birds fed1% ginger root powder. The increased feed intake resulted in corresponding increase in weight gain.

Table 5. Body weight gain of broiler chicks (g/bird/week) as affected by addition of ginger root powder

Items	Ginger levels				
	0%	0.5	0.75%	1%	Sig
1st week	59.1±1.8	72±5.3	65.7±2.1	71.9±4.9	NS
2nd week	117.4±10.8	111.9±5.2	104±11.8	102.9±16.9	Ns
3rd week	159.6±6.5	161.6±8.1	166.9±15.2	166.9±10.4	Ns
4th week	212.5±10.6	222.6±8.9	228.6±15.8	236.6±16.6	Ns
5th week	$251.4±11.6^{d}$	$229.9±23.4^{cd}$	$288.2±34.4^{bc}$	$313.4±9.4^{a}$	*
6th week	264.4±43.7	293.7±28.3	248.8±43.9	216.3±35.9	Ns

Values are means ± standard error of the mean for (4) replicates of (10) birds/pen.
NS = no significant difference (P >0.05).
* Significant different (P < 0.05).

Feed conversion ratio

There were no significant differences (P>0.05) in weekly feed conversion ratio between treatments as appear in table 6.The present results agree with findings of Wafaa *et al*., (2012) who reported that no difference among birds fed on 0.5%, 1% and 1.5% ginger root powder in feed conversion ratio. On other hand Herawati (2006); Tollba (2003); Herawati (2010); Moorthy *et al*., (2009) and Onimisi *et al*., (2005) they illustrated that birds fed with diets containing ginger up to 2% recorded better feed conversion ratio than unsupplemented one.

Table 6. Effect of dietary ground ginger root on Feed conversion ratio of broiler chicks

Items	Ginger levels				
	0%	0.5	0.75%	1%	Sig
1st week	1.7±0.06	1.4±0.09	1.5±0.03	1.4±0.07	Ns
2nd week	2.2±0.12	2.1±0.04	2.2±0.15	2.6±0.4	Ns
3rd week	1.8±0.03	1.8±0.02	1.7±0.02	1.8±0.02	Ns
4th week	1.9±0.09	1.9±0.03	1.8±0.05	1.8±0.04	Ns
5th week	2.5±0.1	3.1±0.5	2.4±0.2	2.2±0.1	Ns
6th week	2.6±0.6	2.3±0.1	2.9±0.6	3.3±0.7	Ns

Values are means ±standard error of the mean for (4) replicates of (10) birds/pen.
Means with different superscripts along rows were not significantly different (P>0.05).

Overall performance

Overall performance results of broiler chicks fed various levels of ginger from 0 to 6 weeks of age are shown in Table 7. The results showed that there were no significant differences (P>0.05) across all the treatment means for all the parameters analyzed. These results could be compared with the findings of Dieumou *et al*., (2009) who fed ginger essential oils to broilers and found that there were no significant differences (P>0.05) among the ginger oil diets and the control in terms of feed intake, final weight, weight gain and feed

conversion ratio among treatments. Herawati (2010) reported that Hubbard strain broilers fed 2% supplemental red ginger in the diet had significantly higher final body weight than those on the control diet. The non significant difference obtained in this study could be as a result of the differences in quantity and or cultivar of the ginger used, strain of broiler used or environment in which the research was conducted.

Table 7. Effect of dietary ginger root powder on overall Performance of broiler chicks (g/bird/)

Parameters	Ginger levels				
	0%	0.5%	0.75%	1%	Sig
Final body weight (g)	1103.35±47.82	1140.22±15.73	1141.25±74.29	1146.97±37.88	Ns
Body weight gain (g)	1064.35± 47.82	1101.22±15.67	1102.25±74.29	1107.85±37.86	Ns
Total feed intake (g)	2266.1± 46.47	2432.67±53.20	2396.3±151.48	2443.65±97.75	Ns
FCR*	2.5±0.1	2.2±0.3	2.2±.03	2.2±.03	Ns

NS: no significant difference. (P>0.05).
*FCR: feed conversion ratio.

Blood chemistry

Serum constituent's results are shown in Table 8. The results show that there were no significant deference (P>0.05), in Serum glucose, cholesterol and triglyceride between all treatments during the experiment time. this result disagree with the findings reported by Wafaa *et al*., (2012) who pointed that feeding chicks ginger root powder at levels 0.5% and 1% decreased serum cholesterol levels.

Table 8. Effect of dietary ginger root powder on serum constituents of the broiler chicks

Parameters	Ginger levels				
	0%	0.5%	0.75%	1%	Sig
Glucose (mg/dl)	181.03±13.6	195.41±12.34	180.74±20.9	194.31±15.42	Ns
Cholesterol (mg/dl)	99.58±9.21	82.50±6.26	99.58±11.55	90.66±7.49	Ns
Triglyceride (mg/dl)	56.81±6.44	49.74±6.47	61.35±10.18	56.56±10.28	Ns

Data are means for 4 replicates of 2 chicks per pen.
NS: no significant difference. (P>0.05).

CONCLUSION

This study indicated that Supplementation of ground ginger root powder at the different levels of 0.5%, 0.75% and 1% in the broiler chick's diet had no significant effect on the parameters analyzed. Chick tolerate up to 1% ginger without adverse effect on performance.

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Effect of Age at Weaning on Growth Performance and Post-Weaning Survival Rate of Different Rabbit Genotypes in South-Eastern Agro-Ecological Zone of Nigeria

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ABSTRACT

This study evaluated the influence of age at weaning on post-weaning growth performance and survival rates of different rabbit genotypes – New Zealand White (NZ), Chinchilla (CH), NZ×CH and CH×NZ in a completely randomized design. The weaning ages considered as treatments across the genotypes were 28 (T28), 42 (T42) and 56 (T56) days, respectively. Data from 67 kits NZ (19), CH (15), NZ×CH (17) and CH×NZ (16) were used for the study. Measurements taken from each genotype for 7 weeks after each weaning age include body weight (BW), body weight gain (BWG), feed efficiency (FE) and survival rate (%). The analysis of variance showed that there were significant differences ($P < 0.05$) among the different weaning ages on the growth parameters. Kits weaned at day 28 had significantly ($P < 0.05$) higher values for BW and BWG as well as better feed efficiency index followed by those weaned at 42 days and then 56 days. Estimates of BW both at the initial and final weeks were: NZ – 414, 809 (T28), 380, 766 (T42) and 234 ,447 (T56), CH – 443, 935 (T28), 436, 751 (T42) and 302, 500 (T56), NZ×CH – 432, 834 (T28), 394, 678 (T42) and 241, 417 (T56) and CH×NZ – 436, 917 (T28), 425, 717 (T42) and 261, 462 (T56). Significant ($P < 0.05$) differences were only observed for survival rate at the final week of measurement for the crossbred genotypes. Generally, however, the survival rates of kits of the different genotypes across all weaning ages were quite high. It ranged from 72.00 – 100 % (NZ), 75.00 – 100 % (CH), 87.70 – 100 % (NZ×CH) and 85.70 – 100 % (CH×NZ). Results of this study highly encouraged weaning at 28 days for optimum production efficiency in the study region. Weaning traits such as weights and survival/mortality rates are not affected greatly by additive gene action and thus can be improved by good management decisions among which is age at which rabbits are weaned.

Keywords: age, genotype, growth traits, Rabbit, survival rate, weaning.

INTRODUCTION

The growth and development of animals as well as their survival depend greatly on the genotype and management practices adopted during the production cycle. Age at weaning is a management practice that influences an animal's growth, production and reproduction. Oshinowo *et al.,* (1993) reported that weaning traits such as weaning rate and weaning weight as well as weaning age influenced herd productivity in goat. Weaning age was also reported to have influenced growth performance and survival of guinea pigs (Fonteh *et al.,* 2005).

In the domestic rabbit, Afifi and Emara (1988) and McNitt and Lukefahr (1996) identified weaning age among other factors as influencing post-weaning growth performance of rabbits. The economics of livestock production actually depends on post-weaning growth performance of young animals as this affects the rate of attainment of market weight.

Xiccato *et al.,* (2003) also noted that weaning age affected growth performance, body composition and caecal fermentation. In their experiment, the authors also found that weaning age influenced body energy balance of weaned kits. Xiccato *et al.,* (2000) and Trocina *et al.,* (2001) in their respective studies compared kits weaned at different ages (21, 25, 28 and 32 days). The authors observed that kits weaned at 21 and 25 days of age had lower weight gain than their counterparts weaned at 28 and 32 days. Studies relating the age of weaning to growth performance and survival of kits are very minimal in literature, particularly in this study region.

Hoon *et al.,* (2010) stated that weaning is normally a stressful period in the life of young animals and is often characterized by a decrease in weight gain, weight loss, and total cease in growth and in some cases death. However, they pointed out that the level or degree of this response known as weaning shock depends on age and body weight of young animals as well as the feeding regime before weaning. From the above statement, it is obviously true that age at weaning affects not only growth performance but also the rate of survival of rabbit kits.

In Nigeria, indiscriminant weaning ages is common among farmers and researchers. This practice influences production output adversely. Therefore, streamlined investigation is necessary to help determine the optimum age at which rabbit genotypes could be weaned for increased productivity. This would find useful application in selection programmed for optimum genetic performance.

The objective of this study was to ascertain the optimum age for weaning rabbit genotypes for efficient growth and survival in the study region.

MATERIALS AND METHODS

Experimental site

The study took place at the Rabbi try Unit of Michael Okpara University of Agriculture, Umudike Teaching and Research farm. Umudike is located on 05° 29' N and longitude 07° 33' E and at approximately 122 m above sea level. It has minimum and maximum daily temperature ranges of 20 - 26°C and 27 - 36°C, respectively with relative humidity of 57 – 91% and annual rainfall of 2177 mm.

Experimental animals and their management

Four rabbit genotypes were considered: New Zealand White (NZ), Chinchilla (CH), NZ×CH and the reciprocal (CH×NZ). Sixteen breeding rabbits comprising of 12 does and 4 bucks were used to generate progeny for this study. Does were flushed for 2 weeks before mating. Mating was done in the morning hours by introducing the females into the buck's pen. Mating ratio was 1 buck: 3 does. Abdominal palpation was done 14 days *post coitus*. Pregnant does were moved to separate hutches while non-pregnant ones were left with the bucks until pregnancy occurred. A total of 67 kits survived and were used for the study. All

routine management operations and medications were duly observed. Fresh clean water and feed were given *ad libitum* all through the experimental period. The feed composed of a concentrate ration of 18 % CP and 2700 Kcal/kgME supplemented with *Panicum maximum* and *Centrosema pubescens*. The animals were reared in individual hutches in row cages made of metal and wire guaze.

Experimental Treatment and Data Collection

Three weaning ages were adopted as treatments:
T28 = weaning at 28 days of age (4 weeks)
T42 = weaning at 42 days of age (6 weeks)
T56 = weaning at 56 days of age (8 weeks)
Data were collected on body weight (g), body weight gain (g), feed conversion ratio and survival rate (%) from each genotype. The measurements lasted for 8 weeks from weaning.

Experimental Design and Statistical Analysis

The experimental was a completely randomized design (CRD) with age at weaning as factor of interest. The statistical model used is as follows:
$Y_{ij} = \mu + T_i + E_{ij}$
Where,
Y_{ij} = parameter of interest
μ = overall mean
T_i = mean effect of the i^{th} age at weaning (i = 1 – 3)
E_{ij} = random error [iind(0, δ^2)]

Data collected were subjected to analysis of variance (ANOVA) using SPSS (1999) analytical package. Significant means were separated with Duncan's New Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

For ease of presentation, only results of initial and final weeks of measurement were presented for all the traits studied.

Effect of Weaning Age on Growth Performance of Kits

The analysis of variance indicated significant differences ($P < 0.05$) among the weaning ages for the growth parameters measured in the different genotypes. Means of the growth performance traits at the different weaning ages for NZ×NZ, CH×CH, NZ×CH and CH×NZ are as shown in Tables 1, 2, 3 and 4, respectively.

Table 1: Effect of weaning ages on post-weaning growth performance of NZ×NZ genotypes at initial and final weeks of age

Week	Parameter	Weaning Ages		
		T28	T42	T56
Initial	BW (g)	414.00 ± 27.31[a]	380.83 ± 11.29[a]	234.25 ± 8.52[b]
	BWG (g)	44.00 ± 5.79[a]	28.75 ± 4.27[b]	22.50 ± 1.71[b]
	FE	0.15 ± 0.01[a]	0.28 ± 0.04[b]	0.31 ± 0.04[b]
Final	BW (g)	809.00 ± 4.58[a]	766.00 ± 16.31[a]	447.50 ± 18.87[b]
	BWG (g)	90.00 ± 1.58[a]	64.10 ± 13.07[a]	11.25 ± 4.27[b]
	FE	0.04 ± 0.02[a]	0.25 ± 0.01[b]	0.35 ± 0.01[c]

[a-c] Means with different superscripts within the same row are significantly different ($P < 0.05$)
BW = body weight, BWG = body weight gain, FE = feed efficiency, T28 = weaning at 28 days, T42 = weaning at 42 days, T56 = weaning at 56 days, NZ = New Zealand White.

Kit of the four genotypes weaned at 28 days recorded significantly ($P < 0.05$) higher body weight body weight gain and better feed efficiency ratio followed by those of T42 and while T56 kits had the lowest values.

Table 2: Effect of weaning ages on post-weaning growth performance of CH×CH genotypes at initial and final weeks of age

Week	Parameter	Weaning Ages		
		T28	T42	T56
Initial	BW (g)	443.33 ± 18.01[a]	436.25 ± 13.48[a]	302.00 ± 28.53[b]
	BWG (g)	37.50 ± 2.81[a]	32.00 ± 5.83[a]	27.50 ± 2.31[b]
	FE	0.22 ± 0.02[a]	0.24 ± 0.05[a]	0.37 ± 2.81[b]
Final	BW (g)	935.50 ± 20.18[a]	751.00 ± 10.54[b]	500.00 ± 24.90[c]
	BWG (g)	60.00 ± 15.60[a]	55.37 ± 15.96[b]	35.00 ± 4.36[c]
	FE	0.06 ± 0.12[a]	0.26 ± 9.18[b]	0.31 ± 0.05[c]

[a-c] Means with different superscripts within the same row are significantly different ($P < 0.05$)
BW = body weight, BWG = body weight gain, FE = feed efficiency, T28 = weaning at 28 days, T42 = weaning at 42 days, T56 = weaning at 56 days, CH = Chinchilla

The result of this study is in agreement with the report of some researchers. In an experiment with rabbits weaned at 28 and 63 days, Marongiu *et al.,* (2006) obtained at 83 day of assessment significant ($P < 0.05$) higher live body weight (2167 g) and body weight gain (28.4 g) for the 28 day kits compared to 1837 g and 18.0 g, respectively of the 63 day weaned kits. They also reported a better ($P < 0.05$) feed conversion index for 28 day kits (3.979) as against the 63 day kits which had a value of 4.439.

Table 3: Effect of weaning ages on post-weaning growth performance of NZ×CH genotypes at initial and final weeks of age

Week	Parameter	Weaning Ages		
		T28	T42	T56
Initial	BW (g)	432.00 ± 19.30[a]	394.29 ± 14.93[a]	241.25 ± 4.27c
	BWG (g)	41.00 ± 4.00[a]	35.00 ± 2.04[a]	22.86 ± 2.86b
	FE	0.18 ± 0.02[a]	0.25 ± 0.02[b]	0.29 ± 0.02b
Final	BW (g)	834.00 ± 15.28[a]	678.30 ± 22.12[b]	417.50 ± 8.54[c]
	BWG (g)	137.00 ± 9.30[a]	80.80 ± 3.27[b]	46.20 ± 2.39[c]
	FE	0.06 ± 0.01[a]	0.33 ± 0.01[b]	0.51 ± 0.03[c]

[a-c] Means with different superscripts within the same row are significantly different ($P < 0.05$)
BW = body weight, BWG = body weight gain, FE = feed efficiency, T28 = weaning at 28 days, T42 = weaning at 42 days, T56 = weaning at 56 days, NZ = New Zealand White, CH = Chinchilla.

For carcass conformation score (using a 5 ± score evaluation scale), the 28 day kits were better in relation to the score for the 63 day weaned kits. Fortun-Lamothe *et al.,* (2002) observed that early weaning provided higher viability and fastest growth in rabbits. Early weaned rabbits had also been reported to compare favourably in post-weaning body weight (Chen *et al.,* 1978) and live weight (Túmova *et al.,* 2006) with those weaned at a later age. In a similar work but with guinea pig kids, Manjeli *et al.,* (1998) and Fonteh *et al.,* (2005) independently reported significantly ($P < 0.05$) higher daily weight gain for kids weaned at 11 days of age in comparison with those weaned at 84 days. Henry *et al.,* (2012) observed that juvenile grass cutters (pups) weaned at 6 weeks (WA_6), which had longer suckling period did not show better post-weaning growth and carcass performance than those weaned at 4 weeks (WA_4) and 2 weeks (WA_2), respectively.

Table 4: Effect of weaning ages on post-weaning growth performance of CH×NZ genotypes at initial and final weeks of age

Week	Parameter	Weaning Ages		
		T28	T42	T56
Initial	BW (g)	436.00 ± 17.78[a]	425.71 ± 17.90[a]	261.25 ± 10.87[b]
	BWG (g)	50.00 ± 7.36[a]	40.83 ± 2.01[a]	27.86 ± 2.86[b]
	FE	0.22 ± 0.02[a]	0.26 ± 0.02[a]	0.42 ± 0.06[b]
Final	BW (g)	917.50 ± 15.85[a]	717.14 ± 6.16[b]	462.50 ± 8.54[c]
	BWG (g)	95.00 ± 8.27[a]	75.00 ± 2.89[b]	47.50 ± 3.23[c]
	FE	0.03 ± 0.02[a]	0.13 ± 0.01[b]	0.33 ± 0.24[c]

[a-c] Means with different superscripts within the same row are significantly different (P < 0.05)
BW = body weight, BWG = body weight gain, FE = feed efficiency, T28 = weaning at 28 days, T42 = weaning at 42 days, T56 = weaning at 56 days, NZ = New Zealand White, CH = Chinchilla.

The significant higher post-weaning body weight and body weight gain observed in this study for the T28 kits could possibly be attributed to high feed intake of the kits, although this parameter is not presented in our work and efficient utilization of the much consumed feed. Gallois *et al.,* (2003, 2004) demonstrated that feed consumption was significantly higher for early weaned rabbits in comparison to those weaned at 35 days of age. Piattoni *et al.,* (1999) stated that weaning at 18 days of age caused a rapid increase in feed consumption of the young rabbits after 1 – 2 days of withdrawal. Feed efficiency explains the difference in body weights and body weight gains resulting from feed intake. According to Fonteh *et al.,* (2005) early weaned guinea pig kids overcame weaning stress and developed the capacity to efficiently handle solid and fibrous feed earlier in life than the late-weaned ones and that this gave them an initial advantage in feed conversion efficiency which was maintained throughout the growth period. Again, they stated that the physiological changes that took place with early weaning might have also exposed the early-weaned kits to a longer period of compensatory growth than those weaned late. Similar reasons could be adduced for observations made in this study using rabbits.

Effect of Weaning Age on Post-Weaning Survival Rate of Kits

The post-weaning survival rates (%) at both the initial and final weeks of measurement of the different rabbit genotypes based on the weaning ages studied is given in Table 5. Generally, the post-weaning survival rates of the different genotypes were high across all weaning ages. They range from 93 – 100 %, 83.4 – 100 % and 75 – 100 % for kits weaned at 28, 42 and 56 days, respectively. No significant (P > 0.05) differences were observed among the weaning ages in all the genotypes at the initial week. Trocina *et al.,* (2001) and Xicatto *et al.,* (2003) recorded no mormatility of rabbit kits among the different weaning ages studied.

Henry *et al.,* (2012) observed similarity in survival of juvenile grasscutter pups weaned at 2, 4 and 6 weeks respectively by recording no mortality among pups of the different weaning ages. However, at final week significant (P < 0.05) differences existed among the weaning ages for NZ×CH and CH×NZ genotypes. Here, kits of T28 had significantly (P < 0.05) higher rates of survival – 100 %, 85.7 % and 90.0 % (NZ×CH) and 100 %, 95.2 % and 87.7 % (CH×NZ) for T28, T42 and T56, respectively. From our result, even where differences existed (numerically or statistically), T28 kits exhibited higher survival rates followed by T42 kits while the lowly survived were those of T56 kits. Fonteh *et al.,* (2005) reported highest mean survival rate with 21 day (87.49 %) weaned guinea pig kids which was closely followed by those weaned at days 16 (83.33 %) and 11 (82.43 %) while 84 day weaned kids recorded the lowest value (62.64 %). However, when average of early (11 and 16) and late (21 and 84) days were compared, the authors observed a difference of 15.63 % in favour of early weaning. These results clearly indicated the increased ability of early weaned kits to easily overcome

shock and survive the extra-maternal environment after weaning irrespective of regions. The result of our study is in corroboration with the fact that survival/mortality rates are not greatly influenced by additive gene action but by management decisions.

Table 5: Influence of weaning age on post-weaning survival rates of the different rabbit genotypes at initial and final weeks

Genotype	Weaning age	Survival rate (%)	
		Initial	Final
NZ×NZ	T28	100.00	97.40
	T42	100.00	83.40
	T56	100.00	72.00
CH×CH	T28	100.00	93.00
	T42	98.00	83.40
	T56	96.00	75.00
NZ×CH	T28	100.00	100.00[a]
	T42	100.00	95.20[a]
	T56	100.00	87.70[b]
CH×NZ	T28	100.00	100.00[a]
	T42	95.20	90.00[b]
	T56	97.70	85.70[b]

[a-b] Means with different superscripts within the same row are significantly different ($P < 0.05$)
T28 = weaning at 28 days, T42 = weaning at 42 days, T56 = weaning at 56 days, NZ = New Zealand White, CH = Chinchilla.

CONCLUSION

The result of this study indicated that kits weaned at 28 days of age had better post-weaning growth performance in terms of body weight, body weight gain and feed efficiency followed by those weaned at 42 and 56 days of age, respectively. Although the survival rates of kids of all the genotypes studied were very high, yet kids weaned at T28 had higher survival which was closely followed by T42 and then T56. It therefore suggests that late weaning apart from being inconveniencing to the farm economy, will not improve rabbit production better than early weaning and thus should be avoided. Apart from lowering the intensive management of the rabbits through shorter rearing period, weaning of kids at 28 day of age will optimize production efficiency thereby improving animal welfare which is of paramount interest to several consumers of nowadays.

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