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Analysis of Drumsticks and Offal of Guinea Fowl (Numida Meleagris) fed Mophane Worm (Imbrasia Belina) as Protein Source and Raised Up to 13 Weeks Under Intensive Management System

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Abstract:- The aim of the study was to investigate the effects of feeding mophane worm as a protein source on the chemical composition of drumsticks and offal of guinea fowl raised up to 13 weeks of age under intensive management system. Ninety-six day old keets were randomly assigned to four dietary treatments i.e., 3% fishmeal (control), 4.5% mophane worm meal, 9% mophane worm meal and 13.5% mophane worm meal. At four weeks of age, keets were transferred to 16 pens (floor space ≈ 0.06 m^2 per bird) with six birds per pen and four replicates per treatment. The houses had concrete floor pens with wood shavings. At 13 weeks of age, all birds were sacrificed by cervical dislocation and drumsticks and offal analyzed. Proximate analysis was carried out on the gizzards, livers, hearts and drumsticks according to the AOAC standard techniques. Data were analyzed using the General Linear Model procedure (GLM) of statistical analysis system (SAS) software version 9.2 and least square means were reported.

Dietary treatment had no effect (P>0.05) on the chemical composition of guinea fowl drumsticks and offal at 13 weeks of age. The moisture content of gizzards from birds on 13.5% *mophane* worm meal was numerically higher (76.0%±1.57) than other treatments, 73.2%±1.53, 73.6%±2.21 and 75.5%±1.47 for Livers, hearts and drumsticks, respectively. The gizzards of guinea fowl fed 9% *mophane* worm meal had numerically lower total ash content (1.3%±0.08) compared with other offal which had 1.3%±0.08, 1.3%±0.05 and 1.3%±0.8 for livers, hearts and drumsticks respectively. Livers from guinea fowl fed 9% *mophane* meal had numerically higher crude protein levels (14.3%±0.27) while guinea fowl fed 13.5% *mophane* meal also had numerically lower crude protein content on drumstick (13.7% ±0.19) with gizzards, hearts and livers recording 14.01%±0.9, 14.04%±0.2 and 14.1%±0.3 respectively.

Mophane worm meal can be recommended to substitute fishmeal up to 13% without affecting drumsticks and offal chemical characteristics. Guinea fowl fed mophane worm meal had less fat content and low amount of sodium which is a good attribute in human nutrition.

Keywords:- *Chemical composition, fishmeal, Guinea fowl drumsticks, mophane worm meal, offal.*

I. INTRODUCTION

The values of offal in the nutrition of most people in developing countries come from a long way. Offal provide needed proteins to diets of low-income sector of community. Marketing of offal has increased in recent times finding their way in shelves of most supermarkets. Managers (Pono, Tsokedi, and Ratshiamo) of Choppies, Supa Spa and Pick and pay alluded in an interview that in Botswana, people eat poultry offal during breakfast. Furthermore, the consumers mostly prefer cooked offal though some would prefer raw offal. According to Ratshiamo the demand for poultry offal are so high because they are sold at a cheap price (eg, P10.00/ pack of 10 gizzards) which attracts more buyers leading to more profit.

Generally, there are no acceptable standards for nutrient requirements for guinea fowl production. As a result various researchers have recommended high levels of crude protein (26% in starter feeds and 15% in grower feeds) for good performance of guinea fowl (Ayeni, 1980). According to Payne and Wilson (1999), guinea fowl feed on a variety of items such as insects, grasses, leaves and seeds in the wild. In Botswana, guinea fowl are fed on commercial broiler and layer diets and cereal grains such as maize, sorghum and sunflower oil cake (Nsoso *et al*., 2008).

According to Mareko *et al*. (2010), *mophane* worms (*Imbrasia belina*) derive their name from the *Mophane* (*Colophospermum mopane*) tree where they feed on the leaves and the worm is more dominantly found in the North Eastern parts of Botswana. *Mophane* worm (also known as *phane*) is a seasonal product, and the main harvesting period starts in late December and lasts for about three weeks. Depending on the availability of rain, a second small crop may also be expected from April to May (Madibela *et al*., 2007). Sekhwela (1989) reported that processed worms have 55-57% protein content

and lipid content ranging from 14 to17%. According to Mareko *et al. (*2009), *mophane* worms are also rich in lipidsof which are found in the gut lining.

Although *Mophane* worms are locally available and not expensive, they face a threat of over harvesting due to minimal restrictions in collection and trade of the worms coupled with increasing levels of poverty in countries where the worms are found (Akpalu *et al*., 2007; Gondo *et al*., 2010). When comparing data from McDonald *et al. (*1992) and Ohiokpehai (1996), Madibela *et al.* (2009) concluded that essential amino acids from *mopane* were higher than those in soyabean but comparable to those in fishmeal.

The nutritive significance of *mophane* worm as feed for highly productive livestock in Botswana could be cost effective compared to the conventional fishmeal which is imported from Namibia and South Africa. Information on guinea fowloffal is limited although the birds are in abundance in the wild and the scarcity of such information is even far worse with regards to its carcass characteristics (Nsoso *et al*., 2006). Therefore, a study was undertaken to investigate the effect of *mophane* worm meal fed as a source of protein on guinea fowl drumsticks and offal characteristics raised up to 13 weeks of age under intensive management system.

II. MATERIALS AND METHODS

The study was carried out at Botswana College of Agriculture (BCA) Guinea Fowl Rearing Unit, Sebele Content farm. Located at coordinates 24º 33'S, 24º 54' E, at an altitude of 994 m above sea level with an average annual rainfall of 538 mm and mean daily temperature of 30 ºC (Aganga and Omphile, 2000; Emongor, 2007).

III. ANIMAL MANAGEMENT

Ninety-six day old keets were obtained from BCA hatchery and raised in a closed brooding unit which provided both warmth and adequate ventilation. At four weeks of age, keets were transferred to 16 pens with six birds *per* pen and four replicates *per* treatment. Birds were housed on concrete floor pens with wood shavings as bedding material.

The floor space was about 0.06 m^2 *per* bird from one day to the end of experiment. The keets were raised in intensive deep litter system at optimal temperature of about 35 ºC which was gradually reduced to 25 ˚C up to 13 weeks of age. At 3 weeks of age, keets were randomly allocated to experimental diets: 3% fishmeal (control), 4.5% *mophane* wormmeal, 9.0% *mophane*worm meal, and 13.5% *mophane* wormmeal (Tables 1 and 2). Each treatment had 24 keets and was replicated four times (6 keets *per* replicate). Keets in each treatment were housed in a paddock of 1.6 m x 1.8 m with fluorescent light.

Water and feeds were given *ad libitum*. Feeders and drinkers were cleaned regularly to avoid contamination and transmission of diseases. Keets were vaccinated against Newcastle disease and Gumboro (infectious bursal disease) at 10 and 14 days of age. At week 13, the birds were sacrificed under standard abattoir procedures for drumsticks and offal analysis.Birds were fed broiler starter diet with 24% crude protein from 0 to 7 weeks and finisher diet with 17% crude protein from 8 to 13 weeks of age. Diets were formulated according to the Botswana Standards for guinea fowl (BOS 234:2006). Furthermore, diets were calculated for energy, protein and minerals to ensure accurate diet formulation. Diets for each feeding phase were is ocaloric and is nitrogenous (Tables 1 and 2).

Crude Protein (%)				
	Fishmeal	*Mophane*	Worm	Meal
Treatments	Control	1	2	3
Inclusion levels (%)	3%	4.5%	9%	13.5%
Ingredients				
Yellow maize (9% CP)	46.29	46.64	49.29	51.91
Soy bean meal (38% CP)	46.61	44.76	37.61	30.49
Fishmeal (60% CP)	3.0	-	-	-
Phane meal (55% CP)	-	4.5	9.0	13.5
Dehydrated alfalfa (16% CP)	2.0	2.0	2.0	2.0
Dicalcium phosphate (%)	0.35	0.35	0.35	0.35
Vitamin/ mineral premix (%)	1.5	1.5	1.5	1.5
Iodised salt (%)	0.25	0.25	0.25	0.25
Antibiotics and coccidiostat (%)	+	+	+	+
Total	100	100	100	100
Calculated composition				
Metabolizable Energy (MJ/kg)	12.97	12.97	12.97	12.97
Crude protein (%)	24	24	24	24
Calcium (%)	0.90	0.90	0.90	0.90
Total phosphorus (%)	0.70	0.70	0.70	0.70
Available phosphorus (%)	0.55	0.55	0.55	0.55

Cp= Crude protein, MJ=Mega joule

Table 1:composition of experimental diets used as guinea fowl starter from week 0 to 7 weeks of age

Crude Protein (%)				
	Fishmeal	*Mophane*	worm	Meal
Treatments	Control	1	2	3
Inclusion levels (%)	3%	4.5%	9%	13.5%
Ingredients				
Yellow maize (9% CP)	70.41	70.79	73.41	76.06
Soy bean meal (38% CP)	22.49	20.26	13.49	6.34
Fishmeal (60% CP)	3.0	-	-	-
Phane meal (55% CP)	-	4.5	9.0	13.5
Dehydrated alfalfa (16% CP)	2.0	2.0	2.0	2.0
Dicalcium phosphate (%)	0.35	0.35	0.35	0.35
Vitamin/ mineral premix (%)	1.5	1.5	1.5	1.5
Iodised salt (%)	0.25	0.25	0.25	0.25
Antibiotics and coccidiostat (%)	+	+	+	+
Total	100	100	100	100
Calculated Composition				
Metabolizable Energy (MJ/kg)	12.97	12.97	12.97	12.97
Crude protein (%)	17	17	17	17
Calcium (%)	0.90	0.90	0.90	0.90
Total phosphorus (%)	0.70	0.70	0.70	0.70
Available phosphorus (%)	0.55	0.55	0.55	0.55

Cp= Crude protein, MJ=Mega joule

Table 2: Composition of experimental diets used as guinea fowl finisher from week 8 to 13 weeks of age

IV. DATA COLLECTION

At 13 weeks feed and water were withdrawn 12 hours prior to slaughter to prevent digesta and faeces from contaminating the carcasses (Hinton *et al.*, 2000and Bell; Weaver Jr., 2002). At 13 weeks, all birds across treatments were manually caught individually and put in crates and transported to BCA slaughter facility where they were sacrificed by cervical dislocation and the drumsticks and offal analysed. After the removal of heads, shanks and feet, carcasses were eviscerated. The hearts, livers and gizzards were weighed after removal from the whole carcass and packaged in zipped plastics and frozen at 0 ºC for further analysis.

Proximate analysis of guinea fowl drumsticks was carried out on the gizzards, livers, hearts and drumsticks according to AOAC (1996). Guinea fowl drumsticks and offal were also analyzed for ash (total mineral content) according to AOAC (1996) methods Fat content (ether extract) and moisture content were determined using the Soxhlet extractor following AOAC (1996) methods.

V. STATISTICAL ANALYSIS

Data on chemical composition of drumsticks and offal were analyzed using the GLM procedure of SAS® software version 9.2 (SAS Institute Inc., 2002-2008) using the following model. The means comparison was conducted using Dunnet test and least square means were reported.

$Y_{ij} = \mu + T_i + \varepsilon_{ij}$

Y_{ij} = ijresponse variable (drumsticks, moisture content, crude protein, ash, ether and individual minerals)

μ =General mean

T_i= i^{th}(1,2….4) Treatments effects ….j= (Phane 4.5%, 9.0%, 13.5% and control diet)

ε_{ij}= ij^{th}experimental error

VI. RESULTS AND DISCUSSIONS

A. Offal

Dietary treatment had no effect on the chemical composition of guinea fowl drumsticks and offal at 13 weeks of age (Table 3). However, the moisture content of gizzards on 13.5% *mophane* worm meal was numerically higher than other treatments (Table 3).Moisture content of the liver from guinea fowl fed 13.5% *mophane* worm meal was numerically lower than that of other three treatments (Table 3). Gizzards of guinea fowl fed 9% *mophane* wormmeal had the highest percentage total ash (1.33±0.08) while birds fed commercial diet (control) had their gizzards and hearts having the lowest ash contents. In the present study, the livers of the guinea fowl fed 9% *mophane* worm meal had the highest total ash while those of control (3% fishmeal) recorded the lowest ash content though it was not significantly different. The livers of guinea fowl fed 13.5% *mophane* worm meal had numerically lower ether extract (0.41±0.30). Livers from guinea fowl fed 9% *mophane*wormmeal had the highest crude protein levels (14.31±0.27) and those of guinea fowl fed 13.5% *mophane* wormmeal had the lowest percentage crude protein (13.70±0.19). Demirbas (1999) reported the protein content of 15.5%±0.45 and 17.9%±0.41 for hearts and livers from chicken broilers, respectively. The author's result is higher than the results found in this study probably due to the different bird type used in the two studies. Among the offal, the liver and the gizzards recorded less fat content than the hearts. The protein content of the guinea fowl livers had numerically higher values while the gizzards had numerically lower protein content. Gizzards have more muscular activity involved in grinding feeds and therefore some protein might have been mobilized towards supplying the muscles with dietary energy leading to low protein content when compared to other offal.

B. Drumsticks

Dietary treatment had no effect on the chemical composition of guinea fowl drumsticks at 13 weeks of age (Table 3).Numerically, the ether extract for the drumsticks

was higher than that of the offal. In this study ether extract of drumsticks recorded less than 1% (Table 3). The drumsticks of guinea fowl fed 3% Fishmeal (control) had numerically higher ether extract (Table 3). Mareko *et al. (*2010*)* reported moisture content in guinea fowl fed 40% *mophane* worm meal to be 73.3%±1.121 while moisture content of 75.5% of drumsticks of birds fed *mophane* worm meal was recorded. Moreki *et al.* (2012)reported moisture content of guinea fowl thigh muscle to be 74.22% and 70.62%, at 6 and 12 weeks, respectively which are comparable to the moisture content of drumstick in this study.

Treatment	Moisture content				Ether extract			
	Gizzard	Livers	Hearts	Drumsticks	Gizzards	Livers	Hearts	Drumsticks
Control	73.40[a]	74.43[a]	75.48[a]	75.0[a]	0.49[a]	0.48[a]	0.47[a]	0.58[a]
4.5%	75.43[a]	75.13[a]	74.76[a]	75.43[a]	0.46[a]	0.43[a]	0.54[a]	0.57[a]
9.0%	75.10[a]	75.13[a]	75.0[a]	74.48[a]	0.54[a]	0.54[a]	0.57[a]	0.44[a]
13.5 %	75.95[a]	73.25[a]	73.63[a]	75.48[a]	0.44 a	0.41[a]	0.44[a]	0.43[a]
Mean	74.97	74.48	74.72	75.34	0.464	0.47	0.50	0.50
CV	4.91	4.10	5.92	3.89	12.32	13.14	16.15	18.93
SEM	1.57	1.53	2.21	1.47	0.29	0.30	0.33	0.30
P-value	0.69	0.80	0.94	1.00	0.99	0.99	0.99	0.97

Treatment	Ash				Protein			
Control	1.16[a]	1.19[a]	1.16[a]	1.20[a]	13.85[a]	14.19[a]	13.70[a]	14.08[a]
4.5%	1.25[a]	1.23[a]	1.30[a]	1.28[a]	13.96[a]	13.88[a]	13.93[a]	13.77[a]
9.0%	1.24[a]	1.33[a]	1.27[a]	1.28[a]	13.96[a]	14.31[a]	13.76[a]	13.93[a]
13.5 %	1.28	1.28[a]	1.25[a]	1.31a	14.01[a]	14.12[a]	14.04[a]	13.70[a]
Mean	1.23	1.25	1.25	1.27	13.95	14.12	13.85	13.86
CV	7.57	6.10	8.21	12.20	2.78	3.67	2.94	2.73
SEM	0.05	0.08	0.05	0.77	0.91	0.27	0.20	0.19
P-value	0.37	0.15	0.30	0.74	0.95	0.72	0.62	0.51

Table 3. Chemical analysis (%) of guinea fowl drumsticks and offal raised under intensive management system at 13 weeks of age

[a,b]Means in a column with the same superscript using Dunnet test do not differ significantly (P>0.05); CV= coefficient of variation; SEM= standard error of the mean

Mineral composition of guinea fowl drumsticks and offal was not affected by treatment at 13 weeks of age (Table 4). However, the liver of the guinea fowl fed 9% *mophane* worm meal had numerically higher sodium content (2.47±0.42) while the hearts of the guinea fowl fed 4.5% *mophane* meal had numerically lower sodium content (1.14±0.47). Sodium plays a major role in maintaining blood volume and blood pressure (Lauitzen, 2009).

According to Lauitzen, (2009) low amount of sodium in human diet leads to decreased chances of high blood pressure. The livers of guinea fowl fed 3% fishmeal (control) recorded the highest phosphorus content (2.478±0.45). Generally, ash content in offal was low for all the treatments. The values for phosphorus and potassium values found by Mareko *et al.* (2010*)* were higher than those found in this study while the sodium levels were numerically lower (Table4). Mariam *et al.* (2004) stated that there are no permissible limits of potassium and sodium in poultry meat.

VII. CONCLUSIONS

Guinea fowl drumsticks and offal has considerably low ether extract, indicating their suitability for the health conscious market. Guinea fowl meat is an important protein source and it is ideal because of its low sodium and potassium content. *Mophane*worm meal can be used to substitute fishmeal up to 13% without affecting drumsticks and offal chemical characteristics. Further research on the energy content and economic importance of offal is suggested. Furthermore, a study on sensory evaluation on guinea fowl offal is recommended to document the information on the general acceptability of guinea fowl offal as a source of human nutrition

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	Treatment	Sodium	Magnesium	Potassium	Phosphorus	Calcium
Gizzards	3% fishmeal	1.56[a]	2.47 [a]	1.56 [a]	1.16 [a]	1.05 [a]
	4.5% phane	1.90[a]	2.20 [a]	1.90 [a]	1.25 [a]	1.09 [a]
	9% phane	1.52[a]	1.14 [a]	1.52 [a]	1.24 [a]	1.52 [a]
	13.5% phane	1.84[a]	2.35 [a]	1.84 [a]	1.28 [a]	1.84 [a]
SEM		0.29	0.27	0.46	0.44	0.29
P-value		0.95	0.74	0.28	0.29	0.95
Livers	3% fishmeal	1.62 [a]	1.65 [a]	1.62 [a]	2.48 [a]	1.46 [a]
	4.5% phane	1.43 [a]	1.32 [a]	1.43 [a]	2.25 [a]	1.43 [a]
	9% phane	2.47 [a]	1.66 [a]	1.67 [a]	1.16 [a]	1.14 [a]
	13.5% phane	1.70 [a]	1.14 [a]	1.70 [a]	2.32 [a]	2.44 [a]
SEM		0.44	0.42	0.27	0.27	0.45
P-value		0.28	0.65	0.95	0.74	0.95
Hearts	3% fishmeal	1.45 [a]	1.16 [a]	1.19 [a]	1.05 [a]	1.52 [a]
	4.5% phane	1.14 [a]	1.20 [a]	1.09 [a]	1.09 [a]	1.77 [a]
	9% phane	1.43 [a]	1.19 [a]	1.64 [a]	1.52 [a]	1.48 [a]
	13.5% phane	2.14 [a]	1.43 [a]	1.90 [a]	1.84 [a]	1.65 [a]
SEM		0.46	0.44	0.29	0.29	0.27
P-value		0.28	0.29	0.95	0.95	0.74
Drumstick	3% fishmeal	1.62 [a]	1.30 [a]	1.52 [a]	1.40 [a]	1.32 [a]
	4.5% phane	1.44 [a]	1.25 [a]	1.24 [a]	1.32 [a]	1.50 [a]
	9% phane	1.67 [a]	1.35 [a]	1.37 [a]	1.50 [a]	1.45 [a]
	13.5% phane	1.70	1.43 [a]	1.60 [a]	1.45 [a]	1.22 [a]
SEM		0.29	0.27	0.46	0.44	0.42
P-value		0.95	0.74	0.28	0.28	0.65

Table 4. Mineral analysis (ppm) of guinea fowl drumsticks and offalraised under intensive management system at 13 weeks of age

[a,b] Means in a column with the same superscript using Dunnet test do not differ significantly (P>0.05); CV= coefficient of variation; SEM= standard error of the mean.

REFERENCES

[1]. Aganga, A.A. and Omphile, C.H. (2000). Forage resources of Botswana. Government Printers, Gaborone.

[2]. Akpalu, W., Muchapondwa, E. and Zikhali, P. (2007). Can the restrictive harvest period policy conserve mopane worms in Southern Africa? A bio-economic modeling approach.University of Pretoria.Working Paper Number 65: 1-11. Accessed 25 October 2013 from http://dx.doi.org/10.1017/S1355770X0900518X

[3]. AOAC (2010).Official Methods of Analysis, 16th Edition.Association of Analytical Chemists. Arlington, Virginia. USA.

[4]. AOAC (2008).Official Methods of Analysis, 16th Edition.Association of Analytical Chemists. Arlington, Virginia. USA.

[5]. Ayeni, J.S.O. (1980). The biology and utilization of helmeted guinea fowl (Numidameleagris galeatapallas) in Nigeria.PhD Thesis. University of Ibadan, Nigeria. Retrieved 25 October 2013from http://www.fao.org/docrep/t9450e/t9450e0t.htm

[6]. Bell, D.D., and Weaver, W.D. (2002).Chicken meat and egg production.Fifth edition.Kluwer Academic Publishers. USA. Pp 230-234.

[7]. Bonds, H. (1997).Alternative Farming: A "United Nations" of alternative farming on the Mornington Peninsula. Retrieved 29 October 2013, from www.independentnewsgroup.com.au/archive/helmi/

[8]. BOS: 234 (2006). Guinea fowl standards.Botswana Bureau of Standards. Gaborone, Botswana.

[9]. Demirbas, A. (1999). Proximate and heavy metal composition in chicken drumsticks tissues.Journal of Food chemistry, 67(1):27-31.

[10]. Emongor , V.(2007). Gibberellic Acid (GA_3). Influence on vegetative growth, nodulation and yield of cowpea (Vignaunguiculata (L.)walp.Journal of Agronomy, 6: 509-517.

[11]. Gondo, T., Frost, P., Kozanayi, W., Stack, J. and Mushongahande, M. (2010). Linking knowledge and practice: assessing options for sustainable use of mopane worms (Imbrasia belina) in Southern Zimbabwe. Journal of Sustainable Development in Africa, 12: 281-305.

[12]. Hinton, A. Jr., Buhr, R.J., and Ingram, K.D. (2000) Physical, chemical, and microbiological changes in the

ceca of broiler chickens subjected to incremental feed withdrawal. Journal of Poultry Science, 79: 483-488.

[13]. Lauitzen, G.C. (2009).Sodium. Accessed on 16 January 2014 from http://extension.usu.edu/files/publications/publication/FN_220.pdf

[14]. Madibela, O. R., Mokwena K.K., Nsoso, S.J. and Thema, T.F. (2009). Chemical composition of mopane worm sampled at three different sites in Botswana subjected to different. Tropical Animal Health and Production, 41: 935-942.

[15]. Madibela, O.R., Seitiso. T.K., Thema. T.F. and Letso, M. (2007).Effect of traditional processing methods on chemical composition and in vitro true matter digestibility of the Mophaneworm (Imbrasiabelina).Journal of Arid Environment, 68:492-500.

[16]. Mareko, M.H.D., Nsoso, S.J., Mosweu, K., Mokate, K.K. and Madibela, O.R.(2010). Chemical composition and sensory evaluation of broilers supplemented on two levels of Phaneworm (Imbrasia belina) meal. Botswana Journal of Agriculture and Applied Sciences, 6(3): 223-233.

[17]. Mareko, M.H.D., Nsoso, S.J., Mosweu, K., and Mokate, K.K. 2009). Chemical composition and sensory evaluation of broilers supplemented on two levels of Phane worm (Imbrasia belina) meal. Botswana Journal of Agriculture and Applied Sciences, 6(3): 223-233.

[18]. Mareko, M.H.D., Nsoso, S.J. and Lebetwa, N. (2008). Nutritive value of meat of guinea fowl raised on concrete and bare soil floors from 16-26 weeks of age. Research Journal of Animal Sciences, 2: 5-11.

[19]. Mariam, I., Iqbal, S. and Nagra, S.A. (2004). Distribution of some trace and macro minerals in beef, mutton and poultry. International Journal of Agriculture and Biology, 6(5): 816-820.

[20]. Moreki, J.C., Podi, K.T., Nthoiwa, G.P. and Machete, J.B. (2012). Chemical analysis and sensory evaluation of guinea fowl meat fed diets containing three cereal grains as energy sources up to 12 weeks of age. International Journal of Science and Advanced Technology. 2(10) 59-66.

[21]. Nsoso, S.J., Aganga, A.A., Madibela, O.R., Maposa, G.T. and Mpuang, P. (2008).Effect of protein source on guinea fowl keets (Numida meleagris) in Botswana. Botswana Journal of Agriculture and Applied Sciences, 4(2) 46-51.

[22]. Nsoso, S.J., Mareko, M.H.D., and Molelekwa, C. (2006). Comparison of growth and morphological parameters of guinea fowl (Numida meleagris) raised on concrete and earth floors in Botswana. Livestock Research Rural Development, 18(12). Retrieved on the 22 March 2011 from http://www.cipav.org.co/lrrd18/12/nos/1878.htm

[23]. Nwagu, B.I., and Alawa, C.B.I. (1995).Guinea fowl production in Nigeria.World Poultry Science Journal, 51: 260-270.

[24]. Ohiokpehai, O., Bulawayo, B.T., Mpotokwane, S., Sekwati, B. and Bertinuson, A. (1996) Expanding the use of mopane, a nutritionally rich local food. Pp. 111-130 in Proc. Multidisciplinary Symposium. Mopane. University of Botswana and Kalahari Conservation Society. Gaborone, Botswana.

[25]. Payne, J.A. and Wilson, R.T. (1999).An Introduction to Animal Husbandry in the Tropics.Blackwell Science Ltd Publishers.(Fifth edition). London, UK. 659-660.

[26]. Sekhwela, M. B. M. (1989). The nutritive value of Mophane bread Mophane insect secretion (maphote or moaboti).Botswana Notes and Records, 20: Pp 151-153.