GROWTH PERFORMANCE OF AFRICAN GIANT LAND SNAIL (*Achatina achatina*) FED VARYING DIETARY PROTEIN AND ENERGY LEVELS

Ani A. O.[1], Ogbu C. C.[1], Elufidipe C. O.[2] and Ugwuowo L. C.[1]
[1]Department of Animal Science, University of Nigeria, Nsukka, Nigeria
[2]Faculty of Veterinary Medicine, University of Nigeria, Nsukka, Nigeria
Email: coschi07@yahoo.com

ABSTRACT

The rational for the study was to investigate the combined effect of dietary protein (CP) and energy levels on the performance of a species of African giant land snail: *Achatina achatina*. Two hundred and forty (240) 8 weeks old *Achatina achatina* were used for the study. The study involved 16 treatments of 15 snails each and 3 replicates of 5 snails each per treatment in a 4 x 4 factorial arrangement: four levels (18%, 20%, 22%, and 24%) of crude protein each combined with four (2.6, 2.8, 3.0 and 3.2 Mcal/kg ME) levels of energy. Results showed significant ($P < 0.05$) treatment effects on final body weight (FBW), body weight gain (BWG), feed intake (FI), protein efficiency ratio (PER), feed conversion ratio (FCR), carcass weight (CW), cost of feed per kg weight gain, shell length (SL) and shell width (SW). Feed intake was significantly ($P < 0.05$) decreased at the 3.0 Mcal/kg ME and 18% CP and 3.2 Mcal/kg ME and 18% CP levels. Feed conversion ratio and feed cost per kg weight gain were most significantly ($P < 0.05$) decreased at the 3.2 Mcal/kg ME and 24% CP level, respectively while shell length and width were enhanced ($P < 0.05$) at the 3.0 Mcal/kg ME and 24% CP and 3.2 Mcal/kg ME and 24% CP levels, respectively. It was concluded that 3.2 Mcal/kg ME + 24% CP and/or 3.0 Mcal/kg ME + 24% CP levels were best for the growth of *Achatina achatina* in the humid tropics.

Keywords: *A. achatina*, crude protein, dietary energy, feed conversion ratio, growth performance, protein efficiency.

INTRODUCTION

The importance of protein in the diet of man cannot be over-emphasized. Protein is required for normal growth and repair of body tissues. Protein can be of plant or animal origin. Most plant proteins are deficient in one essential amino acid or the other and may be associated with anti- nutritional factor(s). Soyabean for instance is a vegetable protein source that contains trypsin inhibitor and is deficient in methionine (Jurgens, 2002). Animal protein is of high biological value and possesses all the essential amino acids in desirable quantities. Sources of animal protein are the products (meat, milk and eggs) of macro and micro livestock. Macro livestock are large farm animals such as sheep, goat and cattle. The costs of production of these animals are however, very high in terms of housing, feeding, space requirement and disease control. On the other hand, micro livestock are cheaper sources of animal proteins (Akinnusi, 1998). They include snails, rabbits and cane rats (Oji, 2000). Snails are invertebrate, shell bearing animals that are inactive during the day, but very active at night and at dusk. Snail meat tastes good and it is considered a delicacy in some cultures. Snail meat is particularly rich in protein (Ajayi *et al*., 1978). Imevbore and Ademosun (1988) indicated that snail meat has a protein content of 88.37% (on dry weight basis), low total fat (1.64%), saturated fatty acids (28.71%) and cholesterol (20.28mg/100g) (fresh sample). Snail meat is also rich in calcium, phosphorous and iron with values of 185.70mg/100g, 61.24mg/100g and 45-50mg/kg, respectively for dry samples (Ademola *et al*., 2004) as well as in such amino acids as lysine, leucine, isoleucine and phenylalanine (Imeivbore, 1990; Stievenart, 1992; Ademola *et al*., 2004).

The two giant land snails common in Nigeria are *Achatina achatina* and *Archachatina marginata*. The conventional feeds of snails are bread fruit, water leaf, pawpaw leaf, cabbage, carrot tops, ripe fruits (pawpaw, mango, plantain, banana, pineapple etc) (Akinnusi, 1998; Amusan and Omidiji, 1999), but these feeds are usually scarce and seasonal especially in the urban areas. There is therefore the need to formulate rations that are balanced in such nutrients as protein, energy and minerals, and to determine their effects on performance for optimal productivity of snails. This study was therefore conducted to investigate the effects of varying combinations of dietary protein and energy levels on the growth performance of *Achatina achatina*.

MATERIALS AND METHODS

The study was conducted at the Snailery Unit of the Department of Animal Science, Teaching and Research Farm, University of Nigeria, Nsukka. Feed ingredients such as soybean meal, groundnut cake, palm kernel cake, fish meal, bone meal, oyster shell, vitamin premix, etc used to formulate the experimental diets were procured from a reputable feed raw material depot in Enugu State, Nigeria.

Animals and management

Two hundred and forty (240) 8 weeks old *Achatina achatina* were used for the study. The snails were randomly divided into 16 groups of 15 snails each. The groups were randomly assigned to 16 diets in a 4 x 4 factorial arrangement involving 4 levels (18%, 20%, 22% and 24%) of protein and 4 levels (2.6, 2.8, 3.0 and 3.2Mcal/kg ME) of energy. The composition of the diets is presented in Table-1. Each treatment was replicated 3 times with 5 snails per replicate. The snails were housed in plastic baskets measuring 30cm in diameter and 13cm in height. Each basket was half filled with hot water-treated loamy soil to 5cm depth. The soil was moistened two times daily by sprinkling of tap water. The baskets were placed on a raised wooden platform with the legs dipped in a container filled with water mixed with condemned motor engine oil to scare away termites and ants. Feed and water were provided *ad libitum* throughout the period of the study which lasted for 16 weeks. Other routine management practices were strictly observed.

Parameters measured

The initial body weights of the snails were measured at the commencement of the study and at weekly intervals thereafter. Daily feed intake was measured as the difference between feed give and feed left over after 24hrs. The shell length and shell width of the snails were also measured weekly with venier caliper. Feed conversion ratio (FCR) was calculated as feed: gain ratio. Protein intake was calculated from feed intake values and used to calculate protein efficiency ratio (PER) as weight gain divided by protein intake while feed cost per kg weight gain was calculated as feed cost per kg x FCR.

Carcass analysis

At the end of the feeding trial, three snails were taken from each replicate for carcass analysis. The shell, foot (edible portion) and viscera of each snail were carefully removed and weighed. The dressing percentage was also determined.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) in a completely randomized design (CRD) (Steel and Torrie, 1980) using the SPSS (2006) computer programme. Significantly different treatment means were separated using the Duncan's New Multiple Range Test (Duncan, 1955) option of SPSS.

RESULT

Effects of crude protein and energy levels on growth performance of *A. achatina*

The composition of the diets is presented in Table-1 while Table-2 shows the proximate composition of the experimental diets. The performance (growth, FCR and PER) of snails fed the experimental diets is presented in Table-3. There were significant differences (P<0.0.5) among treatments in final body weight (FBW), average daily weight gain (ADWG), average daily feed intake (ADFI), feed conversion ratio (FCR), protein efficiency ratio (PER), shell length (SL) and shell width (SW). Snails on treatment 16 (24% CP and 3.2Mcal/Kg ME diet) had significantly (P<0.05) higher FBW and ADWG followed by those of treatment 12. The least FBW and ADWG was observed in snails on treatment 13 (18% CP and 3.2 Mcal/Kg ME diet). Snails on treatment 16 had the highest ADFI and this was significantly (P < 0.05) different from those on other treatments. Snails on treatments 9 and 13 had the least (P<0.05) ADFI. Snails on treatments 12 and 16 had comparable FCR (P>0.05) and this was significantly (P < 0.05) lower and better than those of other treatments. The highest and worst FCR was observed in snails on treatments 1 and 11. The highest PER was observed in treatment 16. Those of treatments 8 and 12 were comparable (P>0.05) but differed significantly (P<0.05) from those of other treatments. The least PER was observed in treatments 5 and 11. Snails on treatments 12 and 16 had significantly (P < 0.05) higher shell length than those on other treatments followed by those of treatments 6, 8, 14, 9 and 1 in descending order. The lowest SL was observed in snails on treatments 2 and 3. Snails on treatments 12 and 16 had the highest SW (P < 0.05) followed by those on treatments 6, 11 and 14. Snails on treatments 3 and 13 had the lowest (P>0.05) SW.

VOL. 8, NO. 2, FEBRUARY 2013 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

Table-1. Percentage composition of experimental diets.

Ingredients/diets	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Maize	24.00	24.00	23.20	22.00	27.00	29.00	27.20	25.00	30.00	40.00	29.50	26.50	34.40	30.00	28.50	22.50
Cassava	16.00	12.80	10.20	9.00	22.00	18.00	16.00	14.40	25.00	18.10	21.60	17.00	25.60	24.00	21.00	20.20
Wheat offal	24.50	22.20	17.30	13.50	16.00	7.50	6.00	4.00	3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soybean meal	11.00	16.50	16.00	20.20	10.50	17.00	17.00	17.00	8.00	11.00	12.00	16.00	6.00	6.00	5.00	5.00
Groundnut cake	8.00	8.00	14.00	16.00	12.00	11.20	16.70	22.30	17.00	19.00	25.00	26.00	21.30	27.00	33.20	39.00
Palm kernel cake	10.00	10.00	12.80	12.80	6.00	10.80	10.80	10.80	9.00	5.00	5.00	5.00	4.00	3.00	2.00	2.00
Fish meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Palm oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.40	0.40	2.50	3.20	3.50	3.80	4.80
Bone meal	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83
Oyster shell	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Calculated composition																
CP (%)	18.04	20.00	22.04	24.00	18.02	20.06	22.06	24.04	18.04	20.08	22.02	24.06	18.02	20.05	22.01	24.04
Energy (Mcal/kg ME)	2.62	2.60	2.61	2.61	2.80	2.81	2.80	2.80	3.00	3.04	3.01	3.02	3.20	3.20	3.20	3.20
Crude fibre	5.29	5.41	5.39	5.33	4.22	4.33	4.33	4.29	3.42	3.15	3.17	3.39	2.67	2.66	2.67	2.73
Cost (N)	4586.05	4863.25	4878.65	5084.25	4693.04	4940.25	5015.83	5067.25	4769.05	5164.55	5075.55	5591.55	5316.25	5374.05	5495.55	5647.55
Cost (N)/kg	45.86	48.63	48.79	50.54	64.93	49.40	50.16	50.67	47.69	51.65	50.76	55.92	53.16	53.74	54.96	56.48

Table-2. Proximate composition of experimental diets.

CP (%)	18	20	22	24	18	20	22	24	18	20	22	24	18	20	22	24
Energy	2.60				2.80				3.00				3.20			
Comp (%)/Diets	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Dry matter	86.2	89.8	90.3	89.1	88.4	88.7	88.7	88.6	88.3	89.7	88.5	90.8	89.5	89.5	88.7	90.00
Crude protein	18.39	20.14	22.11	24.08	18.17	20.14	22.11	24.08	18.16	20.14	22.11	24.08	18.39	20.14	22.11	24.08
Crude fibre	3.0	4.2	5.4	5.0	3.6	3.9	5.3	4.3	4.0	3.0	3.7	3.5	3.3	4.0	4.8	3.00
Ether extract	10.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0	5.0	5.0	5.00
Ash	10.0	7.5	9.0	8.0	7.1	7.0	12.4	9.6	8.3	7.0	7.4	7.6	6.4	5.6	7.5	6.4
NFE	43.85	34.19	41.54	53.49	57.00	44.32	48.63	26.13	60.88	58.82	60.63	47.22	59.54	49.82	43.91	43.66

CP: crude protein; energy (Mcal/kgME); NFE: nitrogen free extract

Table-3. Effects of varying dietary crude protein and energy levels on growth performance of Africa Giant and Snails (*A. achatina*)

CP (%)	18	20	22	24	18	20	22	24	18	20	22	24	18	20	22	24	
ME	2.60				2.80				3.00				3.20				
Diets	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	SEM
IBW (g)	3.10	2.30	2.57	2.63	2.63	3.10	2.50	3.03	2.57	2.23	3.43	3.27	2.90	2.90	2.90	3.57	0.71
FBW (g)	7.23^{de}	7.70^{d}	7.60^{d}	8.47^{d}	8.57^{d}	8.87^{d}	8.45^{d}	7.10^{e}	8.40^{d}	7.33^{de}	7.10^{e}	11.13^{b}	3.90^{f}	8.50^{d}	8.15^{d}	17.50^{a}	0.51
BWG (g)	0.26^{d}	0.34^{cd}	0.39^{c}	0.35^{c}	0.37^{c}	0.36^{c}	0.38^{c}	0.26^{d}	0.37^{c}	0.32^{cd}	0.23^{d}	0.49^{b}	0.06^{e}	0.35^{c}	0.33^{cd}	0.67^{a}	0.03
ADFI (g)	0.47^{bc}	0.36^{b}	0.46^{bc}	0.46^{bc}	0.48^{bc}	0.50^{bc}	0.38^{bc}	0.49^{bc}	0.29^{d}	0.60^{c}	0.49^{bc}	0.59^{c}	0.11^{d}	0.48^{bc}	0.33^{b}	0.66^{a}	0.16
FCR	15.01^{ab}	9.98^{d}	9.89^{d}	10.18^{dc}	9.24^{d}	10.42^{dc}	10.22^{dc}	14.68^{b}	12.01^{c}	12.05^{c}	16.52^{a}	7.73^{e}	11.99^{c}	9.80^{d}	9.77^{d}	5.70^{f}	0.60
PER	0.20^{d}	0.24^{c}	0.24^{c}	0.28^{c}	0.14^{e}	0.21^{d}	0.24^{c}	0.36^{b}	0.23^{cd}	0.22^{cd}	0.14^{e}	0.35^{b}	0.23^{cd}	0.27^{c}	0.28^{c}	0.39^{a}	0.01
SL (cm)	1.92^{cd}	1.79^{e}	1.79^{e}	1.90^{d}	1.87^{d}	2.09^{b}	1.88^{d}	2.01^{c}	1.95^{cd}	1.90^{d}	2.02^{c}	2.21^{a}	1.89^{d}	1.98^{cd}	1.88^{d}	2.19^{a}	0.02
SW (cm)	1.47^{bc}	1.48^{bc}	1.39^{cd}	1.46^{bc}	1.42^{c}	1.57^{b}	1.47^{bc}	1.54^{b}	1.50^{bc}	1.47^{bc}	1.54^{b}	1.67^{a}	1.36^{d}	1.54^{b}	1.42^{c}	1.64^{a}	0.02

^{abcde}: Means bearing the different superscripts on the same row are significantly different ($P<0.05$); ME: Mcal/kgME; BWG: body weight gain; ADFI: average daily feed intake; FCR: feed conversion ratio; SL: shell length; SW: shell weight; SEM: Standard error of the mean

VOL. 8, NO. 2, FEBRUARY 2013 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

Effect of varying levels of crude protein and energy on carcass yield of *A. achatina*

Table-4 shows the effect of varying dietary levels of crude protein and energy on carcass yield of *A. achatina*. There were significant differences (P<0.0.5) among treatments in mean live weight, average shell weight, average edible weight and average visceral weight. Snails on treatment 16 had significantly (P<0.05) higher mean live weight, shell weight and edible weight than snails on other treatments. Visceral weight differed significantly between treatment 16 and 13. The lowest mean live weight, shell weight, edible weight and visceral weight were observed in treatment 13.

Cost implication of feeding varying levels of crude protein and energy to *A. achatina*

Table-5 shows the cost implications of feeding snails with diets containing varying levels of protein and energy. There were significant (P<0.05) differences among treatments in total feed intake, cost of total feed consumed, total body weight gain and cost of feed per body weight gain. Snails fed diet 16 (24 % crude protein and 3.2 Mcal/kg ME) had significantly (P<0.05) higher cost of total feed consumed than snails fed other diets. Snails fed diet 13 had the least cost of total feed consumed. Snails on treatment 16 had the least cost of feed per kg weight gain followed by snails on treatment 12, 5, 2 and 3. The highest feed cost per kg weight gain was observed in treatment 11, 1, 13 and 10 in decreasing order. Snails on other treatments had comparable (P>0.05) cost of feed per kg weight gained.

Table-4. Effect of varying dietary crude protein and energy levels on carcass yield of Africa Giant Land Snails (*A. achatina*).

CP (%)	18	20	22	24	18	20	22	24	18	20	22	24	18	20	22	24	
ME	2.60				2.80				3.00				3.20				
Diets	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	SEM
FLW(g)	6.33^{de}	6.30^{de}	5.75^{e}	7.73^{c}	8.20^{bc}	5.20^{e}	7.05^{cd}	6.70^{d}	6.87^{d}	5.40^{e}	5.43^{e}	8.93^{b}	3.50^{f}	7.10^{cd}	7.10^{cd}	10.37^{a}	0.31
SWT (g)	2.15^{f}	2.13^{f}	1.96^{b}	2.63^{cd}	2.79^{c}	1.77^{b}	2.40^{d}	2.28^{ef}	2.31^{ef}	1.84^{g}	1.88^{g}	3.04^{b}	1.19^{h}	2.41^{de}	2.42^{de}	3.41^{a}	0.10
EWT (g)	2.72^{de}	2.71^{de}	2.48^{e}	3.32^{c}	3.53^{bc}	2.24^{e}	3.03^{cd}	2.88^{d}	2.95^{d}	2.32^{e}	2.38^{e}	3.84^{b}	1.51^{f}	3.05^{cd}	3.06^{cd}	4.31^{a}	0.13
VWT (g)	1.46^{ab}	1.45^{ab}	1.33^{ab}	1.78^{ab}	1.89^{ab}	1.20^{ab}	1.62^{ab}	1.54^{ab}	1.58^{ab}	1.24^{ab}	1.27^{ab}	2.05^{ab}	0.81^{b}	1.63^{ab}	1.64^{ab}	2.31^{a}	0.69

^{abcde}: Means bearing the different superscripts on the same row are significantly different (P<0.05); CP: crude protein; ME: (Mcal/kg ME); FLW: final live weight; SW: shell weight; EWT: eviscerated weight; VWT: visceral weight; SEM: Standard error of the mean

Table-5. Cost implication of feeding varying dietary levels of crude protein and energy to Africa Giant Land Snails (*A. achatina*).

CP (%)	18	20	22	24	18	20	22	24	18	20	22	24	18	20	22	24	
ME		2.60				2.80				3.00				3.20			
Diets	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	SEM
+FC/kg	45.86	45.63	48.79	50.54	64.93	49.40	50.16	50.67	47.69	61.65	50.76	55.92	53.16	53.74	54.96	56.48	-
GFI (g)	52.77^{c}	37.67^{d}	54.23^{c}	55.03^{c}	53.20^{c}	58.73^{c}	41.37^{d}	55.27^{c}	70.17^{a}	61.43^{bc}	60.23^{bc}	66.07^{b}	77.73^{a}	53.47^{c}	63.90^{bc}	73.93^{a}	2.85
GFI (₦)	2.42^{de}	1.86^{e}	2.33^{de}	2.82^{c}	2.50^{d}	2.88^{c}	2.07^{e}	2.82^{c}	3.37^{b}	3.20^{bc}	3.07^{bc}	3.70^{b}	0.41^{f}	2.88^{c}	1.91^{e}	4.14^{a}	0.15
TBWG (g)	4.13^{de}	5.35^{cd}	6.20^{c}	5.83^{c}	5.93^{c}	5.77^{c}	5.95^{c}	4.07^{de}	5.87^{c}	5.10^{cd}	3.67^{e}	7.87^{b}	1.00^{f}	5.60^{c}	5.30^{cd}	13.77^{a}	0.49
(₦)/BWG	0.69^{b}	0.48^{cd}	0.48^{cd}	0.52^{c}	0.43^{cd}	0.50^{c}	0.51^{c}	0.54^{c}	0.57^{bc}	0.62^{b}	0.84^{a}	0.41^{d}	0.67^{b}	0.52^{c}	0.57^{bc}	0.32^{e}	0.03

a, b, c, d, e, f: means on the same row with different superscripts are significantly different (P<0.05); CP: crude protein; ME: (Mcal/kgME); FC/kg: feed cost per kg weight gain; +: not subjected to statistical analysis; GFI: total feed intake; GFI (₦): cost of total feed consumed; TBWG: total body weight gain; (₦)/BWG: cost in naira per weight gain; SEM: standard error of mean

DISCUSSIONS

As shown in Table-3, final body weight, body weight gain, feed intake, feed conversion ratio, protein efficiency ratio, shell length and width were significantly increased at the 24%CP and 3.2Mcal/Kg metabolizable energy levels (treatment 16) and to a slightly lesser degree in treatment 12 (24% CP and 3.0 Mcal/KgME). This could be attributed to the synergistic effect of the levels of protein and energy on performance for these treatments. Jackson *et al*. (1982b) had earlier reported the importance of calorie to protein ratio in the diets of animals. According to the author, high protein-low energy diet caused reduction in growth rate. O' Neil *et al.* (1968) showed that excess energy in relation to protein depressed feed efficiency. Similarly, Jackson *et al*. (1982a) showed that body weight and feed efficiency were improved with higher amount of dietary protein and energy indicating the importance of balanced calorie- protein ratio. Snails utilize high energy and protein foods for good weight gain and optimum production (Hodasi, 1986). The higher performance observed in snails fed the 24% CP and 3.2Mcal/kgME diet was not surprising, therefore, since this diet contained the highest protein and energy levels and this would have met the snails' optimal requirement for growth. Moreover, the snails could have utilized the available protein very efficiently for enhanced growth performance. It does appear that optimal protein utilization corresponds to optimal energy availability. A similar report had been documented (Adegbola and Akinwande, 1981). Considering the superior performance of snails fed the 24% CP and 3.2Mcal/kgME diet, it does appear therefore, that the 24% CP and 3.2Mcal/kgME diet produced a better energy: protein synergy. This suggestion corroborates earlier report by Jackson *et al*. (1982a). Although feeding snails with diets containing 22.60% CP and 23% CP resulted in increased growth rate in an earlier study by Radrizzani (1992) and Bright (1996), decreasing the crude protein level to 18% as in the present study led to reduction in performance with all energy levels. The implication of the present observation is that growing snails require more than 18% dietary protein and 3.0 Mcal/kg ME for optimum performance. Sang-Min and Tae- Jun (2005) however reported that a diet containing 22% and 3.3Mcal/kgME was optimal for snail growth. Also Hodasi (1979) and Omole *et al*. (2000) reported that diets containing 28% CP and 2200Kcal/kgME were optimal for the growth of snails.

Results also revealed that average shell length and width of snails which consumed 24% CP and 3.2Mcal/kgME diet were superior to those of other diets. This could be attributed to the enhanced growth performance of snails on this diet and the positive correlation between growth performance, shell length and shell width. A positive correlation between live weight gain, shell length gain, and shell width gain had been established especially in growing snails (Odunaiya and Akinnusi, 2008). The range of shell length and width (1.79 to 2.21 and 1.36 to 1.67cm, respectively) obtained in the present study fall below the values (2.92 and 2.48cm) reported by Adu *et al.* (2002) for growing snails fed 24.91% CP and the values (5.85 and 4.38cm for shell length and shell width, respectively) reported by Oluokun *et al.* (2005) for snails fed 24.2% CP diet. The disparity with these reports could arise from such factors as differences in age of snail, species as well as management and environment.

As shown in Table-4, carcass yield was significantly increased at the 24% CP and 3.2Mcal/kgME levels followed by 24% CP and 3.0Mcal/kgME probably on account of the superior live body weight of snails on these diets. As a general rule, heavier animals are expected to have higher carcass yield than lighter ones. As stated earlier, these diets contained the highest protein and energy levels and could have met the snails' protein and energy requirements for optimal growth. The snails most probably utilized the available protein very efficiently for rapid growth which led to high carcass yield at these energy levels. This suggestion is corroborated by the report of Adegbola and Smith (1982) that high crude protein enhances animal's growth performance and high meat yield.

The observed overall least cost of feed per kg weight gain at the 24%CP and 3.2Mcal/kgME (Table-5) was probably due to the optimal feed utilization efficiency and weight gain of the treated snails. Earlier reports (Augelovicova and Michalik, 1997; Morkunas *et al*., 1993; Mikulshi *et al*., 1990) had attributed reduction in feed cost/kg gain of birds to enhanced feed utilization and weight gain. The production of animals with significantly higher weight gain at reduced cost is therefore an evidence of the efficiency with which the feed is utilized. This is of major economic importance in livestock production. The fact that the diet containing 24% crude protein and 3.2 Mcal/kg ME led to the least cost of production makes this protein and energy combination economically advantageous.

CONCLUSIONS

In conclusion, considering the combined effects of dietary protein and energy levels on growth performance, carcass yield and feed cost per kg weight gain, the best protein and energy combinations for optimum growth of *A. achatina* in the humid tropical environment are 24% CP + 3.2Mcal/kg ME and 24% CP + 3.0Mcal/kgME.

REFERENCES

Adegbola A.A. and Smith O.B. 1982. Studies on the feed value of cocoa pod husk for cattle. Tropical Anim. Prod. 7: 270-293.

Adegbola T.A and Akinwande V. O. 1981. Energy requirements of rabbits in the humid tropics. J. Anim. Prod. Res. (2): 147-155.

Ademola K.O, Idowu A.B, Mafiana C.F and Osinowo O.A. 2004. Performance, proximate and mineral analyses of African giant land snail (*Achachatina marginata*) fed different nitrogen sources. African Journal of Biotechnology. 3(8): 412-417.

Adu O.A., Ojurongbe A.O. and Omole A.J. 2002. Proc. 27th Conf., Nig. Soc. for Anim. Prod. (NSAP). March 17-21, Fed. Univ. of Tech., Akure, Nigeria. pp. 325-327.

Ajayi S. S., Tewe O. Moriarity O. and Awesu M. O. 1978. Observation on the biological and nutritive value of the African giant land snail (*A. marginata*). East Africa wild life journal. (16): 85-95.

Akinnusi O. 1998. A practical approach to backyard snail farming. Nig. J. Anim. Prod. 25: 193-197.

Amusan J. A. and Omidiji M. O. 1999. Edible land snail. A technical Guide to snail farming in Tropics. Verity printer Limited, Ibadan, Nigeria. pp. 5-50.

Arthur E. C. 1975. Feed and Feeding, Animal Nutrition textbook. Williams and Robins Publishers, New York. pp. 112-118, 205-213.

Augelovicova M. and Michalik I. 1997. A test of enzymatic preparation relation to performance and commercial utilization of feeds in broiler chickens. Zivocisna-Vyroba. 42: 175-180.

Avagina G. 1982. New methods for rearing edible snails. Information Zootenico. (29): 85.

Ayodele J. A. and Asimalowo A. A. 1999. Essentials of snail farming. Agape Printers, Ibadan, Nigeria. pp. 7-37.

Bright S.O. 1996. Prospects and problems associated with snail farming. Heritage Printers Nigeria Limited, Lagos, Nigeria. p. 96.

Donaldson W.E., Combs C.F. and Romoser G.L. 1956. Studies on energy levels in poutry rations. 1. The effects of calorie-protein ratio of the ration on growth, nutrient utilization and body composition of chicks. Poult. Sci. 34: 1191-1195.

Duncan D.B. 1955. New Multiple Range Test. Biometrics. 11: 1-42.

Elliot. M. 2002. Applied Pullet Nutrition of Light-weight Pullet Strains. Degussa Amino News Sept. 3(3): 221-229.

FAO. 1986. Farming snails by F. A. O. Better farming services, 3/33 Rome, Italy.

Hill F.W. and Dansky L.M. 1954. I: Studies on the energy requirements of chicks 1. The effect of dietary energy, protein and amino acids for chickens. Poult. Sci. 38: 126-128.

Hodasi J. K. 1979. Life history studies of Achatina *achatina*. J. Molluscan Studies. 45: 54-56.

Hodasi J. K. 1986. Some observation on edible land snail of West Africa. World Animal Review. 52: 198-217.

Imevbore E. A. 1990. Management Techniques in Rearing African Giant Land Snail (*A. marginata*). Ph.D thesis University of Ibadan, Nigeria (Unpublished).

Imevbore E. A and Ademosun A. A. 1988. The nutritive value of the African giant land snail (*A. marginata*). J. Anim. Prod. Resource. 2(8): 76-78.

Jackson S., Summer J.D. and Leeson S. 1982a. The Responses of Male Broiler to Varying Levels of Dietary Protein and Energy. Poultry Sc. 61(11): 2224-2231.

Jackson S., Summer J .D. and Leeson S. 1982. Effect of dietary protein and energy on broiler performance and production costs. Poult Sc. 61(3): 2232-2240.

Jurgens M.H. 2002. Animal feeding and Nutrition. 9th Ed. Kendall/Hunt Publishing Co., Iowa, USA. pp. 144-146.

Lirette A. Lewis J. C, Macpherson M. D and J. P Madutyre. 1992. Edible land snail production under Natural climate conditions in Nova Scotia. Canadian Journal of Animal Science. 72: 115-157.

Macdonald P., Edwards R. A, Greenhalgh J. F. D and Morgan C. A. 2002. Animal Nutrition. 6th Ed. Pearson Education (Singapore) Press Ltd., Delhi, India. p. 693.

Mikulshi D., Jankoweki J., El-Soud S. B.A., Farugh A. and Abou-Zeid A. E. 1998. Effect of feeding enzyme supplemented triticale-barley diets on broiler chicken. Egyp. Poult. Sci. J. 19: 607-618.

Morkunas M., Kbtitskas G. and Kublitsken V. 1993. An enzyme premix. Ptitsevodstovo, 8(15-16). Poult. Abst. 19(1-4): 43.

NRC. 1991. Micro - livestock little - known small animals with a promising economic future. National Academy press, Washington, D. C., USA.

Odunaiya O. and Akinnusi F.A.O. 2008. Effect of some cheap locally available feeding material on the growth performance of edible land snail. Proc 33rd Ann. Conf. of Nig. Soc. for Anim. Prod. (NSAP). March 16th - 20th, College of Agricultural Sciences, Olabisi Onabanjo University, Yewa Campus, Ayetoro, Ogun State Nigeria. pp. 126-128.

Oji O. E. 2000. Promoting micro livestock production in Nigeria. Proc. 26th Ann. Conf. Nig. Soc. for Anim. Prod. (NSAP), 19-23rd March, Umudike, Nigeria. pp. 330-331.

Oluokun J.A., Omole A.J and Fapounda O. 2005. Effect of increasing the of calcium supplementation in the diets of growing snail on performance characteristics. Res. J. Agric. and Biol Sci. 1(1): 76-79.

Omole A. J., Tewe O. O., Makinde G. O., Adetoro F. O., saka J. O. and Ogundola F. I. 2000. Preliminary studies on the response of growing snails (*A. marginata*) to compounded feed as a supplementary ration. Tropical Animal Production Investigation. 3: 35-40.

O' Neil T.B., Biely T.O.B., Hudgson G.C. and Robert A. B. 1968. Protein - Energy Relationship in the Diet of Chicks. Poult. Sc. 41: 739-745.

Radrizzani F. 1992. Supplementary feeding of Helix snail on pasture; The Carrot Snail Farming Research (iv). pp. 7-11.

Sang-Min L and Tae-Jun L. 2005. Effects of dietary protein and energy levels on growth and lipid composition of juvenile snail. J. Shellfish Res. http;/findarticles.com/articles/mi_m0QPU/is_1_24/ai_n13807889. FindArticles.com.06 Jan.2009.

Steel R. G. D. and Torrie J. H. 1980. Principles and Procedures of Statistics. A Biometric Approach (2^{nd} Ed.). McGraw-Hill Publishers, New York, USA. p. 633.

Stievenart C. 1992. Observation on shell lip formation and reproduction in the giant African land snail (*A. marginata*). Snail Farming Research. 4: 20-29.

Sunde M.L. 1955. The Relationship between Protein Level in Chick Rations. Poult. Sc. (1): 350-354.

Yoloye V. L. 1988. Basic Invertebrate Zoology. Union University Press Ltd. pp. 1-25.