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EFFECT OF RONOZYME® HiPhos SUPPLEMENTATION ON THE GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWER RABBITS FED PROCESSED SUNFLOWER SEED MEAL BASED DIETS

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ABSTRACT

A 42 - day experiment was conducted to evaluate the growth performance and carcass characteristics of grower rabbits fed cooked sunflower seed meal (SFSM) based diets supplemented with RONOZYME® HiPhos. A total of 72 grower rabbits were allotted to nine dietary treatments in a 3x3 factorial arrangement using completely randomized design. The diets were designated as T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 were compounded to be isocaloric (2500 kcal/kg, ME) and isonitrogenous (15%) cp consisted of treatments T_1, T_2 and T_3 with 0% inclusion rate of SFSM and 0, 150 and 250PPM of the enzyme supplementation respectively. Treatments T_4, T_5 and T_6 had 10% inclusion rate of SFSM and 0, 150 and 250ppm levels of the enzyme respectively. While treatments T_7, T_8, and T_9 had 20% inclusion rate of SFSM and maintaining the same levels of enzyme supplementation. The treatments were replicated four times. The result revealed that the average daily weight gain (6.13g, 7.74g, and 9.31g), protein efficiency ratio (0.77, 0.95 and 1.15), feed efficiency (0.10, 0.13 and 0.15) and performance index (0.61, 1.01 and 1.40) for 0, 10 and 20% respectively were significantly ($P<0.05$) increased (20% > 10%> 0%) with increasing level of sunflower seed meal. Feed conversion ratio was significantly ($P<0.05$) lower in 10% (7.87) and 20% (6.53) sunflower seed meal based diets. The protein efficiency ratio of T_1 (0.85), T_2 (0.72), T_3 (0.73), T_5 (0.95) T_6 (0.79) T_7 (1.05) and T8 (1.04) were significantly ($P<0.05$) lower than T_9 (1.37). Head weight (134.72g, 167.19g and 167.92g), forelimbs (181.96g, 200.91g and 205.30g), lumbar region (238.78g, 254.20g and 271.65g), cervical (89,23g, 110.55g and 118.14g), lungs (12.99g, 13.12g and 14.36g) and intestinal length (58.52cm, 60.45cm and 61.32cm) for 0, 10 and 20% respectively, significantly ($P<0.05$) increased (0% < 10% < 20%) with increasing levels of sunflower seed meal. Dressed weight (1636.75g) and stomach weight (79.01g) were significantly ($P<0.05$) higher in rabbit fed 20% sunflower meal than 0% (1491.67 and 78.04g) and 10% (1481.75g and 78.01g) diets which were not significantly ($P>0.05$) different from each other. The result of interaction effect showed that T_6 recorded higher weight in head (205.90g), neck (73.61g), forelimbs (260.10g), hind limbs (454.04g), thoracic region (243.92g) and intestine (195.85g) than other dietary groups. Lumbar region (309.76g), stomach weight (79.44g) and intestinal length (62.75 cm) were significantly ($P<0.05$) higher in T_8 than the rest. However, cervical region (150.88g) and lungs weight (19.19g) were significantly ($P<0.05$) higher in T_9 than other dietary levels. Rabbit fed on T_4 had significantly higher heart weight (7.79g) than the other treatment groups. Cooked sunflower seed meal inclusion up to 20% is recommended for better growth performance and carcass characteristics in rabbit. Moreover, carcass characteristics of rabbit could be improved by supplementing cooked sunflower seed meal based diets for grower rabbits with up to 250ppm of Ronozyme®.

Keywords: Carcass characteristics, Enzyme supplementation, Grower rabbit, Performance, Sunflower seed meal

INTRODUCTION

Rabbit is increasingly becoming an important source of meat worldwide and is recommended for production especially in countries that are experiencing animal protein shortage (Ewuola *et al*., 2012). However, the high cost of feeds does not support the goal of increased availability of cheap animal protein especially in the developing countries through rearing of fast maturing animals like rabbits (Okpanachi *et al*., 2010). Feed, makes up about 70-80% of the total cost of livestock production as reported by Kellems and Church (2010). This is as a result of conventional feed ingredients used in formulating feed most especially cereals and those of protein sources which are scarce and expensive because they suffer stiff competition with channels in the food chain (Esonu *et al*., 2004). An alternative non-conventional source of energy and protein feedstuff is sunflower seed meal (SFSM) (Horvatovic *et al.,* 2015). Previous studies on the effects of SFSM as a replacement for soybean meal showed inconsistent results (Horvatovic *et al.,* 2014).

The inclusion of SFSM resulted in worse broiler performance in some studies (Abdelrahman *et al*., 2007; Peric *et al*., 2010), whereas in others the inclusion of SFSM up to 20% or at even higher levels (Rama Rao *et al*., 2006; Mushtaq *et al*., 2009) did not have any effects on average body weight or weight gain.Tropical plants according to Safwat *et al*. (2014) contain appreciable amount of protein, fat, minerals and carbohydrates that can support growth and production, however most of these plants contain anti-nutritional factors which have negative effects on digestion or absorption and utilization of nutrients.

Exogenous enzyme supplementation has been advocated as one of the ways or methods of alleviating the problems of anti-nutritional factors in feeds (Alu *et al*., 2012; Alu and Onazi 2018). Enzyme supplementation of diets enhances broiler performance by improving some of the basic production parameters such as average feed intake, feed conversion ratio, or average weight gain. There is dearth of information regarding the effect of enzyme supplemented sunflower based diets on growth and carcass characteristics of rabbit. Therefore, the aim of this study was to evaluate the effect of Ronozyme® hiphos supplementation on growth performance and carcass characteristics of grower rabbits fed cooked sunflower (*Helianthus annuus*) seed meal (SFSM) based diets.

MATERIALS AND METHODS

Experimental location

The study was carried out at the Research and Teaching Farm of Faculty of Agriculture Nasarawa State University Keffi, Shabu-Lafia Campus. It is located in the Guinea Savanna Zone of North Central Nigeria. It is located in latitude 08^0 35'N and longitude 08^0 33'E. The mean monthly maximum and minimum temperatures were 35.06°C and 20.16°C respectively at the time of the experiment while the mean monthly relative humidity and rainfall were 74.67% and 168-190mm, respectively (NIMET, 2019).

Source and Processing of Test Ingredient

Sunflower seed (SFS) the test ingredient was purchased at Gambali Unique Gardens Jos, Plateau State. It was then cooked, sun-dried, crushed and mixed with other feed ingredients to compound the experimental diets.

Chemical Analysis

Proximate analysis of sunflower seed (SFS) was carryout at the Animal Science Laboratory

Faculty of Agriculture, Nasarawa State University, Keffi, Shabu-Lafia Campus, using the standard procedure of AOAC (2002). Nitrogen Free Extract (NFE) was calculated using the formula: NFE (%) = 100 – CP + CF + EE + Moisture + Ash. *Metabolizable energy was calculated using Pauzenga Formula (1985) ME =37 x % CP + 81 x %EE + 35.5 x % NFE.

Experimental Diets

Nine experimental diets namely: T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 were compounded to be isocaloric (2500 kcal/kg, ME) and isonitrogenous (15% CP) having treatments T_1, T_2 and T_3 with 0% inclusion rate of SFS meal and 0, 150 and 250ppm of the enzyme supplementation. Treatments T_4 to T_6 and T_7 to T_9 had 10 and 20% levels of SFS meal inclusion rate, respectively but maintaining same levels of enzyme supplementation as in T_1 to T_3. This arrangement means that T_1, T_4 and T_7 serve as the control diets for T_2 and T_3, T_5 and T_6 and T_8 and T_9, respectively. Other ingredients were added to meet the nutrient requirements of grower rabbits as described by Olomu *et al*. (2019). The gross composition of the experimental diets is presented in Table 1.

Management of Rabbits and Experimental Design

Seventy-two cross-bred growing rabbits of about 6-7 weeks old with a mean weight of 567g were obtained from Dagwam Farms, National Veterinary Research Institute (NVRI) Vom, Jos, Plateau State. The rabbits were fed ad-libitum and had access to drinking water at all times and were administered anti-stress vitamin/mineral premix orally at the recommended dosage after randomization before the commencement of the experiment. Other management practices were adopted as described by Aduku (2004). The rabbits were paired and allotted to the 9 treatments and each treatment was replicated 4 times giving rise to a 3x3 factorial arrangement fitted into a Completely Randomized Design.

Data collection

Growth performance

Data on growth performances which include initial weight, final weight, daily weight gain, and total feed intake, were collected over a period of 42 days. The weekly weights of the rabbits were taken using a weighing scale. The difference in weight between feed given and feed left unconsumed was taken as the feed intake. Energy and protein intake were calculated as the quantity of each nutrient in the feed multiplied by the feed intake. Protein efficiency ratio (PER) was determined as gain in body weight to protein consumed. Energy efficiency ratio was calculated as gain in body weight to energy consumed. Feed efficiency was calculated as ratio of body weight gain and feed intake. Performance index was calculated as body weight gain divided by feed efficiency.

Carcass characteristics

At the termination of the feeding trial, two (2) rabbits per treatment of similar live weight were selected and used for carcass studies. Feed was withdrawn for twelve (12 hours) prior to slaughtering but water was supplied *ad libitum*. This was necessary in order not to confuse the weight of the carcass with that of undigested feed and also to prevent dehydration. The sacrificial rabbits were slaughtered, de-haired, eviscerated, split into wholesale cut-parts (head, neck, fore limbs, hind limbs, thoracic region, lumbar region and cervical region) and the organs (liver, kidney, heart and lungs) were weighed using sensitive scale while intestinal length was measured using a measuring tape.

Data analysis

All data obtained from the experiment were subjected to Analysis of Variance (ANOVA) as outlined in Completely Randomized Design (CRD) by Steel and Torrie (1980). Statistical compilations were done using Statistical Package for Social Sciences (SPSS, 2002) while significant difference between treatment means were separated using Duncan's Multiple Range Test (DMRT) (Duncan 1995).

Table 1: Feed and nutrient composition of the experimental diets fed to the grower rabbits

SFS(%)	**0**			**10**			**20**		
Enzyme (ppm)	**0**	**150**	**250**	**0**	**150**	**250**	**0**	**150**	**250**
Feed stuff	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**	**T_9**
Groundnut shell	10.00	10.00	10.00	13.00	13.00	13.00	21.00	21.00	21.00
Maize	30.00	30.00	30.00	21.00	21.00	21.00	11.00	11.00	11.00
Maize Bran	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Groundnut Cake	8.00	8.00	8.00	4.00	4.00	4.00	4.00	4.00	4.00
Sunflower seed meal (Cooked)	0	0	0	10.00	10.00	10.00	20.00	20.00	20.00
Vitamin /Minerals	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Maize	30.00	30.00	30.00	21.00	21.00	21.00	11.00	11.00	11.00
Rice Offal	25.00	25.00	25.00	25.00	25.00	25.00	20.00	20.00	20.00
Soybean (full fat)	17.00	17.00	17.00	17.00	17.00	17.00	14.00	14.00	14.00
Salt (NaCl)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Enzyme(ppm)	0.00	150	250	0.00	150	250	0.00	150	250
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Calculated chemical and energy composition									
Energy (kcal/kg ME)	2515.83	2515.83	2515.83	2532.51	2532.51	2532.51	2579.36	2579.36	2579.36
Crude protein (%)	15.31	15.31	15.31	15.04	15.04	15.04	15.26	15.26	15.26
Crude fibre (%)	8.32	8.32	8.32	11.03	11.03	11.03	15.77	15.77	15.77

Ether Extract (%)	8.52	8.52	8.52	7.56	7.56	7.56	7.13	7.13	7.13
Ash (%)	6.72	6.72	6.72	7.00	7.00	7.00	6.52	6.52	6.52
Calcium (%)	1.32	1.32	1.32	1.28	1.28	1.28	1.30	1.30	1.30
Phosphorus (%)	0.88	0.88	0.88	0.88	0.88	0.88	0.87	0.87	0.87
Lysine (%)	0.92	0.92	0.92	0.98	0.98	0.98	1.03	1.03	1.03
Methionine(%)	0.46	0.46	0.46	0.49	0.49	0.49	0.51	0.51	0.51

T_1 = Control without SFSM and enzyme supplementation, T_2 = 0% SFSM and 150ppm, T_3 = 0% SFSM and 250ppm, T_4 = 10% SFSM and without enzyme, T_5 = 10% SFSM and 150ppm, T_6 = 10% SFSM and 250ppm, T_7 =20% SFSM without enzyme, T_8 = 20% SFSM and 150ppm, T9 =20% SFSM and 250ppm. % = percentage, ppm = parts per million of Ronoxyme® HiPhos enzyme.

TABLE 2: PROXIMATE ANALYSIS OF COMPUNDDED FEEDS

SFS(%)	**0**			**10**			**20**		
Enzyme (ppm)	**0**	**150**	**250**	**0**	**150**	**250**	**0**	**150**	**250**
Feed stuff	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**	**T_9**
Dry matter	88.59	88.86	88.92	88.79	88.68	88.73	88.56	88.83	88.65
Crude protein	13.23	13.58	13.69	13.47	13.34	13.39	13.19	13.52	13.27
Ether extract (%)	3.51	3.69	3.75	3.61	3.45	3.47	3.56	3.64	3.53
Crude fibre (%)	7.22	6.54	6.46	6.79	6.92	6.88	7.36	6.61	7.27
Ash (%)	6.35	6.25	6.23	6.14	6.33	6.31	6.44	6.27	6.38
Nitrogen free extract	58.28	58.80	58.79	58.78	58.64	58.68	58.01	58.79	58.2
Energy (Kcal/kg ME)	2842.76	2888.75	2897.33	2877.49	2854.75	2859.64	2835.75	2882.13	2843.02

RESULTS AND DISCUSSION

Effects of sunflower seed meal (SFSM) inclusion levels on growth performance of growing rabbits

The result in Table 2 shows the effects of SFSM inclusion levels on growth performance of growing rabbits. Average daily weight gain, feed conversion ratio, protein efficiency ratio, feed efficiency and performance index of the rabbit were significantly (P<0.05) affected by different inclusion levels of SFSM. Average daily weight gain (6.13g, 7.74g, and 9.31g), protein efficiency ratio (0.77, 0.95 and 1.15), feed efficiency (0.10, 0.13 and 0.15) and performance index (0.61, 1.01 and 1.40) for 0, 10 and 20% respectively, were significantly (P<0.05) increased (20% > 10%> 0%) with increasing level of SFSM. Feed conversion ratio was significantly (P<0.05) lower in 10% (7.87) and 20% (6.53) SFSM based diets. On the contrary, Akande *et al*. (2009) earlier reported no significant effect of SFSM on average weight gain and feed conversion ratio of growing rabbits. Additionally, Adeniji and Ogunmodede (2006) reported no significant effect of sunflower seed cake on average daily weight gain and feed conversion ratio in broiler chickens. There was no significant (P>0.05) difference between the different inclusion level of SFSM on final weight (1636.67g, 1626.67g and 1760g), average daily feed intake(59.70g, 61.01g and 60.31g), protein intake(7.94g, 8.22g and 8.11g), energy intake(170.28, 175.43 and 172.89 Kcal/Kg ME), energy efficiency ratio (0.05, 0.04 and 0.05) and survival percentage (83.33%, 91.67% and 87.50%). Akande *et al*. (2009) reported similar feed intake when they fed control diet and inclusion of SFSM up to 20% level. Above this level there was a drastic reduction in the intake which could be attributed to the fact that the animals were able to meet their energy requirements at 20% level (Akande *et al*. 2009). The result of final live weight (1658.33- 1684.17g) is similar to the works of Adeniji and Ogunmodede (2006) who found no significant effect of sunflower in the final weight of broiler chickens. The non-significant difference in survival percentage indicates that SFSM has no detrimental effect on the survivability of growing rabbits.

Table 3: Effects of sunflower seed meal (SFSM) inclusion levels on growth performance of growing rabbit

	Level of sunflower seed meal (SFSM) inclusion (%)				
Parameter	**0%SFSM**	**10%SFSM**	**20%SFSM**	**SEM**	**LOS**
Initial body weight (g/rabbit)	1379.17	1301.67	1369.17	42.69	NS
Final body weight (g/rabbit)	1636.67	1626.67	1760.00	43.20	NS
Average daily weight gain (g/rabbit)	6.13^{c}	7.74^{b}	9.31^{a}	0.48	*
Average daily feed intake (g/rabbit)	59.34	60.93	60.76	0.72	NS
Feed conversion ratio	9.68^{a}	7.87^{ab}	6.53^{b}	0.78	*
Protein intake (g/rabbit)	8.01	8.16	8.10	0.10	NS
Protein efficiency ratio	0.77^{c}	0.95^{b}	1.15^{a}	0.06	*
Energy intake (Kcal/Kg ME)	170.70	174.50	173.41	2.07	NS
Energy efficiency ratio	0.04	0.04	0.05	0.00	NS
Survival percentage (%)	91.67	87.50	83.33	6.66	NS
Feed efficiency(FE)	0.10^{c}	0.13^{b}	0.15^{a}	0.01	*
Performance index(PI)	0.61^{c}	1.01^{b}	1.40^{a}	0.12	*

^{abc} means on the same row having different superscript differ significantly (P<0.05); NS = not significantly different (P>0.05); SEM = standard error of mean; LOS = level of significance; SFSM = sunflower seed meal

Effect of enzyme supplementation level on growth performance of growing rabbits fed SFSM based diets

Effect of enzyme supplementation level on growth performance of growing rabbit fed SFSM based diets is presented in Table 4. There was no significant (P>0.05) effect of enzyme supplementation in all the growth performance parameters measured. Rabbits may also benefit from probiotics and/or enzymes feed additives as they are highly dependent on hind gut fermentation to utilize their feed efficiently (Shanmuganathan, 2004**).** The result of feed intake in this study corroborates Raza *et al*. (2009) who reported no significant effect of enzyme supplementation on feed intake in finisher broiler chickens.

Table 4: Effect of enzyme supplementation level on growth performance of growing rabbit fed sunflower meal based diets

	Enzyme (ppm)				
Parameter	**0ppm**	**150ppm**	**250ppm**	**SEM**	**LOS**
Initial body weight (g)	1346.67	1345.00	1358.33	42.69	NS
Final body weight (g)	1680.83	1658.33	1684.17	43.20	NS
Average daily weight gain (g)	7.96	7.46	7.76	0.48	NS
Average daily feed intake (g)	59.70	61.01	60.31	0.72	NS
Feed conversion ratio	7.60	8.18	7.77	0.78	NS
Protein intake (g)	7.94	8.22	8.11	0.10	NS
Protein efficiency ratio	1.00	0.91	0.96	0.06	NS
Energy intake (g)	170.28	175.43	172.89	2.07	NS
Energy efficiency ratio	0.05	0.04	0.05	0.00	NS
Survival percentage (%)	83.33	91.67	87.50	6.66	NS
Feed efficiency (FE)	0.13	0.12	0.13	0.01	NS
Performance index(PI)	1.04	0.90	1.01	0.12	NS

[ab] means on the same row having different superscript differ significantly (P<0.05); NS = not significantly different (P>0.05); SEM = standard error of mean; LOS = level of significance;

Effect of SFSM and enzyme supplementation on growth performance of growing rabbit

Table 5 shows the effect of sunflower and enzyme supplementation on growth performance of growing rabbit. The final weight, average daily weight gain, average feed intake, feed conversion ratio, protein intake, energy intake and feed efficiency were not significantly (P>0.05) affected by interaction of SFSM and enzyme. The protein efficiency ratio of T_1 (0.85), T_2 (0.72), T_3 (0.73), T_5 (0.95) T_6 (0.79) T_7 (1.05) and T8 (1.04) incresed significantly. However, T_4 (1.10) and T_9 (1.37) were not significantly different. There was significantly (P<0.05) higher energy efficiency ratio in T_4 (0.05)), T_7 (0.05), T_8 (0.05) and T_9 (0.06). Although T_4 (0.05), T_7 (0.05) and T_8 (0.05) were not significantly (P>0.05) different from T_1 (0.04), T_5 (0.05) and T_6 (0.04). There was significantly (P<0.05) higher performance index in T_9 (2.01) compared to other treatment groups. The result which revealed a significant (P<0.05) increase in the interaction effect of SFSM and enzyme supplementation on protein efficiency ratio, energy efficiency ratio and performance index in this study might be attributed to the effect of enzyme on SFSM which lead to improved digestion and subsequent absorption of energy and protein content in the diets.

Table 5: Effects of SFSM and enzyme supplementation on growth performance of growing rabbit

SFSM(%)		**0**			**10**			**20**			
Enzyme (ppm)	**0**	**150**	**250**	**0**	**150**	**250**	**0**	**150**	**250**		
Parameter	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**	**T_9**	**SEM**	**LOS**
Initial body weight (g)	1392.50	1335.00	1410.00	1250.00	1332.50	1322.50	1397.50	1367.50	1342.50	73.93	NS
Final body weight (g)	1667.50	1582.50	1660.00	1630.00	1657.50	1592.50	1745.00	1735.00	1800.00	74.83	NS
ADBWG (g/rabbit/day)	6.55	5.89	5.95	9.05	7.74	6.43	8.27	8.75	10.89	0.84	NS
ADFI (g/rabbit/day)	58.40	60.01	59.62	61.12	60.65	61.02	59.59	62.38	60.30	1.25	NS
Energy intake (g/r)	166.01	173.36	172.74	175.86	173.14	174.50	168.99	179.79	171.44	3.59	NS
Feed conversion ratio	8.92	10.19	10.02	6.75	7.84	9.49	7.21	7.13	5.54	1.35	NS
Protein intake (g/)	7.73	8.15	8.16	8.23	8.09	8.17	7.86	8.43	8.00	0.17	NS
Protein efficiency ratio	0.85^{bc}	0.72^{c}	0.73^{c}	1.10^{ab}	0.95^{bc}	0.79^{bc}	1.05^{bc}	1.04^{bc}	1.37^{a}	0.10	*
Energy efficiency ratio	0.04^{bc}	0.03^{c}	0.04^{bc}	0.05^{ab}	0.05^{ab}	0.04^{bc}	0.05^{ab}	0.05^{ab}	0.06^{a}	0.00	*
Feed efficiency(FE)	0.11	0.10	0.10	0.15	0.13	0.11	0.14	0.14	0.18	0.01	NS
Performance index(PI)	0.72^{bc}	0.59^{c}	0.60^{c}	1.36^{b}	1.01^{bc}	0.73^{bc}	1.15^{bc}	1.24^{bc}	2.01^{a}	0.20	*
Survival percentage (%)	87.50	100.00	87.50	75.00	87.50	100.00	87.50	87.50	75.00	11.54	NS

^{ab} means on the same row having different superscript differ significantly (P<0.05); NS= not significantly different (P>0.05); SEM = standard error of mean; LOS = level of significance; SFSM = sunflower seed meal; T1 = Control without SFSM and enzyme supplementation, T2 = 0% SFSM and 150ppm, T3 = 0% SFSM and 250ppm, T4 = 10% SFSM and without enzyme, T5 = 10% SFSM and 150ppm, T6 = 10% SFSM and 250ppm, T7 =20% SFSM without enzyme, T8 = 20% SFSM and 150ppm, T9 =20% SFSM and 250ppm ;ADBWG = Average daily weight gain; ADFI = Average daily feed intake

Effects of different inclusion levels of SFSM based diets on carcass characteristics of growing rabbit

Table 6 shows the effects of different inclusion levels of SFSM based diets on carcass characteristics of growing rabbits. Head weight (134.72g, 167.19g and 167.92g), fore limbs (181.96g, 200.91g and 205.30g), lumbar region (238.78g, 254.20g and 271.65g), cervical (89,23g, 110.55g and 118.14g), lungs (12.99g, 13.12g and 14.36g) and intestinal length (58.52cm, 60.45cm and 61.32cm) for 0, 10 and 20% respectively, significantly (P<0.05) increased (0% < 10% < 20%) with increasing levels of sunflower seed meal. Dressed weight (1636.75g) and stomach weight (79.01g) were significantly (P<0.05) higher in rabbits fed 20% sunflower meal than 0% (1491.67 and 78.04g) and 10% (1481.75g and 78.01g) diets which were not significantly (P>0.05) different from each other. This observation may be attributed to the better average daily weight gain and feed efficiency recorded when the animals were fed increasing levels of sunflower meals. Rabbit fed on 10% SFSM based diet recorded significantly higher weight of neck (60.27g), hind limbs (380.43g), liver (45.80g), kidney (11.99g), intestine (194.18g) and heart (7.13g), than those fed the 0% and 20% diets. Nassiri *et al.*(2012) reported that thigh, gastrointestinal tract and liver were significantly increased due to increasing levels of sunflower meal in broilers diets. However, Christaki *et al*. (1994) found no effect of sunflower seed on carcass weight, carcass yield, liver, heart and gizzard weight of quail birds.

Table 5: Effect of SFSM based diets on carcass characteristics of growing rabbit

Parameters	0%SFSM	10%SFSM	20%SFSM	SEM	LOS
FLW (g)	1636.67	1626.67	1760.00	43.20	NS
DW (g)	1491.67^{b}	1481.75^{b}	1636.75^{a}	38.57	*
Head(g)	134.72^{c}	167.19^{b}	167.92^{a}	0.11	*
Neck(g)	52.07^{c}	60.27^{a}	53.50^{b}	0.06	*
Forelimbs(g)	181.96^{c}	200.91^{b}	205.30^{a}	0.03	*
Hind limbs(g)	349.36^{c}	380.43^{a}	357.42^{b}	0.06	*
TR (g)	181.12^{c}	200.71^{a}	190.55^{b}	0.03	*
LR (g)	238.78^{c}	254.20^{b}	271.65^{a}	0.04	*
CR (g/)	89.23^{c}	110.55^{b}	118.14^{a}	0.02	*
Liver(g/)	41.77^{c}	45.80^{a}	43.77^{b}	0.01	*
Kidney(g)	9.89^{c}	11.99^{a}	11.02^{b}	0.00	*
Lungs(g)	12.99^{c}	13.12^{b}	14.36^{a}	0.00	*
Intestine(l/)	58.52^{c}	60.45^{b}	61.32^{a}	0.01	*
Intestine(g)	190.52^{c}	194.18^{a}	193.51^{b}	0.03	*
Heart(g)	4.90^{c}	7.13^{a}	5.00^{b}	0.00	*
Stomach(g/)	78.04^{b}	78.01^{b}	79.10^{a}	0.01	*

^{ab} means on the same row having different superscript differ significantly (P<0.05); NS= not significantly different (P>0.05); SEM = standard error of mean; LOS = level of significance; SFSM = sunflower seed meal; FLW= Final live weight; DW= Dressed weight; TR= Thoracic region; LR=Lumbar region; CR= Cervical region.

Effects of enzymes supplementation on carcass characteristics of rabbit fed different inclusion of SFSM based diets

The result in Table 7 shows the effects of enzymes supplementation on carcass characteristics of rabbit fed different inclusion levels of SFSM based diets. There was significant (P<0.05) increase on weight of head (140.01-180.60g), fore limbs (177.36-198.61g), hind limbs (342.63-384.46g), thoracic region (172.93-204.74), cervical region (87.83-127.77g) and intestinal weight (59.55-60.55g) as the level of enzyme supplementation increases. Rabbits on 20% SFSM diet had significantly (P<0.05) higher weight of head (180.60g), fore limbs (212.20g), hind limbs (384.46g), thoracic region (204.74g), cervical region (127.77g), kidney (12.09g), lungs (14.99g), stomach (78.47g) and intestine weights (60.55g). This observation could be as a result of increase in the levels of enzyme supplement in the diets of the rabbits. Earlier, Adeyeye *et al*. (2018), supplemented enzyme in the diets of growing rabbits fed cocoa pods based diets and reported an increased weight of lungs. Similarly, Omojola and Adesehinwa (2007) reported improvement in relative weight of head and neck of broilers fed on diets supplemented with exogenous enzymes. Neck (55.72g) and heart (6.73g) weights of 0% SFSM diet was significantly (P<0.05) higher than the other treatment groups. There was no significant (P>0.05) difference between 0% SFSM and 10% in intestine (59.55 and 60.19g) and stomach (78.34 and 78.34g) weights respectively. The reduction in heart and neck weight could be attributed to the increased level of enzyme supplementation.

Table 6: Effects of enzymes supplementation on carcass characteristics of rabbit fed SFSM based diets

Parameters	0ppm	150ppm	250ppm	SEM	LOS
FLW (g)	1680.83	1658.33	1684.17	43.20	NS
DW (g)	1528.00	1523.58	1558.58	38.57	NS
Head(g)	140.01^{c}	149.21^{b}	180.60^{a}	0.11	*
Neck(g)	55.72^{a}	54.80^{c}	55.32^{b}	0.06	*
Forelimbs(g)	177.36^{c}	198.61^{b}	212.20^{a}	0.03	*
Hind limbs(g)	342.63^{c}	360.12^{b}	384.46^{a}	0.06	*
TR (g)	172.93^{c}	194.71^{b}	204.74^{a}	0.03	*
LR (g)	244.61^{b}	288.71^{a}	231.32^{c}	0.04	*
CR (g)	87.83^{c}	102.32^{b}	127.77^{a}	0.02	*
Liver(g)	43.53^{b}	44.53^{a}	43.27^{c}	0.01	*
Kidney(g)	10.72^{b}	10.09^{c}	12.09^{a}	0.00	*
Lungs(g)	12.92^{b}	12.56^{c}	14.99^{a}	0.00	*
IW (g)	59.55^{c}	60.19^{b}	60.55^{a}	0.01	*
IL(cm)	192.85^{a}	192.85^{a}	192.51^{b}	0.03	*
Heart(g)	6.73^{a}	5.63^{b}	4.66^{c}	0.00	*
Stomach(g)	78.34^{b}	78.34^{b}	78.47^{a}	0.01	*

^{abc} means on the same row having different superscript differ significantly (P<0.05); NS= not significantly different (P>0.05); SEM = standard error of mean; LOS = level of significance; FLW= Final live weight; DW= Dressed weight; TR= Thoracic region; LR= Lumbar region; CR= Cervical region; IW= Intestine weight; IL= Intestine length.

Effects of SFSM based diets and enzyme supplementation on carcass characteristics of rabbits

Presented in Table 8 is the effect of SFSM and enzyme on carcass characteristics of rabbit fed SFSM based diets. Interaction effects between SFSM and enzyme showed significant ($P<0.05$) increase in the weight of head, neck, forelimbs, hind limbs, thoracic region, lumbar region, cervical region, liver, kidney, lungs, intestine, heart and also the length of intestine. However, no significant ($P>0.05$) interaction effect was observed on final weight and dressed weight. Treatment six (T_6) recorded higher weight in head (205.90g), neck (73.61g), fore limbs (260.10g), hind limbs (454.04g), thoracic region (243.92g) and intestine length (195.85cm) than other dietary groups. This might be attributed to the supplementation of 150ppm enzyme to the 10% SFSM based diets which encouraged digestion and absorption of inherent nutrients in the diets. On the contrary, Horvatovic *et al*. (2015) reported no significant ($P>0.05$) effect of enzyme on carcass characteristics of broilers supplemented with enzyme. Lumbar region (309.76g), stomach weight (79.44cm) and intestinal weight (62.75 g) were significantly higher in T_8 than the other treatment groups. However, cervical region (150.88g) and lungs weights were significantly ($P<0.05$) higher in T_9 than other dietary levels. Rabbit fed on T_4 had significantly higher heart weight (7.79g) than the other treatment groups.

Table 8: Effect of SFSM and enzyme on carcass characteristics of rabbit fed SFSM based diets

SFSM(%)		**0**			**10**			**20**			
Enzyme (ppm)	**0**	**150**	**250**	**0**	**150**	**250**	**0**	**150**	**250**		
Parameters	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**	**T_9**	**SEM**	**LOS**
FLW (g)	1667.50	1582.50	1660.00	1630.00	1657.50	1592.50	1745.00	1735.00	1800.00	74.83	NS
DW (g)	1495.00	1478.75	1501.25	1489.00	1481.25	1475.00	1600.00	1610.75	1699.50	66.81	NS
Head(g)	135.17^{i}	132.93^{h}	136.07^{g}	138.68^{f}	156.98^{d}	205.90^{a}	146.19^{e}	157.72^{c}	199.84^{b}	0.19	*
Neck(g)	50.60^{e}	62.72^{c}	42.89^{i}	49.88^{f}	57.32^{d}	73.61^{a}	66.68^{b}	44.35^{h}	49.46^{g}	0.11	*
Fore limbs(g)	199.14^{e}	177.96^{g}	168.77^{h}	141.29^{i}	201.34^{d}	260.10^{a}	191.65^{f}	216.53^{b}	207.74^{c}	0.06	*
Hind limbs(g)	361.42^{d}	356.92^{e}	329.74^{h}	330.64^{g}	356.62^{e}	454.04^{a}	335.84^{f}	366.81^{c}	369.61^{b}	0.11	*
TR (g)	166.17^{h}	177.16^{e}	200.04^{c}	187.25^{d}	170.97^{f}	243.91^{a}	165.37^{i}	236.01^{b}	170.27^{g}	0.06	*
Lumbar region(g)	223.72^{h}	282.38^{b}	210.23^{i}	234.62^{f}	273.98^{d}	254.00^{e}	275.48^{c}	309.76^{a}	229.72^{g}	0.08	*
Cervical region(g)	90.23^{g}	86.93^{h}	90.53^{f}	93.03^{e}	96.72^{d}	141.89^{b}	80.24^{i}	123.30^{c}	150.88^{a}	0.03	*
Liver(g)	44.37^{c}	40.17^{i}	40.77^{h}	43.87^{d}	50.76^{a}	42.77^{e}	42.37^{g}	42.67^{f}	46.26^{b}	0.01	*
Kidney(g)	10.19^{f}	8.29^{i}	11.19^{d}	13.29^{e}	8.29^{h}	14.39^{a}	8.69^{g}	13.69^{b}	10.69^{e}	0.00	*
Lungs(g)	13.39^{d}	13.29^{e}	12.29^{g}	14.59^{b}	11.29^{h}	13.49^{c}	10.79^{i}	13.09^{f}	19.19^{a}	0.00	*
IW(g)	59.35^{f}	57.75^{i}	58.45^{h}	58.85^{g}	60.05^{e}	62.45^{b}	60.45^{d}	62.75^{a}	60.75^{c}	0.02	*
IL (cm)	192.85^{d}	188.85^{h}	189.85^{g}	191.85^{f}	194.85^{b}	195.85^{a}	193.85^{c}	194.85^{b}	191.85^{e}	0.06	*
Heart(g)	6.70^{c}	3.90^{g}	4.10^{f}	7.79^{a}	7.29^{b}	6.30^{d}	5.70^{e}	5.70^{e}	3.60^{h}	0.00	*
Stomach(g)	77.84^{g}	78.54^{e}	77.74^{h}	78.04^{f}	77.04^{i}	78.94^{c}	79.14^{b}	79.44^{a}	78.74^{d}	0.02	*

^{abcdefghi} means on the same row having different superscript differ significantly (P<0.05); NS= not significantly different (P>0.05); SEM = standard error of mean; LOS = level of significance; SFSM = sunflower seed meal ; T1 = Control without SFSM and enzyme supplementation, T2 = 0% SFSM and 150ppm, T3 = 0% SFSM and 250ppm, T4 = 10% SFSM and without enzyme, T5 = 10% SFSM and 150ppm, T6 = 10% SFSM and 250ppm, T7 =20% SFSM without enzyme, T8 = 20% SFSM and 150ppm, T9 =20% SFSM and 250ppm; FLW= Final live weight; DW = Dressed weight; TR= Thoracic region; IW= Intestine weight; IL= Intestine length.

CONCLUSIONS

Based on the results of this research, the following conclusion and recommendations can be made;

i. Inclusion of 20% cooked sunflower seed meal showed better average weight gain, feed conversion ratio, protein efficiency ratio, feed efficiency and performance index in rabbits.

ii. Supplementation of sunflower seed meal based diets with 0ppm, 150ppm and 250ppm Ronozyme enzyme showed no variation in growth performance of grower rabbits.

iii. Ronozyme enzyme supplementation in sunflower seed meal of protein efficiency ratio, energy efficiency ratio and performance index in grower rabbits.

iv. Addition of sunflower seed meal up to 20% had better carcass characteristics (dressed weight, head weight, forelimbs, lumbar region, cervical region, lungs, stomach weight and intestinal length) parameters in grower rabbits.

RECOMMENDATIONS

Cooked sunflower seed meal inclusion up to 20% is recommended for better growth performance of grower rabbits

Carcass characteristics of rabbit can be improved by supplementing up to 250ppm of Ronozyme® hiphos in cooked sunflower based diets for growing rabbits.

REFERENCES

Abdelrahman, M. M., Saleh F. H. (2007). Performance of broiler chickens fed on corn sunflower meal diets with ß-glucanase enzyme. *Jordan Journal of Agricultural Sciences*, 3(3):272-280.

Adeniji, C. A. and Ogunmodede, B. K. (2006). Growth, nutrient retention and serum metabolites of broiler chickens fed high fibre hulled sunflower seed cake. *Nigerian Journal of Animal Production.* 33(2): 222-229.

Adeyeye, S. A., Agbede, J. O., Aletor, V. A. and Oloruntola, O. D. (2018). Performance and carcass characteristics of growing rabbits fed diets containing graded levels of processed cocoa (*Theobroma cacao*) pod husk meal supplemented with multi-enzyme. *Journal of Applied Life Sciences International,* 17(2): 1-11.

Aduku, A. O. (2004). Animal nutrition in the tropics; Feeds and feeding, pasture management, monogastric and Ruminant nutrition. pp. 17-18.

Akande, K. E., Abubakar, M. M., Adegbola, T. A. Bogoro, S. E., and U. D. Doma. (2009). Effect of feeding graded levels of roasted sunflower meal on the performance, nutrient digestibility and carcass characteristics of rabbits. *Continental J. Animal and Veterinary Research* 1: 31 – 37.

Alu, S. E., Tuleun, C. D., Kaankuka, F. G. and Carew, S. N. (2012). Meat quality of female quails (*Cortunixcortunix japonica*) fed low or high fibre diets supplemented with Maxigrain® enzyme. *Pakistan Journal of Nutrition* 11 (12): 1101-1106 ISSN 1680-5194 © Asian Network for Scientific Information.

Alu, S. E. and Onazi, B. O. (2018). Chemical composition of sunflower (*Heliathus annus*) seeds (SFS) as influenced by three

different processing methods. *International Journal of Applied Biological Research (IJABR)*, 9 (1): 184-200.

AOAC, (2002) Association of official Analytical Chemists. Official methods of Analysis.(17th Ed).A Publication of the Association of official Analytical chemists, Washington, D.C. pp 52-157.

Christaki, E. V., Florou-Paneri, P., Tserveni-Gousi, A. L. and Spais, A. V. (1994). Performance and carcass characteristics of growing Japanese quail. *Animal Feed Science and Technology*. 48 (1-2): 169-174.

Duncan, D. B. (1955). Multiple Ranges and Multiple F Test. *Biometric*, 11: 1-42.

Esonu, B. O., Azubuike, J. C., Ukwu, H. O. and Nneji, C. S. (2004). Effect of enzymes supplementation on the performance of broilers finishers fed *Microdesmis pubercula* leaf meal. *International Journal of Poultry Science*. 3: 112-114.

Ewuola, E. O., Jimoh, O. A., Atuma, O. V. and Sodipe, O. D. (2012). Haematological and serum biochemical response of growing rabbits fed graded levels of *Moringaoleifera* leaf meal. *Proceeding of the 10th World Rabbits Congress* September 3-6 2012; Sharon –Elsheikh-, Egypt, pp 679-683.

Horvatovic, M. P., Glamocic, D., Zikic, D. and Hadnadjev, T. D. (2015). Performance and some intestinal functions of broilers fed diets with different inclusion levels of sunflower meal and supplemented with or not with enzymes. *Brazilian Journal of Poultry Science*, 17(1): 25-30.

Kellems, R. O and Church, D. C. (2010). Livestock feeds and feeding Boston, Massachusetts, USA. Prentice hall.

Mushtaq, T., Sarwar, M., Ahmad, G., Mirza, M.A., Ahmad, T., Noreen, U., Mushtaq, M.M.H. and Kamran, Z. (2009). Influence of sunflower meal based diets supplemented with exogenous enzyme and digestibile lysine on performance, digestibility and carcass response of broiler chikens. *Animal Feed Science and Technology*, 49:275-286.

Nassiri M, H.,Salari, S., Arshami, J., Golian, A. and Maleki, M. (2012). Evaluation of the nutritional value of sunflower meal and its effect on performance, digestive enzyme activity, organ weight, and histological alterations of the intestinal villi of broiler chickens. *Journal of Applied Poultry Research*, 21(2): 293-304.

NIMET (2019). Nigerian Meteorological Agency, Lafia, Nasarawa State.

Okpanachi, U., Aribido, S.O and Daikwo, I.S. (2010).Growth and haematological response of growing rabbits to diets containing graded levels of sun-dried bovine rumen content. *Africa Journal of Food Agriculture, Nutrition and Development*, 10 (11): 4444-4457.

Olomu, J. M., Bamikole, M. A. and Olomu, C. E. B. (2019). Rabbit production and nutrition: Principles and practice. First Edition. ISBN: 978-9785-978510394-7. A Jachem Publication. pp.158.

Omojola A. B. and Adesehinwa A. O. K. (2007). Performance and carcass characteristics of broiler chickens fed diets supplemented with graded levels of Roxazyme G. *International Journal of Poultry Science*, 6(5):335-339.

Pauzenga, U. (1985). Feeding parent stock. Zootecnica International. December 1985 PP.22 –24.

Peric, L., Milic, D. and Bjedov, S. (2010). The effect of sunflower meal on growth performance of broiler chicks. *Proceedings of the 13th European Poultry Conference*; Tours. France

Rama Rao, S. V., Raju, M. V. L. N., Panda A. K. and Redely, M. R. (2006). Sunflower seed meal as a substitute for soybean meal in commercial broiler chicken diets. *British Poultry Science*, 47:592-598.

Raza, S., Ashraf, M., Pasha, T. N and Latif, F (2009). Effect of enzyme supplementation of broiler diets varying containing level of sunflower meal and crude fiber. *Pakistan Journal Botany*. 41 (5): 2543-2550.

Safwat, A. M., Sarmiento-Franco, L. and Santos-Ricalde, R. H (2014). Rabbits production using local resources as feedstuffs in the tropics. Tropical and Subtropical Agroecosystems, 17: 161-171. Review Article. Retrieved on the 26th of April 2018 at http://www.researchgate.net/publication/270894065.

Shanmuganathan, T., Samarasinghe, K. and Wenk, C. (2004). Supplemental enzymes, yeast culture and effective micro-organism culture to enhance the performance of rabbits fed diets containing high levels of rice bran, Asian-Australian *Journal of Animal science* (5); 678-683.

SPSS. (2002)Version 25. Statistical Package for Social Sciences

Steel, R. G. D. and Torries, J. H. (1980). Principles and procedures of statistics: A Biometrical Approach. McGraw Hill Int.books Co., New York. NY.