Asian Journal of Advances in Agricultural Research

2(3): 1-7, 2017; Article no.AJAAR.35742
ISSN: 2456-8864

Effect of Pumpkin (*Cucurbita pepo* L.) Seed Meal on the Performance and Carcass Characteristics of Broiler Chickens

R. J. Wafar[1*], M. I. Hannison[2], U. Abdullahi[2] and A. Makinta[3]

[1]Department of Animal Production and Health, Federal University, Wukari, P.M.B. 1020, Wukari, Taraba State, Nigeria.
[2]Department of Animal Science and Range Management, Modibbo Adama University of Technology, P.M.B. 2076, Yola, Adamawa State, Nigeria.
[3]Department of Animal Health and Production, Mohammed Lawan College of Agriculture, Maiduguri, P.M.B. 1427, Maiduguri, Borno State, Nigeria.

Authors' contributions

This work was carried out in collaboration between the authors. Author RJW designed, coordinated data collection and wrote the protocol. Author MIH performed the analysis and wrote the first draft of the manuscript. Author UA managed the analyses of the study. Author AM managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAAR/2017/35742
Editor(s):
(1) Dr. Tancredo Souza, Centre for Functional Ecology, Department of Life Sciences, University of Coimbra, Portugal.
Reviewers:
(1) Hakan İnci, Bingol University, Turkey.
(2) M.Sakthi Priya, Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), India.
(3) Md. Abu Sayed, Hajee Mohammad Danesh Science and Technology University, Bangladesh.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/20913

Original Research Article

Received 27th July 2017
Accepted 24th August 2017
Published 11th September 2017

ABSTRACT

A 56 days study was conducted using two hundred (200) *Anak – 2000* one week old chicks to evaluate the effects of feeding varying levels of pumpkin seed meal (PSM) on the growth performance and carcass characteristics of broiler chickens. The chicks were randomly assigned to five dietary treatments consisting of four replicates of ten birds per replicate in a completely randomized design (CRD). Five broiler chicken (starter and finisher) diets were formulated such that diet T1 (control) contained 0.0% pumpkin seed meal (PSM) while diets T2, T3, T4 and T5 contained 5.0%, 10.0%, 15.00% and 20.0% PSM respectively. The study lasted for 56 days. The

**Corresponding author: Email: wafar@fuwukari.edu.ng, rjwafari@gmail.com;*

result of growth performance showed that, final body weight, total body weight gain and average daily weight gain significantly increased (P<0.05) as the levels of PSM increased in the diets. While total feed intake and feed conversion ratio did not differ significantly among dietary treatments There was significant differences (P<0.05) among dietary treatments for live weight and dressed weight, though no particular pattern was observed. Dressing percent, breast, thigh, abdominal fat, kidney, gizzard, liver and lungs weights did not differ significantly as the levels of PSM increased in the diets. It was concluded from the study that pumpkin seed meal is a good source of crude protein and can substitute soybean meal in a broiler chicken diet up to 20.00% since the study did not record any adverse effect on the internal organs.

Keywords: Broilers; pumpkin seed meal; performance; carcass characteristics.

1. INTRODUCTION

The use of conventional feedstuffs such as soybean seeds in poultry feed formulation has become very prominent because of its high crude protein content ranging from 44-47% [1]. In broiler diets, about 20-37% of Soybean is used as a source of protein [2]. High demand for soybean seeds for animal feed formulation and for human consumption has increased the cost of livestock production most especially poultry production in developing countries thereby making poultry products expensive. There is need therefore, to search for other readily available alternatives protein source in order to protect poultry industry in the Nigeria.

Pumpkin (*Cucurbita pepo*) *seed* is one the alternatives that has the potential to serve as protein source in the poultry industry because of its high crude protein content. [3] reported that pumpkin seed contains 30.60 % crude protein, 4.5% Ash, 34.5 % ether extract and 16.24% crude fiber. In Nigeria, pumpkin is cultivated with no commercial importance attached to the seeds. The plant plays an important role in the traditional setting as a cover crop and weed control agent. It is however, grown among Nigerian tribes as a vegetable crop mainly for its leaves, fruits and seed and consumed either by boiling the leaves and the fruits or roasting or baking the seeds [4]. It is known among some Nigerian ethnic groups as '*Kabewa*' in Hausa language and '*Elegede*' in Yoruba language. [3] reported 10% inclusion of pumpkin seed in a broiler diets gave similar treatment effect as that of the control. However the use of Pumpkin seed meal beyond 10% inclusion in broiler diets is lacking. Therefore, the study was designed to evaluate the growth performance, carcass characteristics of broiler chickens fed varying levels (5 – 20%) of pumpkin seed meal.

2. MATERIALS AND METHODS

2.1 Study Site

The study was conducted at the Poultry Research Unit of the Department of Animal Science and Range Management, Modibbo Adama University of Technology Yola, Adamawa State. The study area lies between Latitude 7^{o} and 11' North of the Equator and Longitude 11^{o} 14' East of the Greenwich Meridian. Dry season lasts for a minimum of five months (November-March) while the wet season starts from April to October. It has average annual rainfall of about 700 mm – 1600 mm and relative humidity that ranges from 5 to 42% and average maximum temperature of 39°C [5].

2.2 Experimental Diets, Experimental Design and Management

The diets were formulated using pumpkin seed meal at 0%, 5%, 10%, 15% and 20% levels of inclusion designated as T1, T2, T3, T4 and T5 respectively as shown in (Table 1). Two hundred (200) day old *Anak 2000* broiler chicks procured from Agric. TeD along May-Belwa road Adamawa State Nigeria. The chicks were brooded for one week on commercial starter diet then randomly allocated to five dietary treatments of four replicate with ten birds per replicate in completely randomised designed. The birds were managed on a deep litter system throughout the experimental period which lasted for 56 days.

2.3 Data Collection

Experimental birds were weighed at the beginning of the study to obtain their initial body weights and then weekly, thereafter. Daily feed intake was determined by subtracting the weight of feed left over feed from the weight of the feed offered.

Table 1. Ingredient composition of broiler chicken diets

Ingredients	Starter diets					Finisher diets				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Maize	54.00	54.00	54.00	54.00	54.00	49.00	49.00	49.00	49.00	49.00
Soybean cake	20.00	15.00	10.00	5.00	00.00	20.00	15.00	10.00	5.00	0.00
PSM	0.00	5.00	10.00	15.00	20.00	0.00	5.00	10.00	15.00	20.00
Wheat bran	15.00	15.00	15.00	15.00	15.00	19.00	19.00	19.00	17.00	17.00
Flour milling waste	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Fishmeal	2.75	2.75	2.75	2.75	2.75	3.75	3.75	3.75	3.75	3.75
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Premix*	0.25	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	0.25
Limestone	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	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
Calculated analysis (%)										
Crude protein	22.09	22.10	22.10	22.11	22.10	19.01	19.01	19.02	19.04	19.02
Crude fiber	3.90	3.91	3.97	3.92	3.93	3.08	3.07	3.08	3.08	3.09
Ether extracts	4.14	4.16	4.15	4.14	4.15	4.10	4.08	4.10	4.09	4.12
Ash	5.05	5.06	5.09	5.10	5.08	5.05	5.05	5.04	5.06	5.04
Lysine	1.95	1.90	1.91	1.89	1.93	1.73	1.71	1.74	1.73	1.75
Calcium	1.83	1.91	1.93	1.91	1.91	1.83	1.81	1.81	1.80	1.81
Phosphorous	0.90	0.89	0.88	0.87	0.86	0.90	0.91	0.90	0.89	0.89
Methionine	1.20	1.24	1.23	1.25	1.25	1.24	1.11	1.12	1.11	1.12
ME Kcal/kg	2610	2590	2600	2630	2640	2850	2800	2889	2890	2870

** 0.25 kg of Mineral/ Vitamin Premix manufactured by Animal care LTD provided the following: Vitamin A 1,800IU, Vitamin D 250IU, Vitamin E 8, 000IU, Vitamin K 750 mg, B1 750 mg, B_2 1000 mg, B_6 800 mg, B_{12} 25 mg Folic 300 mg, Niacin 5000 mg, Pantothenate 3000 mg, Biotin 25 mg, Choline 160 g, Thyroxine 300 mg, Copper 0.4 g, Iron 4 g, Manganese 5.5 g, Iodine 0.2 g, Zinc 5 g, Cobalt 0.15 g, Selenium 0.15 g*

2.4 Carcass Evaluation

At the end of the study (56 days), twelve birds were randomly selected from each treatment (three per replicate) for carcass and internal organ weights evaluation. The birds were starved of feed overnight to reduce the gut content. The birds were sacrificed plucked, eviscerated and internal organs removed and weighed. Dressing percent of the bird was determined thus: Dressing % = $\frac{\text{Dressed weight}}{\text{live weight}} \times 100$.

2.5 Chemical Analysis

Proximate analysis the experimental diets and pumpkin seed meal were analyzed for dry matter, crude protein, crude fibre, ether extracts, ash, oxalate, phytate and hydrocyanic acid as described by A.O.A.C [6]. Metabolisable energy was calculated according to the formula of [7].

2.6 Statistical Analysis

Data were subjected to one way analysis of variance (ANOVA) in a completely randomized design (CRD) according Steel and Torrie [8] using SPSS version 20. Treatment means were separated using Duncan's multiple range test (DMRT) option the same software.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Experimental Diets

The proximate composition of the experimental diets (starter and finisher) is presented in Table 2. The crude protein (CP) of the starter diets ranged from 22.14% in T1 to 22.15% in T4. These values are within the recommended values of 22 -24% and 20-23% reported by [9,10] for broiler starter.

Table 2. Proximate composition of experimental diets

Parameters	Starter diets					Finisher diets				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Dry matter	90.23	90.16	90.34	90.89	91.21	89.92	89.86	89.76	89.78	89.79
Crude protein	22.13	22.14	22.14	22.15	22.13	19.16	19.18	19.20	19.19	19.20
Crude fibre	5.12	6.21	6.37	6.32	6.33	6.28	6.41	6.42	6.48	6.51
Ether extracts	6.21	6.18	6.10	6.12	6.15	6.19	6.08	6.10	6.09	6.12
Ash	6.75	6.03	6.10	6.13	6.14	6.55	6.35	6.32	6.33	6.34
NFE	60.39	59.34	59.29	59.28	59.25	61.82	61.98	61.96	61.91	61.83
ME Kcal/kg	2710	2740	2740	2750	2760	2990	2890	2910	2960	2940

The finisher diets recorded crude protein ranging from 19.16% in T1 to 19.20% in T3 and T5. These values are within the range 19.67 – 20.36% reported by [11,12] and [13]. Crude fibre content of both starter and finisher diets varied from 5.12 – 6.51%. This result did not agreed with the opinion of [8] that it is necessary to maintain fibre level of 3.5 – 5% in a broiler diet. The fibre contents of both the starter and the finisher diets are higher than the value of 2.70% recommended by [9]. Ether extracts for both starter (6.10 – 6.21%) and finisher 6.08 – 6.19%) diets were however higher than value recommended by [14] for broiler chickens.

3.2 Proximate Composition of Pumpkin Seed Meal (PLM)

The result of the proximate composition of pumpkin seed meal (PSM) is shown in Table 3. PLM had crude protein (CP) content of 28.53%, crude fibre (CF) was 21.58%, while ether extracts (EE) and ash contents were 37.18 and 6.71% respectively. The CP content of PSM recorded in this study was lower than 29.81% reported b [15] 30.60% by [3], 32.86% by [16] but higher 27.48% reported by [17]. However, the CP content is within the range of 25 – 35% reported by [18], 28 – 40.49% by [19], similar to 29.81% reported by [15]. The ether extracts (EE) was lower than of 73.59% reported by [19], 45.67% by [15] and 43.46% by [16]. The concentration of oxalate (0.021 mg/100 g) recorded in this study is similar to 0.023 mg/100 g reported by [17]. High oxalate concentration in a diet increases the risk of renal calcium absorption [20]. The level of oxalate in the seed meal is not high to pose any health threat to the animals. The phytate content (34.17 mg/100) of the seed meal is lower than that of *Danniellea oliveri* kernel seed 51.05 mg/100 g [21]. Phytate have been reported to bind some essential mineral nutrients in the digestive tract and can result in mineral deficiencies [22]. Variations in the nutrient composition could be as a result of climatic condition, geographical location and methods of processing employed. These results conclusively confirmed the dependency of nutritional content of these seeds to regional climates [16].

Table 3. Chemical composition of pumpkin (*Cucurbita pepo* L.) seed meal

Parameters	% composition
Dry matter	94.48
Crude protein	28.53
Crude fibre	21.58
Ether extracts	37.18
Ash	6.71
Nitrogen free extracts	26.00
ME Kcal/Kg	4992.06
Cyanide	0.27 mg/100 g
Phytate	34.17 mg/100 g
Oxalate	0.02 mg/100 g

Metabolizable energy = ME (kcal/kg) = 37 x % CP + 81 x % EE + 35.5 x % NFE.
Calculated according to the formula of [7]

3.3 Performance of Broiler Chicken of Broiler Chicken Fed Pumpkin Seed Meal

The result of the performance of broiler chicken fed pumpkin seed meal is presented in Table 4. Final body weight, total body weight gain and average daily weight gain significantly increased ($P<0.05$) as the levels of PSM increased in the diets. Final body weight and total feed intake ranged from 1321.50 to 1584.25 g and 3287.28 to 3477.26 g respectively. Increase in final body weight and total weight gain as the level of PSM increases in the diets could be attributed to balance in nutrient composition and proper metabolism associated with the seed meal. [23] opined that imbalance in nutrient composition

and improper metabolism of diets are some of the factors affecting muscle development and growth among in animals. Feed intake was not (P>0.05) influenced by dietary inclusion of PSM in diets. This result disagreed with the finding of [3] who reported that there was significant (p>0.05) increased in feed intake a when broiler chickens were fed with I and 10% pumpkin seed meal. Feed conversion ratio did not differ significantly (p>0.05) among the treatment groups. The values recorded are within the range of 2.1 -5.1 reported by [24] for broiler under tropical environment. Better feed conversion ratio observed could be attributed to proper digestion, absorption and utilization of nutrients.

3.4 Carcass Yield and Internal Organ Characteristics of Broiler Chicken Fed Pumpkin Seed Meal

Table 5 shows the result of carcass and internal organ characteristics. There was significant differences (P<0.05) among dietary treatments for live weight, dressed weight, dressing percent while breast weights, thigh, kidney, gizzard, liver and lungs weight did not differ significantly (p>0.05). Dressed weight and breast weight varied from 1000.85g in T2 (5%) to 1530.12g in T1 (0%) and 353.35g in T1 (0%) to 378.69g in T5 (20%). Dressing percent ranged from 73.07% - 78.88%. While abdominal fat, kidney, gizzard, liver and lungs weights ranged from 14.52 – 17.02, 7.88 – 8.77, 46.30 – 47.86, 16.95 – 18.09 and 6.47 to 6.93 respectively. The dressing percent recorded in this study is similar to the values 73.15 – 89.49% obtained by [25,26] for broiler chicken in the tropics. These results showed that nutrition exert several influence on the development of carcass traits, organs and muscular growth in broiler. The result of internal weight organs similar across the dietary treatments. It is evident that increasing levels of PLM in the diet did not affect the internal organs. [27] and [28] reported that liver and kidney are the major organs of detoxification abnormalities will arise because of increased metabolic rate of the organs in an attempt to reduce the toxic elements or to convert the anti -nutritional agents to non-toxic metabolites.

Table 4. Performance of broiler chicken fed pumpkin seed meal

Parameters	Inclusion levels of pumpkin seed meal					
	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)	SEM
Initial weight (g)	151.00	151.00	151.25	151.25	150.25	0.75^{ns}
Final body weight	1584.25^{a}	1321.50^{c}	1455.50^{b}	1572.75^{a}	1576.25^{a}	10.50^{*}
Total weight gain (g)	1433.25^{a}	1170.50^{c}	1304.25^{b}	1421.50^{a}	1425.00^{a}	9.50*
Total feed intake (g)	3477.26	3287.28	3310.36	3457.49	3469.91	14.70^{ns}
Average daily feed intake(g)	62.07	58.70	59.11	61.74	61.96	0.60^{ns}
Average daily weight gain (g)	25.59^{a}	20.90^{c}	23.29^{b}	25.38^{a}	25.44^{a}	0.20^{*}
Feed conversion ratio	2.42	2.80	2.53	2.43	2.43	0.02^{ns}

*Means on the same row with different subscripts are significantly different (p<0.05) *, ns= not significant (P>0.05)*

Table 5. Carcass and internal organ weight of broiler chicken fed pumpkin seed meal

Parameters	Inclusion levels of pumpkin seed meal					
	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)	SEM
Live weight (g)	1530.12^{a}	1290.00^{c}	1401.90^{b}	1511.45^{a}	1522.25^{a}	10.67^{*}
Dressed weight (g)	1118.16^{b}	1000.85^{c}	1105.93^{b}	1135.93^{a}	1130.99^{a}	9.01*
Dressing percent	73.07	77.58	78.88	75.15	74.29	3.77^{ns}
Breast weight (g)	353.35	358.46	362.86	369.96	378.69	3.87^{ns}
Thigh weight (g)	168.97	170.23	154.94	163.44	170.24	8.63^{ns}
Abdominal fats	14.52	14.78	15.42	17.02	15.34	1.31^{ns}
Kidney	8.45	8.26	8.42	8.77	7.88	0.49^{ns}
Gizzard	47.73	46.30	48.56	47.22	47.86	0.78^{ns}
Liver	18.09	17.10	16.95	17.61	17.26	1.31^{ns}
Lungs	6.60	6.47	6.62	6.68	6.93	0.28^{ns}

*Means on the same row with different subscripts are significantly different (p<0.05) *, ns = not significant (P>0.05)*

4. CONCLUSION

This study clearly shown that pumpkin seed meal is a good source of crude protein substitute for soybean meal in broiler chicken. The study however did not record any adverse effect of pumpkin seed meal on all the parameters studied. Therefore, Pumpkin seed meal can be added in broiler chicken diets up to 20.00%.

ETHICAL CONSIDERATION

The study was conducted with permission from the animal welfare and ethics committee of Department of Animal Science and Range Management, Modibbo Adama University of Technology Yola Adamawa State Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Opara AU, Okorie KC. Effect of cooked *Mucuna sloanei* seed meal on the performance, carcass characteristics and apparent nutrient digestibility on broiler finisher birds. Inter J Agri Biosci. 2015;4(4): 145-149. Incorporated. Tokyo Japan pp 633.
   Available:www.ijagbio.com
2. Wafar RJ, Ademu LA, Kirfi YA, Shehu II. Effect of processing methods on the utilization of *Mucuna sloanei* (horse eye bean) seed meal by broiler chicken. British Journal of Applied Research. 2015;1(1): 0010-0014.
3. Martínez Y, Valdivié M, Martínez O, Estarrón M, Córdova J. Utilization of pumpkin (*Cucurbita moschata*) seed in broiler chicken diets. Cuban Journal of Agricultural Science. 2010;44(4):387–392.
4. Facciola S. Comucopia. A source book of edible plant. Kamping Publication, Califonia USA. 1990;677.
5. Adebayo AA, Tukur AL. Adamawa State in maps. Paraclete Publishers. Yola. 1999; 25.
6. AOAC. "Official methods of analysis" 14th edition, Association of Official Analytical Chemists, Washington DC. USA. 1990;76-86.
7. Paunzenga U. Feeding Parent Stock Zootecnical, International. 1985;22-24.
8. Steel RGD, Torrie JH. Principles and procedures of statistics. 2nd Edition. McGraw- Hill; 1980.
9. Olomu JM. Monogastric animal nutrition. Principles and practice. A Jacchem Publication. 1995;320.
10. Oluyemi JA, Roberts FA. Poultry production in warm wet climates. Rev. Ed. Spectrum Books Limited, Ibadan, Nigeria. 2000;244.
11. Firman JD. Nutrional requirements of chickens and Turkey. Department of Animal Science, University of Missouri, Extension; 1993.
12. Saskatchewan, agriculture, food and rural revitalization. 3085 Abert Street, Regina, Saskatchewan, Canada. S45 OBI; 2000.
13. Akinmutimi AH. Evaluation of sword bean (*Canavalia gladiata*) as an alternative feed resource for broiler chicks. PhD Dissertation, College of Animal Science and Animal Health, Michael Okpara University of Agriculture, Umudike. 2004; 4-17, 2. 29.
14. NRC. Nutrient requirement of domestic animals, nutrient requirement of poultry. 9th Edition, National Academy press, Washington, D.C; 1996.
15. Kim SR, Ha TY, Song HN, Kim YS, Park YK. Comparison f gourd specie. National Institute of Food Department Korea; 1997.
16. Kwiri R, Winini C, Musengi M, Mudyiwa M, Nyambi C, Muredzi P, Malunga A. Proximate composition of pumpkin gourd (*Cucurbita pepo*) seeds from Zimbabwe. International Journal of Nutrition and Food Sciences. 2014;3(4):279-283.
    DOI: 10.11648/j.ijnfs.20140304.17
17. Elinge CM, Muhammad A, Atiku FA, Itodo AU, Peni IJ, Sanni OM, Mbongo AN. Proximate, mineral and anti-nutrient composition of pumpkin (*Cucurbita pepo* L.) seeds extract. International Journal of Plant Research. 2012;2(5):146-150.
18. Chigwe CFB, Saka VW. Collection and characterization of Malawi pumpkin germplasm. Zimbabwe. Journal of Agricultural Research. 1994;32:139-147.
19. Loukou AL. Macronutrient composition of three cucurbit species cultivated for seed consumption in Côte d'Ivoire; 6 March. 2007;529-533.
20. Chai W, Liebman M. Assessment of oxalate absorption from almonds and black beans with and without the use of an extrinsic label. 2004;172:953-957.

21. Bonjour EI, Fargo WS, Renser PE. Positional preference and squash bugs among cucurbits in oklahoma. Journal of Entomology Society America. 1990;83(3): 943-947.
22. Achu MB. Chemical evaluation of protein quality and phenolic compound levels of some *Cucurbitaceae* oilseeds. Cameroon. 2013;12(7):735-743.
23. Wafar RJ, Tarimbuka LI. Effects of substituting groundnut cake with water spinach (*Ipomoea aquatica*) leaf meal on performance, carcass yield and blood profile of Weaner rabbit. FUW Trends in Science and Technology Journal (FSTJ). 2016;1(1):238-242.
24. Oluyemi JA, Roberts FA. Poultry production in warm wet climates. Rev. Ed. Spectrum Books Limited, Ibadan, Nigeria. 2000;244.
25. Yakubu B, Alfred B. Nutritional evaluation of toasted white sesame seed meal *Sesamum indicum* as a source of methionine on growth performance, carcass characteristics, heamatological and Biochemical indices of finisher broiler chickens. IOSR Journal of Agriculture and Veterinary Science. 2014;7(1):46-56.
26. Ogbu NN, Ogbu CC, Okorie AV. Growth performance of broiler chicks fed raw and processed pigeon pea (*Cajanus cajan*) seed meal. Journal of Animal science Research. 2015;5(7):1350–1356.
27. Bone FJ. Anatomy and physiology of farm animals. 2nd Edn., Reston Publishing Comp, Inc Virginia, USA. 1979;560.
28. Carew LB, Hardy D, Gernat AG, Zakrzewska EI. Heating raw velvet beans (*Mucuna pruriens*) reverses some antinutritional effects on organ growth, blood chemistry and organ histology in growing chickens. Journal Tropical and Subtropical Agroecosystems. 2003;1(2-3): 267–275.

Peer-review history:
The peer review history for this paper can be accessed here:
http://prh.sdiarticle3.com/review-history/20913