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Research Paper

COMPARATIVE STUDY TO EVALUATE NUTRITIVE VALUE OF MAIZE AND SORGHUM (FETERITA) WITH OR WITHOUT COMMERCIAL ENZYME (XYLEM) IN BROILER DIETS

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Abstract

This study was conducted to compare the effect of feeding sorghum or yellow maize with and without commercial enzyme preparation (xylam 500) containing xylanase and amylase on performance and economic efficiency of broiler chicks. Complete randomized design under factorial arrangement (2x2) was used in this experiment. Two sources of energy {maize and sorghum grains} were replicated. 5 times with the each of the two levels of commercial xylam enzyme (0 and 500 gm/ton of diet) to formulated 4 iso-nitrogenous and iso-caloric experimental diets. Total number of 200 chicks, 7 days – old unsexed, Ross – 308 strain broiler chicks were used. The chicks were allotted randomly in 4 treatments groups y 5 replicates, each of 10 chicks. All chicks were fed experimental diets for 6 weeks. Experimental parameters covered performance, slaughter and carcass data and economic appraisal. The results of this study indicated no significant differences between broiler chicks fed on maize or sorghum based diet in body weight gain, feed intake, feed conversion ratio, mortality rate. The results of economic evaluation showed that, the higher net profit derived was on maize based diet, due to its lower prices in some parts of country compared to sorghum grains. Adding commercial enzyme to either maize or sorghum based diet resulted in economic benefits but, maize supplemented with enzyme is more profitable.

INTRODUCTION

In poultry management, nutrition is considered master perquisite to health production. In the Sudan feed costs about 56.7% of the total variable cost in broiler production (Elghouth et al., 2013). Approximately 70% of the total cost of broiler feed related to meeting energy needs (Skinner et al., 1992 and Abdelgadir, 2009). Thus, choosing the proper energy source and levels that will optimize growth, carcass quality and feed efficiency makes a difference.

In the Sudan, sorghum grain is predominately used as main source of energy in broiler diets. Sorghum grain is the fifth major stable cereal after wheat, rice, maize and barely. In the Sudan the sorghum rain is main stable food and comprised 80% by weight of the cereal grain grown in the country. Broiler can be fed up to 70% low tannin sorghum in combination with soybean, minerals and vitamins (Jacquin, 1991). Its nutrient composition roughly similar to that of maize

and its particularly rich in starch {more than 70% of DM}, CP of sorghum ranged from a to 13% DM is slightly higher than that of maize though much more variable depending in growing conditions, like maize has also low lysine and tryptophan content and its utilization may require amino acids addition. Fat content is also slightly lower in sorghum grain than maize, sorghum grain is devoid of xanthophy lin (Feedipedia, 2014). Torab (2008) studied the effect of feeding sorghum {Feterita}, white or yellow maize on performance of broiler. The results showed no significant (P≤0.05) differences in feed intake (FI), FCR and mortality among dietary treatments. While, the differences in body weight gain (BWG) were significant (P≤0.05) among the dietary treatments throughout the experiment, birds fed on yellow and white maize maintained significant high BWG compared to the sorghum fed chicks. In conclusion, maize could be replaced sorghum efficiently in broiler diets to support superiority meat production without any effect on skin colour of the carcass. Unfortunately, the rapid growth of human population has intensified the competition between human and poultry for sorghum grains resulting in high cost of feeds and consequently high prices of poultry products in the Sudan (Ahmed *et al.,* 2013). However, the rise of the conventional feed cost demand a research for cheap resources or improving utilization of conventional feed by using some feed additives such as exogenous enzymes in order to maintain and sustain poultry production.

The supplementation of poultry feed with exogenous enzymes can improve the nutritional value of feed ingredients, increasing the efficiency of digestion. Since the mid 1980_s, feed enzymes have dramatically improved the profitability of commercial poultry production. The current feed enzymes market is worth an estimated $ 700-800 million USD (Boa, *et al*., 2013). Cowieson *et al*., [2006^b] stated that the addition a combination of amylase, xylanase and protease and phytase enzymes to the maize-soybean based diets improved the growth performance and digestibility of P, Ca and amino acids of broiler chicks. Lee *et al*., [2010] reported that BWG and FCR improved (P<0.05) in chicks that were fed low energy maize-wheat-sorghum diets supplemented with multiple enzymes {xylanase, glucanase and phytase} than those received the control diets during the finisher period {22-32 d} and the entire experimental period {1-32 d}. The carcass parameters were not affected by the addition of enzymes.

The objective of this study was to evaluate the comparative performance and economics efficiency of broiler fed yellow maize and sorghum grain based diets with or without commercial xylem 500 enzyme supplementation.

MATERIALS AND METHODS

A total number of 200 day-old commercial unsexed broiler chicks of strain were purchased from Salsabeel Company and transported to the Poultry Farm of Kuku Poultry Research Centre– Khartoum North; during the period from 29th July to 9th September – 2012. The ambient temperature averaged {26-39°C} during the experimental periods.. The chicks were adapted to the house environment and feed over 7 days before start the experiment. At the end of adaptation period, all chicks were weighed with an average initial weight of 40g . The chicks were then assigned randomly into 4 dietary groups A, B, C and D in completely randomized design under 2x2 factorial arrangements. Each group was divided into 5 replicates each of 7 chicks. Ground brooding/rearing system was adopted for 6 weeks experimental period chicks were bought vaccinated against Marek's disease in hatchery. On farm the chicks vaccinated against Gumboro disease at 11 days of age and Newcastle at 22 days of age, soluble multivitamin compounds {Pantominovit – Panter – Holland B.V. 5525 ZG Duized Holland} and antibiotics {Neomycin, Avico, Jordan} were given to the chicks before 3 days of the vaccination, and 3 days after vaccination in order to guard against stress.

Two energy sources {maize and sorghum} were used with two levels of commercial enzyme xylam 500 {0 and ½ kg/ton diet} to formulate 4 iso-nitrogenous {22.7 CP} and iso-caloric {3100 Kcal/kg ME} experimental diets A, B, C and D being adequate in all nutrients matching broiler chicks requirements according to NRC, 1994. The commercial enzyme preparation {xylam 500} used in the present study was produced by Nutrer Company. Xylam 500 is a bacterial enzyme preparation produced from Bacillus subtilis and Bacillus amyloliquefaciens. It contains 1.260 u/g endo-1, 4 beta – xylanase and 8.00 u/g aifa – amylase.

An open wire mesh – side poultry house was used. The house was constructed of brick wall 50 cm high, the rest of the wall to the ceiling was made of wire netting on all sides, the roof was made of corrugated iron sheets supported with iron posts. Twenty pens, I m2 each, inside the house were prepared using wire mesh partitioning. Each pen was equipped with one feeder and drinker to allow adlibitum consumption of feed and water. Light was provided 24 hours, in a form of natural light during the day and artificial light during night. Five bulbs {60 watt} were used for this purpose. The house was cleaned and disinfected before commencement of the experiment. Average body weight, weight gain and feed consumption {g} for group were determined weekly throughout the experimental period. Health of the experimental stock and mortality data were closely observed and recorded daily.

Statistical analysis:

Data were statistically analyzed by the General Linear Model {GLM} of SAS [1990] using the replicated means of all parameters. Two ways analysis of variance was used. The model included xylam 500 enzyme and energy sources, {Maize and Sorghum}, and two ways of interactions.

RESULTS:

Response of broiler chicks to dietary microbial xylanase and source of energy

1. Chemical composition of sorghum {Feterita} and Yellow maize:

The crude protein content of yellow maize was significantly ($P<0.05$) lower than that of maize. Sorghum grain had significantly ($P<0.05$) higher crude fiber and lower ether extract values compared to yellow maize, while the two cereals were almost similar in the dry matter, ash, nitrogen free extract and metabolizable energy values (**Table 1**).

2. Performance:

The effect of microbial and energy sources on the performance of broiler is shown in Table (2). Initially all group starter at similar body weight {40 gm}. The result indicated that the addition of xylanase enzyme to the broiler diet had no significant effect on the weight gain. However, the use of dietary microbial enzyme increased the body weight gain.The result showed that the energy source had no significant effect on body weight gain, but the chicks fed on the diet containing maize gained more weight compared to those fed on sorghum grain. The feed intake was not affected significantly by the addition of microbial xylanase enzyme in the diets. However, the chicks fed on diet containing microbial enzyme consumed more feed than control group. The source of energy had no significant effect on feed intake, but the chicks fed on diet containing maize consumed more feed than those fed sorghum grain. The results showed that the enzyme supplementation had no significant ($P<0.05$) effect on feed conversion ratio {FCR} and all values were closely similar in all treatment groups. The FCR values were not affected significantly by the source of energy and all values were similar in treatment groups. No mortality was recorded during the experimental period in all treatment groups. As seen in Table 2, the interaction between the dietary microbial xylanase and source of energy was not statistically significant on weight gain, feed intake and feed conversion ratio.

3. Economic appraisal:

Total cost, return and margins were explained in Table 3 calculations for total cost, total returned and profits showed that the supplementary of dietary microbial xylanase to the diet caused more net profit/kg in group B {10.43} compared to group A {9.79} and in group D the net profit/kg was {14.17} compared to group C {13.71}.

Table 1. Determined chemical composition of sorghum {Feterita} and Yellow maize

Items	Sorghum {Feterita}	Yellow Maize	SE ±
Dry matter %	95.5[a]	95.3[a]	**0.07**
Crude protein %	13.70[a]	11.14[b]	**0.06**
Ether extract %	2.21[a]	5.43[b]	**0.02**
Crude fiber %	3.44[a]	2.92[b]	**0.08**
Ash %	2.33[a]	2.50[a]	**0.32**
Nitrogen free extract %	73.86[a]	74.14[a]	**0.08**
** Metabolizable energy {Kcal/kg}	3411[a]	3423[a]	**0.82**

* Means on the same row with the same superscripts are significant (P>0.05).
** Metabolizable energy was calculated according to the equation of Lodhi, *et al*., (1976).

Table 2. The effect of dietary microbial xylanase and energy sources on the performance of broiler.

Treatment			Initial body weight	Live body weight	Weight gains	Feed intake	F.C.R
Diets	**Enzyme**	**Source of energy**					
A	Without	Sorghum	180	2014.4[a]	1837.8[a]	3675.8[a]	**1.998[a]**
B	Within	Sorghum	180	2057.6[a]	1936.2[a]	3798.4[a]	**2.024[a]**
C	Without	Maize	180	2120.6[a]	1944.6[a]	3718.2[a]	**1.908[a]**
D	Within	Maize	180	2168.2[a]	1986.2[a]	3808.0[a]	**1.918[a]**
SE ±				65.183	59.020	99.537	**0.038**
Main effects:							
Enzyme		M without	180	2067.5	1891.2[a]	3697.[a]	**1.953**
		Within	180	2112.9	1961.2[a]	3803.2[a]	**1.970**
SE ±					41.733	70.384	**0.027**
Source of energy		Sorghum	180	2036	1887[a]	3737.1[a]	**1.98[a]**
		maize	180	2144.4	1965[a]	3763.1[a]	**1.913[a]**
SE ±					**41.733**	**70.384**	**0.027**

a,b, means with columns with no common superscripts differ significantly (P<0.05).
SE ± = Standard error.

DESCRIPTION AND DISCUSSION

The results of the proximate composition of sorghum and yellow maize used in this study showed that the crude protein content of yellow maize was lower significantly (P<0.05) than sorghum, while the two cereals grains were similar in metabolizable energy. These results were similar to those studies Etuk *et al*., [2012] and Kriegshauser *et al*., [2006]. The ether extract values of yellow maize was significantly (P>0.05) higher than yellow maize. These results are in line with the findings of Cowieson, [2005] and Etuk *et al*., [2012]. The sorghum grain had significantly (P<0.5) higher crude fiber content compared to maize. The results of this study showed similarities between the dry matter, ash and free nitrogen extract of maize and sorghum which confirms the reports of Travis *et al*., [2006] and Kwari *et al*., [2011]. In this study there were no mortalities were recorded among the different treatment groups throughout the experimental periods; this may be due to good hygienic situation of the experiment.. Torab, [2008] reported that no significant differences in mortality rate observed between broilers fed sorghum or yellow maize based diets and it was in the normal range. Bin-Baraik [2010] and El-Saeed [2013] stated that the addition of commercial xylam enzyme to the diet had no significant effect on the mortality rate in broilers. All these results were remarkably similar to the results of the current study. Although birds which fed on yellow maize had greater weight gain than those fed sorghum based diet, the weight gain did not show significant differences between the two dietary treatment groups in this study. This results are in

agreement with the reports of Al Khair, [2000]; Tulasi *et al*., [2004], Carmenclta *et al*., [2006]; Clement *et al*., [2010]; Kwari *et al*., [2012] and Ibitoye *et al*., [2012], who found that the body weight gain of broilers was statistically similar in sorghum compared to maize based diets. These results are not in line with the findings of Torab, [2008] who found birds fed on yellow maize maintained significant high body weight to the sorghum fed chicks. The addition of the enzymes to the diet had no significant effect on the body weight gain, even though the diet supplemental with enzyme improved the body weight gain in the percent study. These results contradict with the reports of Amoni *et al*., [2011], Cowieson *et al*., [2006[b]], Wyatt *et al*., [1997] and Selle *et al*., [2010] who found that addition of microbial xylanase individually or in combination with amylase and protease to the sorghum or maize based diet had a significant effect on the body weight gain of broilers. These researchers assumed that the exogenous carbohydrates and protease enzymes improve body weight through increase nutrient digestibility not only via a reduction digesta viscosity but also via a reduction in cell integrity, generation of fermentable disaccharides, low-molecular weight polysaccharides and oligosaccharides, improving protein solubility, decreasing endogenous losses and overcoming anti-nutritional factors.

The feed intake in the present study tended to be higher in the chicks fed on yellow maize based diet compared with sorghum group, but the differences were not statistically significant. This result is equally in harmony with the findings of Al Khair [2000]; Tulasi *et al*., [2004]; Torab [2008]; Clement *et al*., [2010] and Marshall, [2001]. These results disagreed with those obtained by Mohaedain *et al*., [1986] who found that maize fed chick showed significantly higher feed intake compared with those fed sorghum based diets. This result may be due to the tannin content of sorghum variety used because the high level of tannin reduced feed intake [Hassan *et al*., 2003, Makkar, 2003, Kim and Miller, 2005]. Further addition of enzyme to the two energy sources used in this study did not have any significant effect on the feed intake, but the chicks received diets supplemented with enzymes tended to consume more feed than control. These results differs with those obtained by [Amoni *et al*., 2011; Selle *et al*., 2010 and Wyatt *et al*., 1997] who found that incorporation of enzymatic complex {xylanase, amylase and protease} or only xylanasis activity increased significantly the feed intake of broiler chicks received either sorghum or maize based diets.

The results showed that feed conversion ratio {FCR} in this study was not significantly affected in broiler fed either sorghum or maize based diets. These results are in consistent with the findings of Kwari *et al*., [2012]; Ibltoye *et al*., [2012]; Clement *et al*., [2010] and Torab, [2008], but these results differ from that shown by Al Khair [2000] who observed that sorghum {Feterita} fed chicks obtained significantly best FCR than those fed on maize based diet, whereas Camenclta *et al*., [2006] reported that the feed conversion efficiency of birds fed with maize was significantly higher than those fed sorghum based diets. However, there were non-significant differences in FCR between the two energy sources, as far as enzyme addition was concerned in this study. These results agreed with those reported by Makkawi [2009]. These results contradict with Zenella *et al*., [1999]; Pack *et al*., [1997]; Hajati *et al*., [2009]; Neill *et al.,*[2011]; Lee *et al*., [2010] who stated that the FCR was improved significantly with the addition of the microbial enzymes to broiler diets containing either sorghum or maize as based diets. The similarities and disparities in the performance between broilers fed sorghum and those fed maize diets may be due to the nutritive values of sorghum and maize grains produced by farmers varies greatly because of differences in soil, climate, genotype, diseases and management practices in regards to harvesting, drying and storing [Maier, 1995, Lesson and Summers, 1976, Ebadi *et al*., 2005]. On the other hand, the responsiveness of diet or an ingredient to exogenous enzymes is elusive and difficult to be accurately defined but it includes factors such as, substrate concentration and accessibility, inherent digestibility, nutrient interactions, type and amount of anti-nutrient, solubility in water, type, sources and concentration of enzyme used, age and disease status of animal. [Boa *et al*., 2013].

Economics of production analysis in terms of income over feed, management and chick cost indicated that, the higher income derived was on maize with or without enzyme supplementation compared to the sorghum based diets. This suggests that replacement of

sorghum by maize in broilers diet would be economical and also cost effective. This may be due to its lower prices in some parts of the country {North of Sudan}. On the other hand the competition between human and poultry industry in sorghum which is a stable food for human in the Sudan Leads to arise in its prices. These results are in line with the findings of Amoni *et al*., [2011], who reported that addition of xylam enzyme to maize based diets decreased the relative cost of broiler feeds and enhanced economic efficiency.

CONCLUSION

The productive performance of broilers was statistically similar in maize compared to sorghum based diets, but economically the maize diet was more efficient due to its low prices in some parts of country. The incorporation of commercial xylam enzyme in the broiler receiving maize or sorghum improved numerically the performance and resulted in economic benefits.

REFERENCES

Abdelgadir, M. O. (2009). Use of dietary plant oils in broiler rations Ph. D Thesis.Faculty of Agricultural Studies. Sudan University of Science and Technology.

Ahmed, M.A.; Bakheit, M.; and Abdelatti, K.A. (2013). Effect of substituting yellow maize for sorghum on broiler performance. Journal of World's Research 3, 1: 13-17.

Al-Khair, S.M. (2000). Comparative evaluation of the nutritive value of Feterita, Maize, Millet and Wheat in broiler chicken diet. M. Sc. Thesis. Department of Poultry Sciences – Faculty of Animal Production – University of Khartoum.

Amoni, W.; Youssef, H.M.A.; Hassan, H.M.; Ali, M. and Mohamed, M.A. (2011). Performance, abdominal fat and economic efficiency of broiler fed different energy levels supplemented with xylanase and amylase from 14 to 40 days of age. World Journal of Agricultural Sciences. 7 3: 291-297.

Bin-Baraik, B.S. (2010). Effect of adding xylanase and phytase enzymes to broiler diets on the performance and carcass yield and quality. Ph. D. Theses. College of Agricultural Studies. Sudan University of Science and Technology.

Boa, Y.M.; Romero, L.F. and Cowieson, A.J. (2013).Functional patternsof exogenous enzymes in different feed ingredients. World's Poultry Science Journal Vol. 69, 12: 759-773.

Carmenelta, D.; Mateo, S. and Nelia, F. (2006). Feeding and economicevaluation of corn, wheat and sorghum based-diets in broilers. Philippine Journal of Science 135, 1: 49-58.

Clement, I.M.; Ibrahim, D.K.; Joseph, I.; Iro, N.; Ibrahim, D.M. and Bruce, H. (2010). Performance and economics of production of chickens fed sorghum or millet as replacement for maize in the semi-arid zone of Nigeria. Agric. Biol. J. N. Anim. 1, 3: 321-325.

Cowieson, A.J.; Singh, D.N. and Adeola, O. (2006b). Prediction of ingredient quality and the effect of a combination of xylanase, amylase, protease and phytase in the diets of broiler chicks. 2- Energy and nutrient utilization. Br. Poultry Sci. 47: 490-500.

Cowieson, A.J. (2005). Factors that affect the nutritive value of maize for broilers. Animal Feed Science and Technology. 119: 293-305.

Ebadi, M.R.; Pourreza, J.; Jamalian, J.; Edris, M.A.; Samie, A.H. andMirhadi, S.A. (2005). Amino acid content and availability in low, medium and high tannin sorghum grain for poultry. Int. J. Poult. Sci. 1: 27-31.

Elghouth, F.O., Yassin, O.E.; Angara, T.E.; Wahab, I.A. (2013). Somemanagement and economic aspects of broiler production in Khartoum State. Journal of Science and Technology Vol. 14, Agricultural and Veterinary Science. No. 1: 80-85.

Elsaeed, M.A. (2013). The utilization of mesquite prosopis juliflora pods with xylanase and phytase enzymes in the broilers diets Ph. D. Thesis. College of Agricultural Studies. Sudan University of Science and Technology.

Etuk, E.B.; Ifeduba, A.V.; Okata, U.E; Chiaka, I.; Okoli, I.C.; Okeudo,N.J.; Esonu, B.O.; Udedibie, A.B.I. and Moreki, J.C. (2012).Nutrient composition and feeding value of sorghum for livestock and poultry a review J. Anim. Sci. Adv. 2, 6: 510-524.

Feedipedia Animal Feed Resources Information (2014). Sorghum grain 1-4.

Hajati, H.; Rezaei, M. and Sayyahzadeh, H. (2009).The effects of enzyme supplementation on performance, carcass characteristics and some blood parameters of broilers fed on corn-soybean meal-wheat diets. International Journal of Poultry Science 8, 12: 1199-1205.

Hassan, I.A.G.; ElZubeir, E.A.; ElTinay, A.H. (2003). Growth and apparent absorption of minerals in broiler chickens fed diets with low and high tannin content. Tropic. Anim. Health Prod. 35: 189-196.

Ibitoye, E.B.; Olorede, B.R.; Jimoh, A.A. and Abubakar, H. (2012). Comparative performance and organ relative weight of broiler chickens fed three sources of energy diets. Journal of Animal Production Advices 2, 5: 233-238.

Jacquin, C.C. (1991). Le sorgh grain culture et utilization. JICF.

Kim, H.S. and Miller, D.D. (2005). Praline – rich proteins moderate theinhibitory effect of tea on iron absorption in rats. J. Nutr. 135: 532-537.

Kriegshauser, T.D., Tuinstra, M.R. and Hancock, J.D. (2006). Variationin nutritional value of sorghum hybrids with contrasting seed weight characteristics and comparisons with maize broiler chicks. Crop Science 46: 695-699.

Kwari, I.; Diarra, S.; Igwebuike, J.; Nkama, I.; Issa, S.; Hamaka, B.;Hancock, J.; Jauro, M.; Seriki, O.A. and Murphy, A. (2012). Replacement value of low tannin sorghum {Sorghum bicolor} for maize in broiler chickens diets in the semi-arid zone in Nigeria. International Journal of Poultry Science 11, 5: 333-337.

Kwari, I.D.; Saleh, B.; Diarra, S.S.; Mkighir, T. and Umanah, M.J. (2011). Nutrient digestibility and carcass characteristics of broiler chickens fed different cultivars of sorghum replacing maize in the semi-arid zone of Nigeria Roavs, 1, 9: 578-581.

Lee. S.Y.; Jong, S.K.; Jin, M.K.; Byoung, K.A. and Chang, W.K. (2010).Effects of multiple enzymes {Ravabio-Max} containing carbohydrases and phytase on growth performance and intestinal viscosity in broiler chicks fed corn-wheat-soybean male based diets. Asian-Aust. J. Anim. Sci. 23, 9: 1198-1204.

Leeson, S. and Summers, J.D. (1976). Effect of adverse growing conditions on corn maturity and feeding value for poultry. Poultry Sci., 55: 588-593.

Maier, D.E. (1995). Indian corn quality survey composition data. GrainQuality task force 24. Prdue University Extension Service.a

Makkar, H.P.S. (2003). Effects and fate tannins in ruminant animals, adaptation to tannins, and strategies to overcome detrimental effects of feeding tannin - rich feeds. Small Rumin. Research 49: 241-256.

Marshall, D. (2001). Towards sustainable broiler production-does use of sorghum {Sorghum bicolour} as an adjunct substitute of maize affect broiler performance. Journal of sustainable development in Africa. 13, 8: 225-235.

Mohaedain, G.M.; Babiker, S.A. and Mohammed, T.A. (1986). Effect of feeding millet, maize and sorghum performance yield and chemical composition of broiler meat. Trop. Agric. {Trinidad} 63, 2: 173-176.

NRC (1994). Nutrient requirement of poultry 8th revised edition, NationalAcademy Press Washington, DC USA.

SAS . SAS/STAT user's guide, v. 6. 4th ed. Cary: SAS Institute; 1990

Selle, P.H.; Cadogan, D.J.; Ru, Y.J. and Partridge, G.G. (2010). Impact of exogenous enzymes in sorghum-or wheat-based broiler diets on nutrient utilization and growth performance. International Journal of Poultry Science 9 (1): 53-58.

Skinner, J.T.; Waldroup, A.L. and Waldroup, P.W. (1992). Effects of dietary nutrient density on performance and carcass quality of broilers 42 to 49 days of age. J. Appl. Poult. Res. (1): 367-372.

Torab, A.M. (2008). Comparative studies to evaluate the nutritive value of Feterita, white and yellow maize in broiler diets. M. Sc. Thesis. College of Agricultural Studies. Sudan University of Science and Technology.

Travis, D.K.; Tuinstra, M.R. and Hancock, J.D. (2006). Variation in nutritional value of sorghum grain hybrids with contrasting seed weight characteristics and comparisons with maize in broiler chicks. Crop. Sci., 46: 695-699.

Tulasi, S.L.; Reddy, A.R.; Reddy, G.R.; Prasad, V.L.; Raju, M.V.; Rao,C.L.; Reddy, B.V.; Rao, P.P. and Ramach-andraiah, D. (2004). Performance of broilers on sorghum based diets. International Sorghum Millets Newsletter, 45: 37-40.

Wyatt, C.; Soto, M. and Pack, M. (1997). Applying enzymes to sorghum- based broiler diets. Proceeding of Australia Poultry Science, 9: 116-118.

Zanella, I.; Sakomura, N.K.; Silversides, F.G.; Fiquerido, A. and Dack,M. (1999). Effect of enzyme supplementation of broiler diets based on corn and soybeans. Poultry Sci. 78: 561-568.