Utilization

Performance of Broilers on Sorghum-based Diets

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Introduction

In India, sorghum (*Sorghum bicolor*) is grown in both the rainy and postrainy seasons. The postrainy season grain is generally of good quality and used for human consumption. The rainy season sorghum is often vulnerable to grain deterioration due to grain mold attack, making it unfit for food. Normal as well as moldy grain has enormous demand for industrial uses such as animal/poultry feed, alcoholic beverages, etc. However, the lack of an assured supply of the rainy season produced sorghum grain limits its use to only about 10% of the industrial demand. By 2010, the demand for rainy season sorghum for industrial use is estimated to increase by 10 to 30%; the major demand is expected to be from the poultry industry, which is growing at a rate of 15–20% per annum (Kleih et al. 2000). Consequently, the estimated feed requirement is about 18 million t by 2005 as against current production levels of 16 million t, leaving a gap of 2 million t. Maize (*Zea mays*) is the principal energy source in poultry feed. The demand and supply of maize reveals a large gap that can be filled by sorghum, the next best alternate cereal. At present, normal as well as moldy sorghum grain is used in poultry feed rations to a limited extent whenever maize supply is low or its price is too high. The apprehensions of some poultry producers/feed manufacturers about the energy levels of sorghum-based poultry feed rations in relation to maize rations is one of the major reasons for its limited use.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (Patancheru, India), along with Acharya NG Ranga Agricultural University (ANGRAU) (Hyderabad, India) and in collaboration with the non-governmental organizations (NGOs), Federation of Farmers' Associations (FFA) and Andhra Pradesh Poultry Federation (APPF), and Janaki Feeds (Hyderabad), a private partner, has implemented a project funded by the Department for International Development (DFID), UK. The project aimed at enhancing the use of rainy season sorghum in poultry feed rations as a potential alternative to maize and to create sustainable marketing linkages between sorghum growers and the poultry industry through innovative institutional systems. We report here the performance of broilers fed with sorghum-based feeds replacing maize in different proportions.

Materials and Methods

The grain from four improved sorghum cultivars, CSH 16, CSV 15, PSV 16 and S 35, and one traditional (yellow) sorghum variety planted in the rainy season 2002, were harvested. The grains were used in poultry feed trials (PFTs), which were conducted at the Poultry Experimental Station, ANGRAU, Rajendranagar, Hyderabad. Yellow (hybrid) maize procured from the market was used as control in the PFTs. The grain lots were analyzed for proximate composition, calcium and phosphorus (AOAC 1984); amino acids (Degussa Laboratory, Germany) and metabolizable energy; tannins and phenolic compounds by the Folin Denis method; aflatoxins, fumonisin (Feng-Yih and Furi 1996) and grain mold severity (AICSIP 2003) (Table 1). A broiler PFT was conducted by formulating starter (1–4 weeks) as well as finisher (5–6 weeks) diets by replacing maize (control diet) with sorghum at 50%, 75% and 100% levels and adjusting with oil and saw dust to make the diets iso-nitrogenous and iso-caloric. All the diets were made homogenous in lysine, methionine and cystine levels. One-day old 512 commercial (Cobb) female broilers were randomly distributed to 64 groups and housed in battery brooders with a floor space of 1.1 ft^2 $bird^{-1}$. A total of 16 dietary treatments (Table 2) were evaluated in four replications, each comprising eight birds. In the second trial, part-by-part replacement of maize with sorghum was conducted without homogenizing the diets for nitrogen and energy. Eight treatments (four each for mash and pellet forms) were evaluated in four replications (Table 3). Feed and water was offered ad libitum and standard management practices with routine vaccination schedule were adopted. Body weight gains and feed consumption were recorded weekly. Shank and breast skin color was scored by visual method (using Roche fan color equipment) to assess the carcass yellow pigmentation. The carcass weight, length of intestine and caecum, and weight of certain visceral organs, the liver, spleen, pancreas and bursa of fabricus, were measured. The data on these measurements were subjected to one-way analysis of variance to test statistical significance of the treatments and a t-test was used to assess pair-wise treatment significance. Cost of feed was calculated for each of the diets and feed efficiency (feed kg^{-1} live weight gain) was assessed.

Results and Discussion

Sorghum cultivars contained more protein (9.56 to 11.79%) than maize (hybrid yellow) (9.3%). However, metabolizable energy was greater in maize (3700 kcal kg^{-1}) than in sorghum cultivars (3196 to 3422 kcal kg^{-1}) (Table 1). Similar results were also reported by Rama Rao et al. (1995). Amino acid profile was almost similar except tryptophan content, which was higher in sorghum (0.09–0.12%) than maize (0.07%). Tannins, phenolic compounds as tannic acid equivalent and catechin equivalent, were found low in all the sorghum cultivars (0.023 to 0.045%). The chemical analysis conducted at ICRISAT indicated that all the sorghum cultivars had low levels of grain mold and mycotoxins.

Performance data of 6-week-old birds showed that body weight gains and feed consumption of broilers were statistically similar on sorghum diets at all inclusion levels compared to the control diet (Table 2). However, the feed efficiency of broilers with sorghum-based diets at 100% inclusion level was found to be significantly higher than the maize-based diet ($P = 0.05$). Among the sorghum cultivars, better feed efficiency was found with CSV 15, CSH 16, PSV 16 and local variety at 100% inclusion level. However, yellow pigmentation of skin and carcass of broilers were better with maize-based diet compared to sorghum-based diets. Cost of feed for live broiler weight gain was similar for most of the feed rations. The cost varied among sorghum cultivars as well as within the cultivar among the different inclusion levels. The cost of feed kg^{-1} live weight gain was significantly lower with CSV 15, PSV 16, S 35 and local sorghum-based diets than that with maize. It is interesting to note that the cost reduction is much lower with 100% inclusion level of CSV 15, PSV 16 and local sorghum cultivars in place of maize in the broiler feed rations.

Table 1. Chemical composition and nutritive value of maize and sorghum grain.

Parameter	Yellow maize	Sorghum cultivars				
		CSV 15	CSH 16	PSV 16	S 35	Local
Dry matter (%)	92.00	92.57	92.13	92.98	93.44	92.00
Metabolizable energy (kcal kg^{-1})	3700	3422	3196	3402	3238	3196
Crude protein (%)	9.30	9.56	10.13	10.96	11.79	10.40
Ether extract (%)	3.80	3.01	2.85	2.40	3.73	2.63
Crude fiber (%)	2.19	3.20	2.48	2.81	4.02	2.00
Ash (%)	1.31	1.13	1.29	1.37	1.53	1.46
Nitrogen-free extract (%)	83.40	83.10	83.25	82.46	78.93	83.51
Calcium (%)	0.052	0.051	0.047	0.050	0.052	0.036
Phosphorus (%)	0.300	0.226	0.270	0.260	0.304	0.200
Grain mold scale[1]	Nil	2	2	2	3	2
Tannins (%) (catechin equivalent)	Nil	0.038	0.023	0.030	0.023	0.045
Aflatoxins (ppm)	Nil	0.0025	0.011	0.054	0.036	NA[2]
Fumonisin (ppm)	Nil	0.160	1.132	0.277	0.157	NA
Methionine (%)	0.18	0.15	0.16	0.17	0.17	NA
Cystine (%)	0.19	0.17	0.18	0.18	0.19	NA
Methionine (%) + cystine (%)	0.37	0.32	0.34	0.35	0.36	NA
Lysine (%)	0.27	0.20	0.20	0.20	0.22	NA
Threonine (%)	0.32	0.27	0.29	0.30	0.33	NA
Tryptophan (%)	0.07	0.09	0.10	0.11	0.12	NA
Arginine (%)	0.44	0.33	0.34	0.36	0.40	NA
Isoleucine (%)	0.31	0.31	0.35	0.36	0.40	NA
Leucine (%)	1.07	0.99	1.16	1.19	1.31	NA
Valine (%)	0.42	0.40	0.45	0.47	0.51	NA

1. Threshed grain mold rating (TGMR) on a 1–5 scale, where 1 = no mold, 2 = 1 to 10% grains molded, 3 = 11 to 25% grains molded, 4 = 26 to 50% grains molded and 5 = >50% grains molded.
2. NA = Data not available.

Dixit and Baghel (1997) observed lower feed cost kg^{-1} body weight gain on sorghum diets than maize diets.

The second trial on part-by-part replacement (maize with sorghum) also indicated that sorghum could totally replace maize (56 parts in starter and 60 parts in finisher diets) without affecting broiler performance. The feed cost per kg live weight gain was lower with CSV 15 (Rs 17.16) and PSV 16 (Rs 17.62) than with maize (Rs 18.02) (Table 2). Further, pelletization improved the broiler performance over the mash feed in the sorghum diets (Table 3). Despite the increased feed cost (by Rs 0.25 kg^{-1}) on pellet feeds, the efficiency of broiler production was better on sorghum pellets than on mash (Table 3). Inclusion of *Stylosanthes* leaf meal at 3% in 100% sorghum-based

Table 2. Relative performance of broilers fed on sorghum-based and maize-based feed rations.

Cultivar	Grain inclusion level (%)	Body weight gain[1] (g)	Feed consumption[2] (g)	Feed efficiency[3]	Cost of feed kg^{-1} live weight gain[4] (Rs)
Yellow maize	100	1779	3298	1.854 ab	18.02 bc
CSV 15	50	1757	3302	1.879 a	18.40 abc
	75	1816	3279	1.805 abcd	17.75 bcd
	100	1845	3220	1.745 cde	17.16 d
CSH 16	50	1781	3195	1.794 bcd	18.24 abc
	75	1888	3214	1.702 e	18.05 bc
	100	1833	3217	1.755 cde	18.47 ab
PSV 16	50	1755	3163	1.803 abcd	17.93 bcd
	75	1841	3261	1.771 cde	17.66 bcd
	100	1799	3171	1.762 cde	17.62 cd
S 35	50	1863	3282	1.762 cde	17.92 bcd
	75	1793	3275	1.826 abc	19.02 a
	100	1821	3283	1.802 abcd	19.03 a
Local sorghum	50	1812	3242	1.790 bcd	17.97 bcd
	75	1800	3153	1.751 cde	18.25 abc
	100	1795	3098	1.726 de	17.89 bcd

1. Birds were 6 weeks old. Values are not significant.
2. Values are not significant.
3. Feed kg^{-1} live weight gain; values followed by the same letter are not significantly different at 5% level.
4. Values followed by the same letter are not significantly different at 5% level.

Table 3. Relative performance and economics of sorghum-based and maize-based feed rations (pellet and mash forms) on broilers[1].

Treatment	Body weight gain[2] (g)		Feed intake (g)		Feed conversion ratio		Feed cost (Rs kg^{-1} feed)		Feed cost (Rs kg^{-1} live weight gain)	
	Mash	Pellet	Mash	Pellet	Mash	Pellet	Mash	Pellet	Mash	Pellet
Maize 100% (control)	1961 bc	1942 bcd	3495	3500	1.81	1.80	11.54	11.79	21.01	21.37
Sorghum 50%	2000 cde	2081 e	3589	3533	1.79	1.70	11.36	11.61	20.17	19.36
Sorghum 75%	1871 ab	2033 de	3442	3651	1.84	1.80	11.18	11.43	20.46	20.31
Sorghum 100% + *Stylosanthes* 3%	1784 a	1974 cd	3512	3608	1.97	1.83	11.09	11.34	22.39	20.65
SEm±		33.9		0.023		49.7		–		–

1. Cost of maize and sorghum was Rs 6.00 kg^{-1} and Rs 5.40 kg^{-1}, respectively. Birds were 6 weeks old. Data are means of two trials. The grain used in the second trial is not cultivar specific.
2. Values followed by the same letter in a column are not significantly different at 5% level.

broiler diets improved the shank and skin color of carcass to a desired level. Carcass yields and abdominal fat on all sorghum diets as well as sorghum diet fortified with *Stylosanthes* meal were comparable to that of maize. Thus, it appears that pelletization of 100% sorghum-based diets with *Stylosanthes* leaf meal at 3%, besides improving the skin and carcass color, improved the feed conversion ratio and lowered the total feed cost for production of live broilers.

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Socioeconomics

Economics of Improved Sorghum Cultivars in Farmers' Fields in Andhra Pradesh, India

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Introduction

India is the second largest producer of sorghum (*Sorghum bicolor*) in the world, producing 7.8 million t in 2001–02 (CMIE 2004). Sorghum in India is grown in the rainy season (June–October) on around 4.5 million ha and in the postrainy season (September–January) on around 5.4 million ha. In the state of Andhra Pradesh, rainy season sorghum is grown on 0.3 million ha, producing 0.29 million t of grain while the postrainy season sorghum accounts for 0.34 million ha producing 0.35 million t of grain (Government of Andhra Pradesh 2003). Generally, resource-poor small farmers in the semi-arid regions of Andhra Pradesh with less than 1 ha of land grow sorghum. The crop is mainly cultivated under semi-subsistence farming to meet household requirements of food and fodder with a small marketable surplus. While postrainy season sorghum is almost completely used for human consumption, rainy season sorghum, which is used for food, is also used for non-food purposes such as poultry and livestock feed, and alcohol and starch manufacturing (Kleih et al. 2000). Lack of availability of rainy season sorghum in bulk quantities and assured supplies is one of the main reasons constraining its usage in industry. High per unit cost of production of local sorghum and unremunerative grain price reduce its profitability to farmers. Although about 35% of marketable surplus is available, these are often scattered and hence non-economical to procure in sufficient bulk quantities by industrial users (Marsland and Parthasarathy Rao 2000).

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, along with Acharya NG Ranga Agricultural University (ANGRAU), Hyderabad, India has been implementing a project, funded by the Department for International Development (DFID), UK, in collaboration with the non-governmental organizations (NGOs), Federation of Farmers' Associations (FFA) and Andhra Pradesh Poultry Federation (APPF), and Janaki Feeds, a private poultry feed manufacturer.