



Response of broiler chickens *Gallus gallus domesticus* to dietary supplementation with LAB-treated sorghum seed

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ARTICEL INFO

Keywords:

Broiler
Fermentation
Lab-treated
Diet

Received: 12 October 2020

Accepted: 17 September 2021

Available online: 21 April 2021

DOI: 10.13170/ajas.6.3.18271

ABSTRACT

In recent years, livestock production has been heavily affected due to the effects of climate change with shortages in feed being recorded. A study was conducted to determine the effect of fermented Sorghum bicolor grain on the growth of broiler chickens. The study aimed to utilize available feed resources without compromising on animal productivity and health. A total of 160 day-old Cobb broiler chicks were used which were randomly allocated to four dietary treatments of 10 birds for each treatment. The treatments were replicated four times. Different levels of ground, LAB-treated sorghum were analyzed on growth performance, feed intake, and feed conversion ratio (FCR), carcass, and organ weights. The diets were each formulated as T1, T2, T3, and T4 for 25%, 50%, 75%, and 0% LAB-treated sorghum inclusions respectively. T4 was the control. The remaining percentage was filled with general feed which is the commercially available feed. The results revealed that growth performance and FCR of the broilers on T1 were similar to those of the control diet but interestingly superior ($P < 0.05$) to T2 and T3-fed birds. Birds fed on T3 had a low feed intake ($p < 0.05$) as compared to other treatment diets. Mortality was depressed ($p < 0.05$) in T1 as compared to T2, T3, and T4 respectively but was significantly ($p < 0.05$) similar between T4 (control) and T2. Live weight of birds with 25% sorghum inclusion compared favorably with the control (T4) ($P < 0.05$) as was the carcass and percentage dressed weights. Internal organ weights (liver, gizzard, and heart) of the 3 treatments (T1, T2, and T4) were significantly ($p < 0.05$) lower than that of birds under T2 (50% sorghum inclusion). It was concluded that the inclusion of 25% LAB-treated sorghum in broiler rations brought about a better performance than 0%, 50%, and 75% LAB-treated sorghum inclusion levels.

Introduction

Broiler chickens *Gallus gallus domesticus* have assumed an important role in the livelihoods of urban, peri-urban, and rural households in Zimbabwe (Gororo and Kashangura, 2016). The Livestock and Meat Advisory Council of Zimbabwe in 2013 revealed that 70% of all commercial day-old chicks produced in Zimbabwe are broilers, and emerging, relatively small-scale informal producers account for the bulk (65%) of production. Zimbabwe has been experiencing a steady increase in poultry production since the year. In subsequent years, 55.1 million and 64.4 million birds were recorded by 2012 and 2013 year ends respectively. In the years 2015 and 2016 production remained steady at 75.9 million

and 78.8 million birds respectively. However, in the year 2017, production plummeted to 68.9 million due to the avian influenza disease outbreak (FAO, 2017). Since then, there have been efforts for the sector to regain consciousness and this has been adversely affected due to the current economic impasse in the country characterized by high operating costs.

Droughts on the other hand have been degrading the levels of production of the much-needed feed ingredients like maize and soya. Meanwhile, poultry production cannot be ignored as it is the main source of protein in most African diets (Roppa, 2012; Munengwa *et al.*, 2020; Khaskheli *et al.*, 2020; Akintunde *et al.*, 2021). It is regarded as an important enterprise of Agriculture due to its immediate

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returns, that is, especially in broiler production which requires a matter of weeks to full maturity and is sold. As such, individuals undertake such an enterprise to get returns and improve livelihoods. It is from this background that feeds enhancements need attention as climate change is negatively affecting feed raw material production. Concerning the rise in demand for the cash crops, the use of maize and soya in feed has been met with a high cost which consequently led to a rise in feed prices. More so, due to climate change, the need for feed enhancement to minimize the effects of adverse weather becomes imperative since this affects feed raw materials availability. More research is therefore warranted on how to sustain the poultry section. While that is the case, sorghum could be used in place of maize, considering that it can be obtained at a lower cost or in most cases is homegrown in rural areas, with almost the same nutrients as maize. *Sorghum bicolor* is the only species of sorghum family that is grown for grain and as feed for livestock (Prasad and Staggenborg, 2009). It is a small grain crop that is grown for food and its many forms are drought tolerant. Sorghum is mostly produced in rural areas and as such is available for food and also as feed for animals. *Sorghum bicolor* is the fifth most important grain crop in Africa after wheat, maize rice, and barley (Etuk et al., 2012). It is highly preferred due to its drought-resistant nature. However, its exposure to harsh conditions also results in the emergence of a higher concentration of antinutritional factors (ANFs). Such factors play a major role in feeds as they affect palatability and, mostly, they have deleterious effects in monogastrics (Achi and Ukwuru, 2015). Dehulling of grains and bacterial fermentation was identified as the best natural method of eliminating the antinutrients (Gororo and Kashangura, 2016). Other methods include cooking, autoclaving, soaking, or roasting. The use of enzymes and tannin binding chemicals are also considered for the control of antinutrients. Phytate and tannin levels are very high in sorghum and thus their elimination will improve the acceptability, palatability, and efficiency of the feed. With the elimination of ANFs, coupled with nutritional advancement, sorghum may go a long way in improving the performance of livestock production.

The elimination of ANFs using the fermentation method needs an evaluation of the overall feed nutrient value through feeding of the fermented sorghum grain to animals since the use of living organisms during the process may affect the nutrient status of that feed, either improving or diminishing

the composition. As such, in the current economic hardships and climatic changes, feed improvement has become detrimental in all spheres, especially for both humans and animals.

Materials and Methods

Ethical statement

This study was performed upon approval from the Animal Ethics Committee of the Marondera University of Agricultural Sciences and Technology.

Project site description

The project was conducted from January 2019 to March 2020 at the National University of Sciences and Technology (NUST) in the Matebeleland region in the city of Bulawayo. The area is located in Agro-ecological Region IV which is characterized by low rainfalls averaging between 400mm and 650mm per annum. It lies at an altitude between 600m and 1200m. It lies on the latitude of 20.0954°S and longitude 28.3831°E. At an altitude of 1350m above sea level, the area is characterized by deep greyish-brown sands and sandy loam derived from granite rocks. Soil pH ranges from 4.4 up to 4.8 and the soils have a characteristic low water holding capacity. The area experiences severe dry spells within the rainy season and as many seasonal droughts. As the area is considered not suitable for crop production, mostly livestock production is practiced. Extensive livestock production of cattle is usually practiced and so is wildlife production. Drought-resistant crops are grown within this region. Drought-tolerant crops including resistant varieties of maize, sorghum, and millet are grown. The region is located in the low-lying areas of Zimbabwe that is, the South-west of the country. The area experiences a sub-tropical climate.

Diets

Sorghum bicolor (red variety) was obtained from a local market in Bulawayo, Zimbabwe from grain traders and was cleaned from impurities such as grit and dirt by winnowing and then subjected separately to the following preparation and treatments: The sorghum was partially ground and soaked for one night in chemical-free water. Chemical-free water was obtained by distilling water to disassociate all impurities and some strains of bacteria that may have been in water which would interfere with the experiment. Chemical-free water is used since it does not affect the LAB which is of importance to the success of the experiment.

This mixture was then stirred thoroughly and covered completely in water. The feed soaked up the water. During the process, 20-liter plastic containers

were used, each filled with 15kg sorghum grains, and, to prevent problems with mold and bad bacteria, and the feed was submerged the whole time. To make this process faster, an existing culture juice from homemade Lacto-ferments was added. This process took 5 days to achieve effective fermentation.

The feed was constantly stirred until satisfactorily immersed in water as a mixture. Treatments were headed under LAB-treated (fermented) sorghum rations, each of these having three proportions of rationing, that is, 25%, 50%, and 75%. Four replications were done to have an acceptable average value. The control experiment had an allocation of 100% commercial feed (Table 1).

Table 1. Feed rationing (sorghum: general feed).

Treatment	% Fermented Sorghum	% General feed
T1	25	75
T2	50	50
T3	75	25
T4 (control)	-	100

Experimental design

A total number of 160 broiler chicks (Cobb 500) were bought from a renowned commercial company in Zimbabwe. Also, feed mentioned as general feed was purchased at the same company. This was done as a three-phase program including broiler starter, broiler grower, and broiler finisher meal. The birds were distributed randomly using the completely randomized design distributing 10 chicks in each treatment (Table 2).

Table 2. Outline of the experiment.

Replication	Layout			
1	T1	T2	T3	T4
2	T3	T4	T1	T2
3	T4	T1	T2	T3
4	T2	T3	T4	T1

Management

At the poultry house, a foot bath was set up and virukill was used as the disinfectant. The housing system was cleaned and disinfected daily and the bedding was changed twice a week. Vaccination of all the birds was done on day 9 against Newcastle using Nobilis Lasota and on day 14 against Infectious Basal Disease (I.B.D). From day 1 to day 49 chicks of each treatment were reared in separate (2 × 2m) pens within a closed and well-ventilated room. Infrared lamps (75 watts) were used as a source of heat and light. As the days progressed, the room temperature

was gradually decreased from 32°C for day-old chicks to 21°C for 21-day olds by raising the infrared lamps and extension of the pen's surrounds. The poultry house was 6m wide and 6m long. *Hyparrhenia* tall-veld grass was used as bedding as it is most abundant in the area. Feed was given *adlibitum* and the birds had unlimited access to drinking water.

The birds were also protected from adverse environmental conditions, predators, theft, and diseases in all treatments. Hygiene at the poultry house was the main theme to avoid spreading diseases to the birds. The bedding was changed every week to avoid ammonia build-up.

Table 3. Nutritional composition of the different phase feeds of the commercial feed.

Nutrient (%)	Starter	Grower	Finisher
Crude protein	21	19.5	18
Moisture	12	12	12
Crude fiber	3	3.7	3.7
Fat	4	4.5	5
Calcium	0.90	0.87	0.85
Phosphorus(avail)	0.42	0.42	0.4

Data collection

Feed consumption was measured every week to establish the average daily feed intake g/bird/d. Feed conversion ratio (FCR g/g) was calculated as the total feed intake for each bird per unit of live weight gain. Mortality was recorded as and when it occurred. Bodyweight changes were determined by measuring the bodyweight for each bird every week starting from the first week of the experiment. Data on average body weight at maturity were used to calculate the average daily gain of the bird g/bird/d. At week 7, the final weight was recorded and slaughtering of the birds was done to obtain the organ weights as a percentage of the final carcass weight. The birds were starved overnight to ensure that the viscera had no food debris. Only water was supplied to the birds during this period. At the end of the trial, random selection and evaluation of carcass characteristics and internal organ weights were done on 15 birds from each feed treatment regime, that is, 5 birds from each replication. The birds were slaughtered at 0600hrs in the morning. Warm water was used for the easy removal of feathers. Feathers were plucked manually. Carcasses were then eviscerated and weighed using a digital electronic scale. Internal organs comprising of the liver, heart, and gizzards were also collected and weighed.

Statistical analysis

The results were analyzed using the Graphpad Prism software version 8.3 of 2019. The 95%

($P < 0.05$) was the level of significance used in this research. The significance found was then continued with further testing Duncan's multiple range test (Duncan, 1955).

Results

Mortality

A total of 46 birds died during the experiment with T1 (25% sorghum) having a 26% mortality which was the lowest. There was a significant difference ($p < 0.05$) in the mortality of birds on T1 (25% sorghum), diets T2, T3, and T4 having 36%, 56.7%, and 33.3% mortality respectively.

Average daily feed intake

There was a significant effect ($p < 0.05$) of feed graded level on average daily feed intake during the study period. Chickens fed on a 25% sorghum diet had a higher ($p < 0.05$) average daily feed intake (85.3 ± 1.23 g/bird/d) than those fed on a 75% sorghum diet (79.56 ± 1.23 g/bird/d). However, there was no significant difference ($p > 0.05$) among 25% sorghum, 50% sorghum, and 75% sorghum inclusion (Table 4).

Feed conversion ratio

The incorporation of fermented sorghum feed affected ($p < 0.05$) the FCR. Birds on 75% sorghum feed had the highest ($p < 0.05$) FCR of 2.6:1 (feed/chicken weight), followed by those on 50% sorghum feed with 2.48:1 (feed/chicken weight), whilst those on 25% sorghum feed with 2.21:1 (feed/chicken weight) had a lower FCR.

The control diet had the lowest ($p < 0.05$) FCR of 1.98:1 (feed/chicken weight) (Table 4).

Bodyweight at maturity

There were significant differences among the graded levels of sorghum feed in the weight of birds at 7 weeks of age. Birds fed with 25% sorghum with an average live weight of $1,928 \pm 131.3$ g/bird were heavier ($p < 0.05$) than chickens on 50% and 75% sorghum diet with $1,670 \pm 131.3$ g/bird and $1,530 \pm 131.3$ g/bird respectively. Birds on the control diet (100% general feed) had a significantly higher ($p < 0.05$) live weight (2118 ± 131.3 g/bird) than those of the three sorghum graded levels (Table 4).

Carcass characteristics and organ weights

There was however no significant difference ($p > 0.05$) for diets with 25%, 75% sorghum, and 0% sorghum inclusion for the percentage dressed weight with 87.66 ± 0.62 g/bird, 88.10 ± 0.62 g/bird, and 89.24 ± 0.62 g/bird respectively. However, diet at 50% sorghum inclusion level had a significantly lower ($p < 0.05$) percentage dressed weight (86.23 ± 0.62 g/bird) as compared to all the other treatments. Carcass weights were significantly ($p < 0.05$) higher ($1,890 \pm 122.8$ g/bird) for T4 (control) than those of 25%, 50% and 75% sorghum diets with $1,690 \pm 122.8$ g/bird, $1,440 \pm 122.8$ g/bird and $1,348 \pm 122.8$ g/bird which were significantly ($p < 0.05$) lower and different respectively (Table 5).

Table 4. Effect of different levels of diet on growth and performance of broilers.

Parameters	Treatment				SEM	Significance
	T1	T2	T3	T4		
Final live weight, g/bird	1928 ^b	1670 ^c	1530 ^c	2118 ^a	131.3	***
Total feed intake, g/bird	4265 ^a	4138 ^a	3978 ^b	4197 ^a	61.27	****
Daily feed intake, g/bird	85.30 ^a	82.76 ^a	79.56 ^b	83.94 ^a	1.23	****
Feed conversion ratio (FCR)	2.21 ^c	2.48 ^b	2.60 ^a	1.98 ^d	0.14	***
Mortality % from 30 birds	26.0 ^c	36.7 ^b	56.7 ^a	33.3 ^b	6.57	*

¹SEM- standard error of measurement. ²Values in the same row with different superscripts differ: NS; Not Significant, *, $P < 0.05$, **, $P < 0.01$, ***, $P < 0.001$

Table 5. Effect of graded levels of feed on carcass characteristics of broilers.

Parameters	Treatment				SEM	Significance
	T1	T2	T3	T4		
Live weight, g/bird	1928 ^b	1670 ^c	1530 ^c	2118 ^a	131.3	***
Carcass yield, g/bird	1690 ^b	1440 ^c	1348 ^c	1890 ^a	122.8	***
Dressed versus live weight%	87.66 ^a	86.23 ^b	88.10 ^a	89.24 ^a	0.62	****

¹SEM- Standard error of measurement. ²Values in the same row with different superscripts differ: NS; Not Significant, *, $P < 0.05$, **, $P < 0.01$, ***, $P < 0.001$

Table 6. Effect of different levels of feed on internal organ characteristics of broilers

Parameters	Treatment				SEM	Significance
	T1	T2	T3	T4		
Heart	0.19c	0.25a	0.23b	0.19c	0.015	***
Gizzard	1.94c	2.11a	2.07b	1.90c	0.055	****
Liver	0.66b	1.09a	1.03a	0.85b	0.096	**

NB: Organ weights are expressed as a percentage to live weights.

²SEM- Standard error of measurement. 2Mean values in the same row with different superscripts differ: NS; Not Significant, *; P < 0.05, **; P < 0.01, ***; P < 0.001

Heart weight was significantly lower in birds on both 25% of sorghum feed and the control (100% general feed) with 0.19 ± 0.015 g/bird inclusive than those on the 50% sorghum (0.25 ± 0.015 g/bird) and 75% sorghum diet (0.23 ± 0.015 g/bird). The highest liver weights were recorded in birds on a 50% sorghum diet (1.09 ± 0.096 g/bird) followed by those on 75% of sorghum inclusion (1.03 ± 0.096 g/bird) and 25% of sorghum inclusion diet (0.66 ± 0.096 g/bird), in that order. An almost similar trend was observed for gizzard weights with 2.11 ± 0.055 g/bird, 2.07 ± 0.055 g/bird, 1.94 ± 0.055 g/bird, and 1.90 ± 0.055 g/bird for 50%, 75%, control, and 25% sorghum diet. Results (Table 6) show a significant ($p < 0.05$) difference in all organs with T2 and T3 having heavier organs as compared to T1 and T4.

Discussion

Growth performance

The better utilization and superior performance exhibited by birds on T1 suggested that the 25% inclusion level was more effective in nutrient provision as compared to higher levels of sorghum nutrient provisions. This can be due to lower antinutrients due to the lower levels of the feed. The decreased growth rate, feed intake, and FCR of the birds on T2 (50% sorghum) and T3 (75% sorghum) suggests a positive correlation between ANFs and sorghum inclusion levels. This follows earlier reports on the presence of anti-nutritional factors, including hydrogen cyanide, phytate tannins, saponins, and oxalate in fermented sorghum by [Anhwang et al. \(2004\)](#). Although these were reduced significantly through grinding and fermenting, traces of these antinutrients cannot be completely sidelined. Tannins have been un-avertedly reported as they induce an astringent taste that affects palatability, lowers feed intake, and ultimately body weight ([Etuk et al., 2012](#)). Studies with rats, chicks, and other livestock revealed that high ANFs in diet adversely affect the digestibility of proteins and carbohydrates, thereby reducing growth, feeding efficiency, and bio-

availability of amino acids ([Mella, 2011](#)). However, birds on T4 (0% sorghum inclusion) performed quite well as there were no alterations to the commercial feed. This was strongly supported by [Chikumba and Chimonyo, \(2014\)](#) in which diets with commercial feed had the best performance.

[Reddy et al. \(1982\)](#) stated that phytate binds to mineral elements like Ca, Zn, Mn, Fe, and Mg by forming phytic-complexes which are indigestible substances, thereby limit the absorption of minerals and thus growth rate. Setting aside the relatively high CF content of the diet as compared to other diets may have contributed to lowering in feed and nutrient intakes and the overall performance of the birds. A diet with a high amount of fiber has been shown to lower feed and consequently nutrient intake in animals ([Chikumba and Chimonyo, 2014](#)). Dietary fiber can also lead to early gut-fill. Thus birds on T3 with the lowest feed intake also had the lowest live weight gain and vice versa.

Carcass and organ characteristics

Lower carcass weight of the birds fed with 50% sorghum inclusion and 75% sorghum inclusion diets resulted from their smaller live weight ([Aderemi, 2003](#)). This result agrees with reports of [Achi and Ukwuru, \(2015\)](#) that reduced carcass weight could be attributed to ANFs. Heavier carcass weight is observed at 0% sorghum inclusion levels to show little to no irregularities in digestion and absorption ([Gabriel et al., 2008](#)). The relative organs of the heart, liver, and gizzard of T1, T4, and T2 showed no significant differences but were significantly heavier in birds fed with 75% sorghum inclusion. This net effect is because of development due to the need for handling toxicities and also a great proportionality of proteins in diet ([Makovický et al., 2012](#)). The birds on a high level (50% and 75% sorghum) diets were slightly affected probably due to some residual ANFs which might not have been completely acted upon.

An increase in the size of these organs in T2 and T3 especially the liver of the birds could be due to increased metabolic activities to make up for the

reduced availability of protein inhibited by the ANFs through increased production of anti-toxins (Aderemi, 2003; Chikumba and Chimonyo, 2014). Etuk *et al.*, (2012) reported that when ANFs are reduced through some treatments to non-toxic levels, the liver would not be enlarged. This confirms the results on birds fed on 25% sorghum as the organs were not significantly affected when compared with a diet with high inclusion levels. The higher gizzard weight of birds on T2 and T3 diets may show the high muscular activity in breaking down the feed due to the high fiber content in the sorghum grains as they are unprocessed. The amount of work done by the muscular walls of a particular organ to grind feed particles determines the size of the gizzard (Abdel-Rahman and Osman, 2011).

Conclusions

The inclusion of LAB-treated sorghum in combination with general feed supported growth performance, carcass, and organ weights development of finisher broilers at 25% incorporation. The poor performance of birds on 50% and 75% inclusion levels suggested that there is a need for detoxification of phytate or processing of DM before its incorporation into chicken feed rations. However, moderate performance was noted in birds fed on T4 with mortality being a major disadvantage.

Declaration of interest

The authors declare no conflict of interest.

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