EFFECT OF SPROUTING ON CHEMICAL COMPOSITION AND PERFORMANCES OF IMPROVED CHICKENS FED WITH HYDROPONIC SORGHUM FODDER (HSF)

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN TROPICAL ANIMAL PRODUCTION OF THE SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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EXTENDED ABSTRACT

Raising chickens is rapidly gaining popularity in the developing world. However, high feed costs associated with intensive poultry rearing as well as increased competition between humans and animals/chicken on feed demand have necessitated the need for exploring new options in chicken feeding. Furthermore, chickens have a limited foraging range a factor that translates in a very narrow array of feeds they can access. Sorghum is one such feedstuff which is widely grown in Tanzania and has nutritional value almost similar to maize and also drought-resistant crop. Given this, two studies were conducted to determine the effect of sprouting sorghum grain on the chemical composition of sprouted sorghum and bird performance fed on the HSF based diet. In the first study, sorghum grain was sprouted in a hydroponic system for 168 hours and sampled for proximate analysis, minerals, anti-nutritional factors and amino acids. The sprouted sorghum seeds were subjected to proximate analysis in duplicate samples at 0, 24, 72, 120 and 168 hours. Whereas, in the second study the aim was to assess the effect of sprouted sorghum hydroponic fodder-based diets on growth performance, feed intake, feed conversion ratio, carcass yield and digestibility using Sasso chickens.

In the second study one hundred and forty-four, growers were allocated randomly to four dietary treatments with three replications for each diet. Each replicate had 12 chickens. The treatment diets were designated as T1: Control; formulated ration with no fodder, T2: 25% HSF: 75% formulated ration, T3: 50% HSF: 50% formulated ration and T4: 75% HSF: 25% formulated ration. The HSF used in this experiment was that which was sampled for 168 hours. The formulated diets were based on locally available low-cost ingredients. Data collected were body weight, feed intake, digestibility and mortality rate. The digestibility trial was conducted at the end of the feeding trial. Three randomly sampled birds were

slaughtered from each treatment at the end of 13^{th} weeks and evaluated for dressing percent, weights of components (breast, thigh, and drumstick), the weight of non-carcass components and carcass weight.

The results in the first study revealed an increase in CP CF, Ash, EE and decrease in NFE from 12.47 to 17.43%; 2.42 to 5.57%; 1.8 to 2.2%; 2.03 to 2.44% and 71 to 60.77% respectively with an increase in sprouting time. However, the DM content declined from 90.56 to 88.09 % with increased sprouting time. There was a decreasing trend for mineral elements with increase sprouting time. Similarly, there was a corresponding decline for anti-nutritional factors with increased sprouting time. The decline ranged from 4.26 to 1.77 g/100g; 4.94 to1.64 mg/Kg; 6.19 to 1.17 µg/100g and 26.46 to 1.07 g/100g for tannin, cyanide, phytic acid and phenols respectively at 168 hours. The maximum reduction of tannin, phytic acid, total phenol and cyanide was achieved between 72 and 120 hours. The results further showed a corresponding increase in the percentage of amino acid, the percent increase of methionine, lysine, and tryptophan ranged from 0.12 to 0.59, 0.22 to 0.79 and 0.08 to 0.16 respectively with sprouting time.

Results in the second experiment showed significant treatment effects on all measured variables. Further increase in HSF inclusion resulted in a declined in body weight gain. The decline ranged from 1970 to 1113.96 g, 6847.39 to 6153.67g, and 3.69 to 6.83 for weight gain, total feed intake, and feed conversion ratio respectively. There was a significant difference ($p< 0.005$) between treatments on live weight and carcass components. Apparent digestibility of sprouted sorghum decreased from 76.08% to 64.24%, while true digestibility decreased from 72.81% to 64.1%. This study concludes that sprouting increases the nutritive value of HSF and led to a significant reduction of anti-nutritional factors. However, the performance of chickens was depressed when the quantity of HSF was increased beyond 25%, due to the lowering of the energy: protein ratio. Thus, the use of HSF should, therefore, be limited but where maize grain availability is limited then, sprouted sorghum can be included at a rate not exceeding 25% as energy sources.

DECLARATION

1, Violet Israel Kidulani, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my original work and that it has neither been submitted nor being concurrently submitted for a degree award in any other institution.

__________________________ ____________________

Violeth Israel Kidulani Date

(MSc. Tropical Animal Production Candidate)

The above declaration is confirmed by;

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Dr, S.H. Mbaga Date

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Prof, A.A.O. Aboud Date

(Supervisor)

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DEDICATION

This dissertation is dedicated to my family for their total support and patience.

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ABBREVIATIONS AND SYMBOLS

µ	Microgram
ACGG	African Chicken Genetic Gain
ANOVA	Analysis of Variance
Ca	Calcium
CF	Crude Fibre
conc	Concentration
CP	Crude Protein
DAARS	Department of Animal, Aquaculture and Range Sciences
DED	District Executive Director
DM	Dry Matter
EE	Ether Extracts
FAO	Food and Agricultural Organization of the United Nations
g	Gram
K	Potassium
Kg	Kilogram
Mg	Milligram
MSc	Master of Science
P	Phosphorous
HSF	Hydroponic Sorghum Fodder
SUA	Sokoine University OF Agriculture

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Raising chickens is rapidly gaining popularity in the developing world, Tanzania inclusive. However, high feed costs associated with intensive poultry rearing and increased competition for cereals grains between humans and animals/chickens have necessitated the need for exploring new options in chicken feeding. For example, Baba *et al. (*2012) and Emami *et al*. (2012) reported that in developing countries about 68 - 98 % of cereals are used for human consumption, thus less is left for livestock. Kaijage *et al.* (2015) reported further that in commercial or semi-commercial farming, the huge cost of supplementary feeds of chickens often comes from cereals (60-65%), maize and maize by-products being the commonest. Moreover, cereals such as sorghum are less used by humans except for drier parts of Sub Saharan Africa where crops such as maize do not do well (Baba *et al*., 2012).

Sorghum cultivation can be intensified to replace maize for poultry feeds since the crop has adaptive features that favor its growth in areas where other cereals cannot survive. Furthermore, the nutritive value of sorghum grain is well established and is comparable to maize as a source of energy, protein, minerals, vitamins and antioxidants (Rungiang *et al*., 2016).

Sorghum has been shown to have very high fiber and iron contents with moderately high protein levels, but with inferior organoleptic quality due to the presence of anti-nutritional factors such as tannins and phytates which inhibit protein digestibility and absorption of iron (Baba *et al*., 2012). To reduce the levels of anti-nutritional factors processing methods, such as soaking and sprouting have been used for various cereal grains (Tranel, 2013; Naik *et al*., 2015; Mbaenyi and Onweluzo, 2010). When processed correctly, sorghum can serve as the primary grain source in animal diets. To improve sorghum feeding value further, a greater understanding of key anti-nutritive properties, including cyanide, phenolic compounds, tannin, and phytate is needed (Kimberly *et al.,* 2019; Iyabo *et al*., 2018). Tannins form complexes which may render unavailability of nutrients and may impair feed palatability. Besides, tannin levels of more than 1% in poultry diets reduce dry matter intake, body weight gain and feed efficiency (Kaijage *et al*., 2014; Selle and Bryden, 2010).

Sprouting method has been successfully used in grains to improve feeding values and increase digestibility (Azhari *et al.,* 2015; Kaijage *et al.,* 2014). Hydroponics involves the production of fodder without soil in a confined environment (Mouneshwari *et al.*, 2019). The nutrient composition of HSF is affected by the length of the harvesting period. Research conducted by, Chrisdiana (2018) reported a decrease of DM and an increase in CP, Ash, NDF and ADF in barley fodder when the harvesting period increased from 6 to 7 days. Feeding of hydroponics grains fodder as a partial feed substitute of calf starter on protein basis at seven percent level improves the DM intake and average daily gain (Rajkumar *et al.,* 2018). Alinaitwe *et al.* (2019) observed the highest live weight of 3.34 kg in Kuroiler chicken when fed with 25% Hydroponics barley fodder while beyond 25% inclusion level resulted into poor performance. Even though sorghum is widely grown in the tropics its use in form of hydroponic sorghum fodder (HSF) is not well documented. Thus, the main objective of the present study was to evaluate the effect of sprouting on the chemical composition of sorghum hydroponic fodder and to assess the effect of sprouting on performances of Sasso chickens fed with a diet supplemented with sorghum hydroponic fodder.

1.2 Objectives of the Study

1.2.1 General objective

To evaluate the suitability of using sorghum hydroponic fodder as supplemental feed for chickens.

1.2.2 Specific objectives

i. To assess the effects of sprouting of sorghum grains on proximate composition values, minerals, amino acids and ant nutritional factors.
ii. To assess the effect of hydroponic fodder-based diets on growth performance, feed intake, feed conversion ratio and digestibility when fed to Sasso chickens.
iii. To assess the effect of hydroponic sorghum fodder-based diets on the carcass and non-carcass characteristics of Sasso chickens.

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CHAPTER TWO

MANUSCRIPT 1

EFFECT OF SPROUTING ON CHEMICAL COMPOSITION OF HYDROPONIC SORGHUM FODDER (HSF)

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EFFECT OF SPROUTING ON CHEMICAL COMPOSITION OF HYDROPONIC SORGHUM FODDER (HSF)

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Abstract

This experiment was conducted to evaluate the chemical composition of Hydroponic Sorghum Fodder (HSF) and determine its suitability as a supplementary poultry feed. Four kilograms of sorghum grain were sprouted in a hydroponic system for a duration of 168 hours. Samples for chemical analysis were drawn at 0, 24, 72, 120 and 168 hours after sprouting. These were compared to a sample of soaked sorghum grain taken before sprouting for standard proximate analysis. Similarly, determinations were made for the contents of minerals, amino acids, cyanide, tannin, phenols and phytic acids. Sprouting for 0, 24, 72, 120 and 168 hours led to increase in CP, CF, Ash, EE and decrease in NFE from respectively 12.5 to 17.4%; 2.4 to 5.5%; 51.76 to 56.18%1.8 to 2.2%; 2.03 to 2.4% and 71.84 to 60.77%. The decrease in the NFE was probably what to the increase in the level of the rest of the components. The DM content also declined from 90.56 to 88.09 %. Methionine, Lysine and Tryptophan increased from 0.12 to 0.59%, 0.22 to 0.79% and 0.08 to 0.16% respectively. However, the proportion of Ca, P and K declined with sprouting time. Sprouting caused a significant decline in anti-nutritional factors. The percentage declines were 58.45; 66.8; 81.09 and 96.21 for tannin, cyanide, phytic acid and phenols at 168 hours. It was concluded that sprouting is an efficient method for reducing the level of anti-nutritional factors and increasing nutritive values of Sorghum grains.

Keywords: Anti-nutritional factors, feed, hydroponic fodder, poultry, sorghum.

1.0 Introduction

In the wake of climate change, the production of conventional animal feedstuffs such as maize has been declining while the human population has continued to increase hence, threatening food security (Ehrlich and Harte, 2015). This necessitates the alternative drought resistant feedstuffs for livestock including poultry. One such feedstuff is sorghum which is drought and pest resistant and has nutritional value almost similar to that of maize (Sonia, Y, and Naik *et al*., 2015).

Despite being a good substitute for maize, sorghum grains has limitation in its inclusion in poultry diets due to the presence of anti-nutritional compounds such as cyanide, phytic acids, phenols, tannins and phytates that affect nutrients and minerals uptake (Baba *et al*., 2012). In recent years some scholars have recommended sprouting as a means of reducing anti-nutritional compounds in sorghum grains and thus, enhancing its utilization in poultry feed.

Sprouting has been reported to influence the breakdown of complex compounds into simpler forms during germination hence, improving the feed digestibility and nutrient uptake (Sharif *et al*., 2013). Moreover, this method is relatively new in the feed industry and information on the existing nutritive value of sprouted sorghum grains is not well documented (Kaijage *et al.,* 2015). Hence, the current experiment was undertaken to evaluate the effect of sprouting sorghum grains on the nutritional composition, mineral content and anti-nutritional compounds.

2.0 Methodology

2.1 Description of the Seed Source and Study Area

Mature sorghum grains (Kakera white) were collected from the Singida Rural district in Central Tanzania. The district is located below the equator between latitude 3^0 and 7^0 and between longitude situated between 33^0 and 35^0 east of Greenwich, with average rainfall ranging between 600 to 700 mm per annum. Sprouting was done at the Department of Animal, Aquaculture and Range Sciences, Sokoine University Poultry unit.

2.2 Study Design and Data Collection

Four kilograms of Kakera white sorghum grains were initially cleaned to remove debris and washed with clean tap water. Thereafter the cleaned sorghum grains were divided into two portions, one of 3 kilograms and another with one kilogram. The one-kilogram portions were sun-dried and ground in the mill to pass 2mm sieve and denoted as unsprouted sorghum (US). The remaining 3 kilograms were soaked in 2 liters of water containing 50% sodium hydroxide solution for 40 minutes to arrest mold growth. This was followed by rinsing in distilled water for 20 minutes to remove all the chemical residuals. Thereafter, sorghum grains were soaked in the distilled water for 24 hours with the water changed halfway in the 12th hour. The grains were drained on a single layer filter cloth.

The drained sorghum grains were then covered with a dark cloth for after the formation of the radicles, seeds were then spread in six single plates of 6.5 x 3.5 cm each, the carrying capacity of each plate was 0.45 kg. Each plate was then covered by a transparent white plastic sheet to allow germination. Following the formation of the radicles, the white cover sheet was removed until the green leaves appeared. Then, the cover was opened and rinsing was done twice every day. The sprouted sample was collected at 0, 24, 72 and 120 and 168 hours, oven-dried, grounded and packed in bottled ready for chemical analysis.

Sprouted and unsprouted sorghum seeds were subjected to proximate analysis in duplicate samples. The duplicated sample for 0, 24, 72, 120 and 168 hours were analyzed for dry matter (DM), ether extracts (EE), crude protein (CP), crude fiber (CF), (NFE) and ash content according to (AOAC, 1990). Functional components such as amino acids lysine, methionine and tryptophan were determined by test method using Near Infra-Red Spectroscopy (NIRS) at Tanzania Veterinary Laboratory Authority (TVLA) (Valentin and Baianu, 2011) while, tannin, phenolic, phytates and phytic acid were determined by Vinyl method (Sudhir *et al*., 1989) at Food Science and Technology Laboratory of Sokoine University of Agriculture Tanzania. Mineral components were determined by atomic absorption spectro-photometric methods (AOAC, 1990) at the Soil Science Laboratory of Sokoine University of Agriculture.

3.0 Results and Discussion

3.1 Proximate compositions

The results in Table 1 show the proximate composition of HSF. There was a general linear increase in all the proximate components studied as a result of sprouting, except for the DM content. The increase in CP, ash, CF, and EE was 40%, 23%. 130% and 20% respectively after 168 hours of sprouting. Generally, all parameters were at the maximum level between 72 to 120 hours of sprouting. Similar observations were reported by Fazaeli *et al.* (2012) from barley grains, who also reported an increase in proximate components between 6 and 8 days of sprouting. Sneath and McIntosh (2003) on the other hand reported an increase of CP from 11.38% to 24% for sprouted barley.

This study reported that, there was a fall in fiber contents by 2.5% unit. On the other, Azhari *et al.* (2015); Fazaeli *et al.* (2012) and Gebremedhin (2015) reported a fall in fiber content of 3.15% which is contrary to this study. Sneath and McIntosh (2003) observed a slight increase in EE 3.4% when barley were sprouted and the increase which has been associated with the production of chlorophyll in the green shoots shortly after sprouting.

Table 1: Proximate composition of HSF at different times

Proximate Component (%)	Composition (%) at different Sprouting times				
	0	**24**	**72**	**120**	**168**
DM	90.56	89.59	89.59	89.22	88.09
CP	12.47	12.83	14.1	15.4	17.43
ASH	1.8	1.46	2.08	2.18	2.22
CF	2.42	2.72	3.56	4.84	5.57
EE	2.03	2.73	2.37	2.38	2.44

3.2 Mineral Contents

Table 2 shows a decreasing trend for the three assayed minerals with sprouting time. In all cases, the levels of these minerals declined much faster especially between 24 and 120 hours of sprouting. The observed trend was similar to the findings reported by Raihanatu *et al.* (2011) and Sneath and Mclntosh (2003). On the contrary, Fazaeli *et al.* (2012) and Azhar *et al.* (2015) reported a significant increase in calcium contents with sprouting time. Hence, the decrease in mineral contents implies that one needs to pay attention to formulating poultry diets. The observation is in agreement with Raihanatu *et al. (*2011) and Saidi and Omar (2015) who recommended fortification to balance the Ca:-P ratio in feeds.

Table 2: Effect of sprouting time on mineral contents

Mineral Components (%)	Composition (%) at different Sprouting times				
	0	**24**	**72**	**120**	**168**
K	3.01	2.36	2.36	1.96	1.96
CA	0.29	0.03	0.02	0.02	0.01
P	0.55	0.41	0.35	0.34	0.32

3.3 Anti-nutritional factors

The results for anti-nutritional factors presented in Fig. 1 shows that all components declined with time particularly for phenols and phytic acids. The percentage decline between sprouting time were from 17.81% to 66.8% for cyanide; 43.78% to 81.1% for phytic acid; 26, 76% to 58.45% for tannin and 46.75% to 95.96% for phenols between 0, 24, 72, 120 and 168 hours respectively. The decrease in anti-nutritional factors has been associated with the activation of the peroxidase enzymes (Azhari *et al.,* 2015). However, the results in the present study show that tannin contents were lower than those of Kaijage *et al*. (2015) for white sorghum before sprouting; this could be due to the climatic condition and soil type where sorghum was grown. The reductions in anti-nutritional factors following sprouting conform to findings reported by Azhar *et al.* (2015). Kumar and Verma (2015) reported similar trend for tannin and phenols at 24 hours, 48 hours, 72 hours and 96 hours of sprouting time, the values being 6.55 ± 0.013 to 3.72 ± 0.006 and 2.45± 0.035 to 0.74 ± 0.003 mg/g for black gram grains (Sheker and Uradsadabahar variety).

On the other hand, Raihanatu *et al.* (2011) noted that tannin content for the raw variety ranged from 3.4 mg/g to 4.9 mg/g while that of the sprouted variety ranged from 3.2 to 4.7 (mg/g). However, these findings were higher than the current findings, the difference observed was attributed to variety and variation in the quantity of pigment in seed coat (Nithya *et al.,* 2007; Baba *et al*., 2012). On the other hand, Azra *et al.* (2008) reported a higher reduction in cyanide, phenols and phytic acids after sprouting. The maximum reduction in anti-nutritional factors of sprouted seeds was recorded after 96 hours similar to the observation in the current study. From these results, it is obvious that the process of sprouting grains appears to have beneficial effects by reducing the anti-nutritional factors.

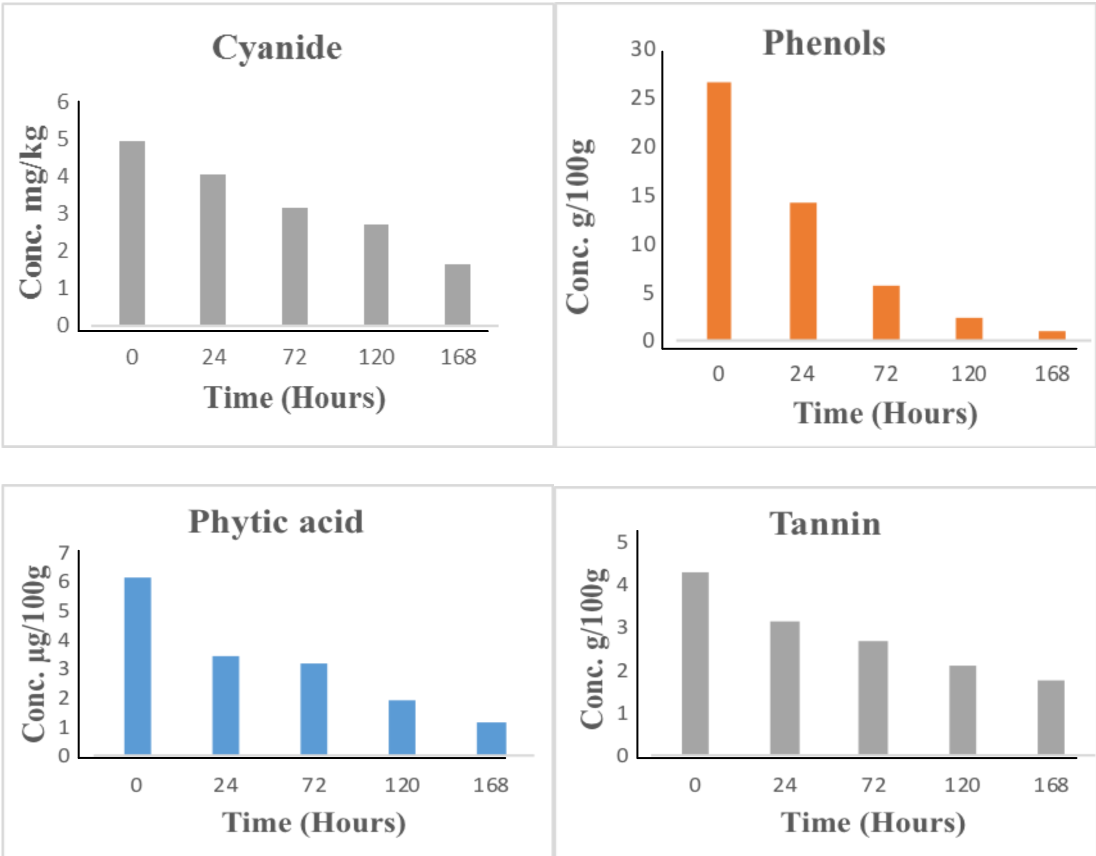

Figure 1: Anti-nutritional contents of Hydroponic Sorghum Fodder from 0 to 168 hours of sprouting; Tannin-CT conc. (g/100g). Total Phenols conc. (g/100g). Cyanide-HCNmg/Kg. Phytic Acid-Conc. µg/100g. (0 represent whole grains)

3.4 Essential Amino Acids

As for proximate content, there was an increase in the proportion of amino acids with sprouting time (Fig. 2). The trend shows an increase of lysine following sprouting time, but the increase was at the maximum level between 72 to 120 hours. On the other hand, tryptophan increased slightly, the maximum being between 24 to 168 hours of sprouting time. The percent increase of methionine, lysine and tryptophan ranged from 0.12 to 0.59, 0.22 to 0.79 and 0.08 to 0.16 respectively. All amino acids registered a sharp increase for the first 72 hours followed by a smaller rise in their content.

This trend was expected and corroborate observations by Sneath and Mclntosh (2003) who reported that sprouting grains causes an increase in the contents of total proteins, fat and certain essential amino acids. On the contrary Nithya *et al.* (2007) and Rungiang *et al.* (2016) reported much higher values for total amino acid contents (1.42%) following sprouting, the increase is explained by partial hydrolysis of stored proteins by endogenous proteases during germination of seeds. Nithya *et al.* (2007) discussed that most of the nutrients change with sprouting result from enzymes activation in grains which led to the breakdown of stored compounds in grains into simpler and digestible fractions such as simple sugars, free fatty acids and amino acids. Saidi and Omar (2015) elaborated on the increase in lysine content with sprouting to be caused by the degradation of prolamines (protein) into lower peptides and free amino acids.

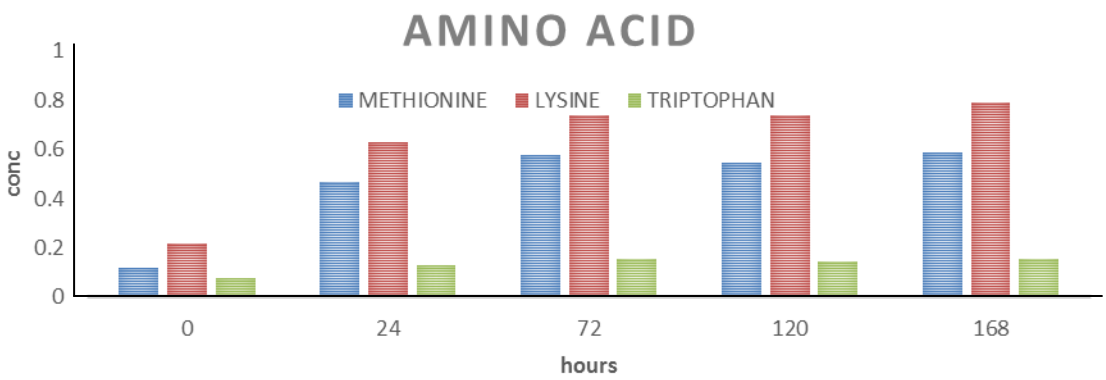

Figure 2: Effect of sprouting on Methionine, Lysine and Tryptophan contents (0 represent unsprouted grains)

4.0 Conclusion

It is concluded that sprouting increases the nutritive value of hydroponic sorghum fodder and leads to a significant reduction of anti-nutritional contents. The reduction in anti-nutritional factors opens up the possibility of sprouted sorghum as an additional feed supplement for chickens.

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CHAPTER THREE

MANUSCRIPT 11

Effect of sprouting on performances of improved Sasso chickens fed with sorghum hydroponics fodder

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EFFECT OF SPROUTING ON PERFORMANCES OF IMPROVED SASSO CHICKENS FED WITH SORGHUM HYDROPONIC FODDER

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Abstract

A study was conducted to evaluate the effects of Hydroponic Sorghum Fodder (HSF) as supplementary feed on the growth performance of improved Sasso chickens housed indoor. One hundred forty-four (144) growing chickens were randomly allocated to four dietary treatments with 3 replicates each with 12 chickens. The formulated diet was based on locally available low-cost ingredients. The basal diet comprised a mixture of compounded maize grain, maize bran, sunflower seed cakes, fish meal, soya bean meal, vitamin premix, common salt, bone meal, limestone, lysine and methionine. HSF was included in basal diet at 0 (control), 25% (T2), 50% (T3) and 75% (T4). Sprouting was done for 168 hours, the time which was found to give minimum levels of anti-nutritional factors. The results showed that performance decreased as levels of HSF increased, T4 being the poorest. Based on these results it is concluded that higher levels of HSF in the diets are undesirable on account of its effect on lowering energy concentration in the diet. Therefore, the level of inclusion did not exceed 25% HSF can be recommended for supplementation of indoor reared chickens.

Keywords: Chickens, hydroponic fodder, sprouting,

1.0 Introduction

Sorghum (*Sorghum bicolor*) is considered one of the most important food crops in the world, following wheat, rice, maize and barley. Sorghum provides the staple food of a large population in Africa, India and the semi-arid parts of the tropics and it is commonly consumed by the poor masses of these countries (Raihanatu *et al*., 2011; Mamoudou *et al.*, 2006.) In Tanzania, sorghum is grown mainly in central-arid regions including Dodoma, Singida and parts of Shinyanga. Sorghum grains have very high fiber contents with moderate protein levels and inferior organoleptic quality due to the presence of anti-nutritional factors such as tannins, cyanides and phytates. Anti-nutritional factors have been shown to inhibit protein digestibility and absorption of iron (Raihanatu *et al*., 2011). Alwala *et al*. (2014) reported a depressed growth rate when poultry was fed diets containing 0.5 to 2.0% tannin. Moreover, processing methods, such as soaking, sprouting, and cooking has been reported to improve the nutritional and functional properties of plant seeds such as sorghum, wheat and barley (Naik *et al*., 2015; Tranel, 2013; Saroeun, 2010). Underutilization of sorghum as poultry feed implies a greater competition for maize between human and animals. Anti-nutritional factors have thus limited its inclusion in diets of poultry. The study on hydroponic sorghum fodder (HSF) has been conducted elsewhere, but in Tanzania, the knowledge is relatively new and information on the existing nutritive value of sprouted sorghum grain and its effect on birds performance is not well documented. Sprouting as a technique to reduce anti-nutritional factors will increase the exploitation of available sorghum varieties in Tanzania and thus it is expected to reduce the competition on maize as human and livestock feed. This study, therefore, intended to assess the effects of sprouted sorghum on the performances of Sasso chickens.

2.0 Materials and Methods

2.1 Location of the Study

The experiment was done at the Department of Animal, Aquaculture and Range Sciences (DAARS) poultry unit, Sokoine University of Agriculture (SUA) Morogoro Tanzania. SUA is located at an altitude of 500 - 600 m above sea level. The ambient temperature ranges from 20^0C to 35^0C and the area receives about 600 to 1000 mm of rainfall annually.

2.2 Experimental Diet and Birds

Sorghum grains were soaked in water containing 50% sodium hydroxide solution for 40 minutes to retard mold growth during germination. The grains were then washed with water several times and soaked in water for 20 minutes to make sure that the chemical residuals are completely removed (Ebenezer and Bernahardit, 2013). The grains were further soaked in water for 12 hours then water was drained and hydrated again for a further 12 hours. The grains were then covered with a dark cloth for the whole night and left for 48 hours to sprout and continued to be rinsed twice every day.

Sprouting was done for 168 hours, the time which was found to give minimum levels of anti-nutritional factors. One hundred and forty-four Sasso chickens were brooded for one month using a commercial starter diet. The birds were vaccinated against Newcastle disease and Fowlpox disease as per recommendations. Strict biosecurity measures were followed throughout the experimental periods. After brooding, the chicks were randomly allocated to four dietary treatments with three replicates each, and each replicate had 12 chickens. The diets were formulated such that sprouted sorghum replaced the basal diets (control) by 0% (T1), 25% (T2), 50% (T3) and 75% (T4) on fresh basis harvested at 168 hours as (Table 1). The basal diet (Gross composition) is presented in Table 2.

2.3 Experimental treatments

Four treatment groups were used in the study each with different inclusion levels of HSF and basal diet as shown in Table. 1.

Table 1: Experimental treatment groups

Treatments	Inclusion %	Feed Rate
Treatment 1	100% Basal diet	Based on the average weight per week
Treatment 2	25% Hydroponic Sorghum Fodder and 75% basal diet	
Treatment 3	50% Hydroponic Sorghum Fodder and 50% basal diet	
Treatment 4	75% Hydroponic Sorghum Fodder and 25% basal diet	

Table 2: Gross composition of feed ingredients of formulated feed for Grower chickens

Ingredients	Amount kg/100kg
Maize	24
Maize bran	45
Salt	0.25
Sunflower seed cake	9
Soya bean meal	10
Bone meal	2
Methionine	0.25
Lysine	0.25
Fish meal	8
Vit- Premix	0.25
Limestone	1
Total	100

Results of the feed composition of the basal diet analyzed in the laboratory are presented (Appendix 2 and Table 3). Results show that ME, CP, CF, EE were 13.03 MJ/kg, 19.35%, 5.2%, and 4.7% respectively, while Amino acid such as lysine, methionine and tryptophan were 1.1%, % 0.7%, 0.19% respectively. The percent Calcium (Ca) and phosphorus (P) were 0.9% and 0.9% respectively.

Table 3: Nutrients composition of the basal diet

Nutrients	Nutrients composition	Unit
ME	13.03	MJ/kg
CP	19.35	%
CF	5.27	%
EE	4.71	%
Lysine	1.1	%
Methionine	0.7	%
Tryptophan	0.19	%
Calcium	0.91	%
Phosphorous	0.3	%

Source: Laboratory analysis

According to these results the basal diet fed to chickens contained adequate nutritive value for chicken growth if feeding is not restricted. Feed spillage was controlled by making sure that feed was offered twice a day and the feeders were hanged properly as well as refusal was collected and weighed. Daily feed allowance was adjusted as birds grew, while drinking water was offered *ad libitum* throughout the experiment. Experimental diets were introduced in the fifth week and body weights were measured once every week from the 5th week to 13th week. Daily feed intake (on a pen basis) and mortality were also recorded. A digestibility trial was conducted at the end of the experiment. A total of twelve birds were used for this experiment whereby three birds were randomly placed in cages for each level of HSF inclusion. The birds were fed with experimental diets, (100% diet as control, 25% HSF, 50% HSF and 75% HSF for five days of the preliminary period to adjust the experimental environment. It was followed by a collection period of 7 days. Amount of feed given, feed refusal and fecal voided were measured consecutively for seven days. DM and nitrogen content (uric acid) in fecal voided were determined by AOAC (2000). The determination of true protein from the poultry fecal sample was according to Zaklota *et al.*, 2011) using 10 mls of 10% TCA (Trichloroacetic acid). The apparent and true digestibility was calculated based on DM.

Digestibility was calculated as follows:

$$\text{Apparent digestibility (\%)} = \frac{\text{Feed intake (DMg/day) -(Faecal voided (DMg/day)}}{\text{Feed intake (DM/day)}} \times 100$$

True digestibility was then determined as:

$$\text{True digestibility (\%)} = \frac{\text{N-intake -Fecal-N}}{\text{Feed intake}} \times 100$$

At the end of a 13th-week random sample of three birds were slaughtered from each treatment and evaluated for dressing percent; carcass weight; non- carcass components (breast, thigh and drumstick); the weight of non-carcass components (gizzard, spleen, liver and length of intestines). The General Linear Model (GLM) procedure of SAS (2000) was used to assess the effect of hydroponic fodder-based diets on growth performance, carcass yield (Model 1), while model 2 was used to analyze feed intake and feed conversion ratio. The models used were as follows;

Yij = μ+ Ti + b(x-Σx ⁄n)ij + eij...1

Where:

Yijk = an observation for given variables (body weight, Carcass, non-carcass components)

μ = Overall mean

Ti = Effect of ith treatment (i = T1, T2, T3, T4)

b(x-Σx ⁄n) = Initial body weights as covariate

b = regression coefficient

x = initial weight of chicken

Σx ⁄n = average initial weight

eijk = residual random error

Yij = μ+Ti +eij..2

Where:

Yijk = an observation for given variables (feed intake and feed conversion ratio)

μ = Overall mean

Ti = Effect of ith treatment (i = T1, T2, T3, T4)

eijk = residual random error

3.0 Results

3.1 Growth Performance, Feed Intake and Feed Conversion Ratio

Results in Table 4 show significant differences among treatment effects on all measured variables. All parameters measured declined with an increase in HSF in the diets.

Table 4: Growth performance, feed intake and feed conversion ratio (mean ± se) of chickens fed HSF

Variables	Treatments				
	1	2	3	4	P-value
INW (g)	633.42±13	620.15±14	602.76±11	638.96±16	0.1954
FNWT(g)	2493.72±67[a]	1996.29±63[b]	1786.53±57[c]	1411.29±57[d]	0.0001
TWG (g)	1970.7±27[a]	1467.87±57[b]	1256.56±57[b]	1113.96±93[b]	0.0168
ADG (g)	33.22±10[a]	24.57±10[b]	21.13±10[c]	13.79±10[d]	0.0001
TFI (g)	6847.39±44[a]	6525.28±44[b]	6362.53±44[c]	6153.67±44[d]	0.0001
ADFI (g)	122.27±10[a]	116.49±10[b]	113.62±10[c]	109.89±10[d]	0.0001
FCR	3.69±10[b]	5.47±10[ab]	5.80±10[ab]	6.83±10[a]	0.0134

FNWT- Final weight gain, **TWG**-Total weight gain, **ADG**- Average daily gain, **TFI**-Total feed intake, **ADFI**- Average daily feed intake, **FCR**-Feed conversion ratio, **IWG**-Initial weight gain. Values within rows sharing a similar superscript letter are not statistically different (*p>0.05*)

3.2 Carcass Yield

Table 5 shows that treatments differed significantly for all carcass parameters measured as well as live weight except for gizzard, spleen and intestine length. The trend for these variables decreased with an increase in HSF. However, there was no significant difference between T2 and T3 for all measured parameters.

Table 5: Least square means (Mean ± se) for slaughter weight and carcass yield of chickens fed HSF

Variable	Treatments				
	1	**2**	**3**	**4**	**P-value**
Inwt (g)	633.42±13	620.15±14	602.76±11	638.96±16	0.1954
Fnwt (g)	2493.72±67^{a}	1996.29±63^{b}	1786.53±57^{c}	1411.29±57^{d}	0.0001
Slaughter wt. (g)	2479.04±116^{a}	1985.78±116^{ab}	1776.38±116^{bc}	1403.63±116^{c}	0.0007
Carcass wt. (g)	1942.00±130^{a}	1431.50±130^{b}	1280.50±130^{bc}	909.50^{c}±130^{c}	0.0010
Dressing %	73.41±1.31^{a}	71.53±1.31^{b}	70.14±1.31^{b}	62.76±1.31^{c}	0.0001
Thigh (g)	326.00±23^{a}	240.00±23^{b}	211.50±23^{bc}	149.50±23^{c}	0.0014
Drum stick (g)	264.00±23^{a}	217.00±23^{ab}	182.00±23^{bc}	138.00±23^{c}	0.0014
Breast (g)	538.50±49^{a}	338.50±49^{b}	338.00±49^{b}	254.50±49^{b}	0.0103
Gizzard (g)	59.75±5	50.50±5	50.00±5	47.25±5	0.8660
Liver (g)	53.25±5^{a}	37.25±5^{b}	33.25±5^{b}	30.50±5^{b}	0.0370
Spleen (g)	4.00±10	3.00±10	2.50±10	2.25±10	0.4403
Intestine length (cm)	200.25±11	197.50±11	221.50±11	195.50±11	0.4177

^{a,b,c,} Values within rows sharing a similar superscript letter are not statistically different (*p>0.05*).**HSF**- Hydroponic sorghum fodder.

3.3 Mortalities

Mortality rates were low (1.4%) and only two chickens died due to coccidiosis in T3 and T4.

3.4 Digestibility

Table 6 shows results for the apparent and true digestibility of experimental feeds. Apparent digestibility ranged between 76.08% to 64.24% while, that of true digestibility ranged from 72.81% to 64.10%. Digestibility decreases as the level of HSF inclusion level increased.

Table 6: Calculated results for apparent and true digestibility in g/DM

Treatment	Feed Intake	DM-Intake	Fecal voide	DM Fecal	CP Feed	N-Faecal voided	Uric acid	Apparent digestibility (%)	True digestibility (%)
T 1	108.57	90.56	58.65	40.10	12.47	5.33	0.67	76.08	72.81
T 2	105.93	89.59	62.74	41.21	12.63	5.03	1.77	72.76	69.17
T 3	105.15	85.02	65.00	44.21	14.10	4.84	1.29	67.86	66.84
T 4	104.05	83.21	65.58	47.21	15.40	4.95	1.44	64.24	64.10

T1-Treatment one, **T2**-Treatment Two, **T3**-Treatment Three, T**4**-Treatment four.

4.0 Discussion

The results of the current study show that body weight gain, feed conversion ratio, and feed intake were reduced with an increased level of Hydroponics sorghum fodder (HSF). Similar observations were reported by Akinola *et al.* (2012). Fanimo and Akinola (2006) reported that weight gain decreased with an increased level of sprouted sorghum among the various levels of treatments for three types of sorghum sprout (FMSP, AMSP and RMSP). The authors argued that such observations were probably due to the presence of dietary tannin that reduces utilization of energy, protein and amino acids which lead to decreased feed intake and subsequent lower weight gain. Increased levels of HSF lead to an increase in feed bulkiness which in turn might affect feed acceptability, digestibility, and utilization as reported by Gemede and Ratta (2014).

Kakade and Hathan (2015) argued that the proportion of protease inhibitors contents can also be lowered to permissible limit by applying pre-treatment such as soaking of grains (finger millet). In poultry, small quantities of ant- nutritional contents such as Tannin in the diet may cause severe effects, for instance, the level of 0.5-2.0% may cause depression, while 3-7% can cause death (Tripathi and Mishra, 2007). Previous analysis of sprouted sorghum that was used in this study indicated that the level of tannin was 1.77g/100g, which was low implying that the depression in birds' performance could be due to bulkiness rather than tannin content. However, the present study challenges the observation by Gemede and Ratta (2014) and Sale (2015) who reported that the performance of chickens improved when sprouted grain was added to the ration at the level of 15% to 30%, while in the present study the performance of Sasso chickens was depressed.

Tannins have been described as a group of substances with the ability to bind proteins in aqueous solution. However, an interesting aspect of sprouted sorghum is that the tannin is basically bound within the sprout and therefore may have been inactive when ingested hence become a major contributor to the endogenous losses. Again, contrary to the findings of the current study, Ansari (2016) reported that germinated grains did not affect the growth performance of poultry. However, when days of germination increased it depresses the growth due to an increase in tannin contents. These results corroborate the report by Sharif *et al*. (2013) who argued that sprouting does not decrease the tannin content of the grain, but favor the formation of complexes between testa tannin and endosperm proteins. It, therefore, appears that performance is more likely to be affected by the amount of sprouted sorghum consumed by the bird rather than by the act of sprouting. Increased level of sprouted sorghum was also associated with a reduction in feed intake as the level of the HSF increased, such reduction has been associated with poor palatability and bitterness due to the presence of tannins and other anti-nutritional factors.

Treatments had significant effects on carcass and non-carcass components and consequently an overall decline in measurements with increased HSF inclusion. The results are in agreement with the results reported by Kwari *et al.* (2014) who reported significant differences among treatments for breast and thigh, as well as the carcass yield due to the low protein intake.

The current study indicated that, there was a decrease in digestibility when HSF was added in chicken feed at 50% and 75% level of inclusion. However, this result is in contrary from Sneath and Mclntosh (2003) who reported that, there was a decrease in digestibility when HSF exceed 87% inclusion level due to the increased bulkiness and fiber contents. Current results also contradict the findings of Baba *et al*. (2012) and Ebenezer, (2015) who reported that, sprouted sorghum improve feed intake and digestibility when fed to poultry. However, for the current study, FCR declined as HSF increased in the diet. Consequently, chicken receiving diets with a high content of HSF showed reduced feed conversion ratio and hence, poor performance, probably due to the high level of crude fiber and possibly unfavorable energy: protein ratio (Azhari *et al.,* 2015).

5.0 Conclusion

In conclusion, the present findings suggest that HSF may substitute maize up to 25% level of inclusion without any adverse effect on birds. It is more likely that higher HSF inclusion levels reduce energy; protein ratio.

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CHAPTER FOUR

4.0 GENERAL DISCUSSION AND CONCLUSION

4.1 General Discussions

The general objective of this study was to evaluate the suitability of using sorghum hydroponic fodder as a supplementary feed for Sasso chickens. The nutritive values i.e. proximate composition, minerals, amino acids and anti-nutritional contents of sprouted sorghum grains were determined. Initially, an experiment was conducted to assess the effects of post-sprouting and duration on proximate composition and levels of anti-nutritional factors. Amino acids and minerals contents were also evaluated. This was followed by assessing the effect of the inclusion of hydroponic fodder in diets on growth performance, feed intake, FCR and digestibility in chickens. Finally, was to assess the effect of hydroponic sorghum fodder-based diets on carcass yield.

The White sorghum from Singida Region was used. Laboratory analysis before sprouting showed that the variety had generally high levels of anti-nutritional contents which declined upon sprouting. Whereas the maximum reduction of anti-nutritional factors was achieved between 72 and 120 hours.

The present findings showed that the chickens had higher body weight when fed with a diet that contained 0 sprouted sorghum. Increased level of sorghum i.e. 50% HSF and 75% HSF led to a significant reduction of the measured performance parameters. These results reflected the inadequacy of nutrients responsible for growth in sorghum based formulations. The results contradict most other published work where it was expected that sprouting will improve nutrient availability coupled with a reduction in anti-nutritional factors.

4.2 General conclusion

The study showed that sprouting increases the nutritive value of HSF and sorghum grain and it reduces the anti-nutritional compounds. However, the performance of Sasso chickens was depressed when HSF was included beyond 25%.

4.3 General Recommendation

Based on the findings obtained from this study, it is recommended that hydroponic sorghum fodder has some potential and limitations and therefore, more studies need to be undertaken before recommending sorghum for inclusion in poultry feeds.

APPENDICES

Appendix 1: Anti-nutritional contents of HSF

	Composition at different time				
Components	**0**	**24**	**72**	**120**	**168**
Tannin	4.26	3.12	2.69	2.1	1.77
Phytic acid	6.19	3.48	3.19	1.92	1.17
Phenols	26.46	14.09	5.7	2.32	1.07
Cyanide	4.94	4.06	3.16	2.71	1.64

Tannin-CT conc. (g/100g). Total Phenols conc. (g /100g). Cyanide- HCN mg/Kg. Phytic Acid-Conc. µg/100g.

Appendix 2: Feed composition of the basal diet

Nutrient	Required	Analysis	Units
ME	12.5	13.03	MJ/kg
Crude Protein	19	19.35	%
Crude Fat	3	4.71	%
Fiber	3	5.29	%
Linoleic acid	1.1	1.65	%
Lysine	1	1.15	%
Methionine	0.50	0.75	%
Met+Cys	0.80	1.01	%
Arginine	0.95	1.10	%
Cystine	0.30	0.26	%
Isoleucine	0.80	0.79	%
Tryptophan	0.19	0.19	%
Tyrosine	0.50	0.57	%
Valine	0.90	0.76	%
Calcium	1.00	0.91	%
Phosphorus(total)	0.60	0.99	%
P. Available	0.50	0.30	%
Sodium	0.15	0.05	%
Mn	100	111.77	mg/kg
Zn	50.00	79.93	mg/kg
Ca: Avail. P	2.00	4.87	
ME: CP	565.00	673.27	

Source. 1. Evans, M. (1985) Nutrient Composition of Feedstuffs for Pigs and Poultry. Queensland Department of Primary Industries Information Series QI85001. ISBN 0-7242 2440 8. Queensland Department of Primary Industries, Brisbane. **2.** Lab analysis.