Response to and cost effectiveness of Improved *Kienyeji* Chicken fed on Maize-Substituted Sorghum-Based Rations

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Abstract

Rearing improved indigenous chicken fed on locally available low cost, low tannin, sorghum based diets in the semi-arid areas of Western Kenya could address the region's food insecurity resulting from low crop and livestock productivity. In this study, the response to and socio-economic significance of improved Kienyeji chicken fed on 4 maize substituted, sorghum-based diets was assessed. The diets had 2 varieties (V1 and V2) of sorghum substituting maize at 4 levels designated as T1 (0%)-as a control, T2 (50%), T3 (75%), T4 (100%). The eight dietary treatments (V1T1, V1T2, V1T3, V1T4, V2T1, V2T2, V2T3, and V2T4) were fed for 20 weeks to 256 randomly assigned into sixteen pens in 2 replicates. Nutritional values, feed intake, growth rate, survival rate, egg production and gross margins were determined. Results showed statistical differences (p<0.05) among treatments in the values for crude protein (CP) and Digestible Energy (DE). Treatment V2T3 had the highest CP content (20.49%) while VIT2 had the lowest (15.03%). Digestible Energy (DE) content was highest in V1T1 (3.3 Kcal/kg) while V1T4 had the lowest (2.483 Kcal/kg). There was also statistical differences (p<0.05) in the feed intake, growth response parameters, feed conversion ratio (FCR) and survival rate (SR). Treatment V1T2 (54.2g) had the highest feed intake while V1T4 (39.3 g) had the lowest. Feed intake in variety V2 rations was significantly different but lower than that of varietyV1 rations. Growers fed on the control rations (V1T1 and V1T2) had the best growth response (1118.8 g & 1096.1 g respectively) while V1T4 (559.0g) recorded the lowest. Treatments V2T2, V2T3 and V2T4 (961.45 g) recorded lower growth rate but were statistically similar to the control. Feed conversion ratio was highest with V1T4 (6.7) and lowest in the control (V1T1 and V2T1). Treatment V2T4 recorded the highest survival rate (94.1%) while V1T4 had the lowest (61.3%). The highest egg production (10.12%) was observed in V2T1 while V1T4 had the lowest (0.56%). Gross margin analysis based on feed cost showed diet V2T1 (control) had the highest gross margin (Ksh 330.79) while Diet V1T4 recorded the lowest (Ksh 135.97). To optimize cost of formulation and cost of feeding without adversely affecting performance, sorghum variety V2 should be added at an optimum inclusion rate of 75% while V1 should be at an optimum inclusion rate of 50% in the diets.

Key words: Food insecurity, maize-substituted, sorghum based, low-tannin, Improved *Kienyeji* chicken, formulated diets

INTRODUCTION

Semi-arid western regions of Kenya occupy about 30% of Kenya's landmass and is a part of the sub-Saharan semi-arid tropics. They experience food insecurity that is a result of low crop yields due to characteristic low and erratic rainfall, and relatively high ambient temperatures that can peak to 38^0C for most part of the year (Mwadalu & Mwangi, 2013). Malnutrition and hidden hunger are thus prevalent here with relatively high levels of poverty

(Medugu et al., 2010). These climatic conditions are however suitable for certain crops like sorghum, which due to its high drought tolerance can thrive better than maize. Sorghum can grow well in areas with an annual rainfall of 500-700 mm/year unlike maize that requires more rain and has been the main source of energy in most manufactured poultry feeds in Kenya (Kumaravel and Natavaran. 2014). Maize remains to be the main staple food in most rural communities and for that reason there is great competition for it as a resource for both animal feed and human food. As a result, manufactured poultry feeds are expensive and become unavailable during periods of maize shortage. Therefore, sorghum as subsistence food crop for many food insecure people has great potential to insure food security as well as curbing protein energy malnutrition and micronutrient deficiencies by inclusion in poultry feed production.

The main constraint limiting sorghum use in poultry feeds is the presence of anti-nutritive tannins which affects its dietary utilization by binding to protein and enzymes thus inhibiting enzymes and reducing protein digestibility. This reduces the performance of chicken (Hassan et al., 2003). The impact of tannin mainly through decreasing feed intake, weight gain and feed conversion ratio, feed utilization and nutrient digestibility in poultry has been reported in many studies (Emami et al., 2012). Some of the varieties grown in western Kenya such as like *Odhuwa* and *Gadam* are reported to contain low tannin levels *(*Mugalavai et al., 2018) and can be increasingly utilized in poultry feeds without adverse effects on performance (Hassan et al., 2003). The two sorghum varieties are classified as low tannin but *Gadam* is white while *Odhuwa* is brownish red in colour. Sedghi et al. (2012) noted that there is a direct correlation between coloration and tannin levels hinting at the possibility of the former having relatively lower tannin levels.

Farmers in the study area usually feed their chicken on whole grains and other resources that often are not balanced as was deduced from initial baseline information obtained through structured interviews. The low tannin sorghum varieties could therefore be used in well balanced homemade chicken diets by the smallholder sorghum-growing farmers to satisfy their chicken nutritional requirements. According to Olomu (1995) the ME and percent crude protein content of sorghum are 3270 kcal kg^{-1} and 9.5%, respectively, which is comparable with 3319 kcal kg^{-1} ME and 10.1% CP, respectively of maize.

Poultry production is an important source of livelihood for many smallholder farmers around the ASALS of western Kenya contributing a lot to human nutrition as a fairly cheap source of high value protein and also as a source of cash income directly from the sale of eggs and live birds, and indirectly through the sale of manure to crop farmers (Behnke and Muthami, 2011). Poultry production has the advantages of small space requirements, simple management practices, quick return on investments and ready market outlets for its products (Kingori et al., 2010). The Kenya Economic Report (KIPPRA, 2009) reveals that poultry is one of the lead livestock enterprises that can contribute the most towards the attainment of the Millenium Development Goals (MDGs). Indigenous chicken is attractive to rural households due to its good adaptation to the rural environment, survival on low inputs and requires less start-up capital (Kyule et al., 2014). Indigenous chicken breeds are characterized by free-ranging birds that scavenge around the farmhouse and usually interact with other birds and receive some grains in the process (Aila et al., 2012). High population growth in most parts of western Kenya has led to the shrinking of land sizes favouring chicken production compared to other livestock (Omiti and Okuthe, 2009) However, productivity is usually negatively affected by inadequate poultry nutrition that is due to unreliable and fluctuating supply of quality feed resources and low genetic potential in breeds (Okello et al., 2010).

The use of improved indigenous (*Kienyeji*) chicken- upgraded from indigenous chicken, can help address the challenge of poor breed potential while at the same time maintaining the characteristic hardiness of the *Kienyeji* chicken (Omiti et al., 2009). There are 4 common improved *Kienyeji* chicken breeds available and accessible in this region namely Kenbro, Kroilers, KALRO Naivasha and Rainbow Rooster.

The objective of this study was to determine the performance of improved *Kienyeji* chicken (Rainbow Rooster) fed on maize substituted sorghum-based formulated rations and the cost-effectiveness of using these rations.

METHODOLOGY

Feed nutrient composition analysis was done at KALRO Muguga Food Crops Research Institute and KALRO Kakamega Small Ruminant Research Institute while the performance analysis was done through an on-station feed trial experiment at University of Eldoret. The eight formulated treatment diets each contained a mix of maize and a low tannin sorghum variety *Odhuwa* (V1) or *Gadam* (V2), soya bean and a vitamin-mineral premix. Sorghum substituted maize at 4 levels designated as T1 (0%) as control, T2 (50%), T3 (75%), T4 (100%). The eight dietary treatments were fed to 256 growers for 20 weeks to determine performance and gross margins.

Determination of ration nutrient composition

The eight formulated rations were analysed in Muguga KALRO Food Crops Research Institute and KALRO Kakamega Small Ruminant Research Institute for dry matter, Crude protein, Digestible energy (DE) and ash content. This helped us make comparisons with accepted standard nutrient requirement levels.

Crude Protein content in each of the feed was determined using Kjeldahl method (AOAC, 2005), which essentially measures the amount of nitrogen in the feed as a measure of crude protein. Crude protein (CP) was calculated using nitrogen to protein factor of 6.25 as follows:

$$\% \text{ CP} = \frac{\text{T x N HCL x 14 x 6.25}}{1000\ X\ Weight\ of\ Sample} \times 100$$

Where

T- ml of Hydrochloric acid (HCL) used in titration

N HCL- Normality of HCL used for titration (0.1N)

14- Molecular weight of nitrogen

6.25- is a factor for conversion of nitrogen content into crude protein content based on assumption that almost all protein contain 16% nitrogen.

Digestible Energy in the 8 treatment feeds was determined using the *in-vitro* Pressure Transducer Technique (PTT) procedure that essentially uses volume of gas released during digestion as well as the difference in weight after digestion to calculate and determine Digestible energy content. Digestibility was then calculated from the difference in weights of the readings with the blanks as the weight of digestible material in each of the 100 g of feed dry matter. Digestible energy (DE) was then calculated by multiplying the percentage digestible organic matter (OMD) by 0.16.

Assessment of productive performance indices

The experiment was done at University of Eldoret Commercial Farm in the Poultry Unit. Sixteen pens, each measuring 4sq feet were constructed using plywood. The floor was covered with wood shavings as litter for comfort, ease of manure collection and hygiene. The pens were disinfected and each randomly stocked after three days with sixteen 8-week old Rainbow Rooster improved *Kienyeji* chicks.

Eight formulated treatment diets each contained a mix of maize and one of two low tannin sorghum varieties *Odhuwa* (V1) & *Gadam* (V2), soya bean and a vitamin-mineral premix with sorghum substituting maize at 4 levels designated as T1 (0%) as control, T2 (50%), T3 (75%), T4 (100%). The eight dietary treatments were fed to 16 growers each randomly assigned into sixteen pens and fed at 10% of live weight for 20 weeks. Each treatment involved 2 subplots of the two varieties of low tannin sorghum. There were 2 replicates for each treatment. Feed intake, growth rate, feed conversion ratio, survival rate, egg production rates and gross margins were determined.

Research Procedures

Study site

The experiment was done at the University of Eldoret Commercial farm in the poultry unit that was renovated and repaired to suit the experimental design. The experimental diets ingredients were purchased from Sega in Siaya County in Western Kenya.

Experimental design

Two hundred and fifty six (256) rainbow rooster chicks of mean weight 625 ± 0.43 g were selected and then randomly stocked, sixteen birds each, into sixteen (16) pens. The eight (8) experimental diets in two (2) replicates were fed to the growers in a completely randomized design (CRD). There were 4 treatment diets (T1, T2, T3, T4) for each variety of sorghum (V1 and V2). However, it is important to note that treatment T1 was similar for both varieties as it contained only maize as the main energy ingredient. The two are however separated for logistical convenience. Each of the 8 treatments therefore had 2 replicates giving us a total of 16 experimental units (Table 1.0). General linear model for the completely randomized design (CRD) was;

$$Y_{ij} = \mu + T_i + \varrho_{ij}$$

Where

Y_{ij} = Total observation on j^{th} bird and i^{th} treatment
μ = the overall population mean
T_i = the effect due to maize-sorghum mixture level (0%, 50%, 75% and 100%)
ϱ_{ij} = is the error term

Table 1.0 Illustration of the design of the on-station feed trial experiment

	T1 (M100/S0)	T2 (M50/S50)	T3 (M25/S75)	T4(M0/S100)
SUBSTITUTION LEVEL (%)	0%	50%	75%	100%
V 1	REP 1 (16b)	REP 1 (16b)	REP 1 (16b)	REP 1 (16b)
Odhuwa	REP 2 (16b)	REP 2 (16b)	REP 2 (16b)	REP 2 (16b)
V 2	REP 1 (16b)	REP 1 (16b)	REP 1 (16b)	REP 1 (16b)
Gadam	REP 2 (16b)	REP 2 (16b)	REP 2 (16b)	REP 2 (16b)

2 Sorghum Varieties X 4 Treatments X 2 Replicates =16 experimental units (pens) each with 16 birds) where T=treatment; REP=replicate; M=maize %content; S=Sorghum % maize replacement; 16b=16 birds.

Experimental set up

Three hundred (300) improved *Kienyeji* chicks of Rainbow Rooster hybrid with mean initial body weight of 36 ±0.25 g were obtained from Kukuchic Hatcheries and reared in a brooder for 8 weeks being fed on commercial *Kienyeji* mash to acclimatize before being transferred at 8.5 weeks into the experimental pens

At 8.5 weeks the birds with a mean weight of 625 ± 0.43 g were randomly stocked into the experimental pens and their diets gradually changed from commercial *Kienyeji* mash to the prepared sorghum-based diets by the 9th week.

Experimental diets

Eight formulated treatment diets each containing a mix of maize and 2 respective low tannin sorghum varieties *Odhuwa* (V1) & *Gadam* (V2) , roasted soya bean and a premix with sorghum substituting maize at 4 levels designated as T1 (0%) as control, T2 (50%), T3 (75%), T4 (100%)with 2 subplots of 2 sorghum grain varieties *Odhuwa (V1)* & *Gadam (V2)* believed to be low tannin (Mugalavai and Onkware, 2018) were used as alternative sources of energy to replace maize at an increasing rate in the feed ration as shown in table 2.0 below.

Apart from sorghum and maize; roasted soybean (18%) was included as a source of protein and Premix (2%) as a source of minerals and vitamins as is standard practice (Kingori et al., 2010). The feed was thoroughly mixed for uniformity after grinding and passing through using coarse sieves. It is notable that soya bean contains more protein than any other food crop thus being a major incentive for its choice as a locally available protein resource in western Kenya.

Table 2.0 Mixing ratios for the different ingredients in each 100 kg of treatment ration

TREATMENT → INGREDIENT@ 100 kg ↓	Sorghum variety 1 (*Odhuwa*)				Sorghum variety 2 (*Gadam*)			
	V1T1	**V1T2**	**V1T3**	**V1T4**	**V2T1**	**V2T2**	**V2T3**	**V2T4**
Maize (kg)	80	40	20	0	80	40	20	0
Sorghum (kg)	0	40	60	80	0	40	60	80
Soya bean (kg)	18	18	18	18	18	18	18	18
Premix (kg)	2	2	2	2	2	2	2	2
TOTAL (kg)	100	100	100	100	100	100	100	100

Feeding and data collection

For every 100 kg feed ration there was not more than 80 kg of either maize or sorghum or both at predetermined ratios as shown in the table 2.0. The feed quantity was fed each day according to daily requirements of ration at each week (ranging from 50 g to 100 g per bird per day) from 9 weeks to 20 weeks, and 100-150 g per bird per day during the laying period. The rule of thumb normally is feeding a chicken at 10% of its weight (Ferket and Gernat, 2006). This ensured equitable distribution of feed across the experimental pens to avoid bias. Water was provided ad-libitum.

Survival and Mortality Rate

Survival rate (SR%) was calculated by subtracting the number of birds that died during the experimental period from birds stocked divided by number stocked multiplied by 100 to convert the figure into percentage (Charo et al., 2006) as below:

$$\text{SR}\ \% = \frac{Initial\ number\ of\ birds\ stocked - Dead\ birds}{Initial\ number\ of\ birds\ stocked} \times 100$$

Mortality rate (MR%) was given as:

$$\text{MR }\% = 100 - SR\%$$

Feed intake rate

Feed intake per bird was estimated by subtracting total amount of feed remaining in feeder after active feeding hours from total amount of feed given to each pen then divide the amount, excluding feed wastage, with total number of birds in the pen (Ferket and Gernat, 2006):

$$\text{Feed Intake} = \frac{Fb - Fe}{Np}$$

Where;

Fb = feed wt in feeder given to birds at beginning of the day
Fe = feed wt in feeder after 8 hours
Np = number of birds actively feeding in the pen during the active feeding hours.

Chicken weight growth performance

The chicken were weighed at an interval of 2 weeks to determine weight gain. This also helped avoid stressful disruption of the chicken if the weighing was to be done more often. Chicken in each pen were weighed and an average weight gain per bird calculated.

Average Daily Gain (ADG) was calculated by getting the difference between the final body weight (g) and the initial body weight in grams over a period of time according to the equation:

$$\text{ADG} = \frac{Final\ Body\ weight - Initial\ Body\ Weight}{Number\ of\ days}$$

Average weekly gain (AWG) in grams per week was worked out as:

$$\text{AWG} = \frac{Final\ Body\ weight - Initial\ Body\ Weight}{Number\ of\ Weeks}$$

Specific growth rate (SGR) was determined from the equation;

$$\text{SGR} = \frac{Log\ Final\ Body\ Weight - Log\ Initial\ Body\ Weight}{Number\ of\ Weeks} \times 100$$

Relative Growth Rate was calculated as:

$$\text{RGR} = \frac{Initial\ Body\ Weight}{Final\ Body\ Weight} \times 100$$

Feed conversion ratio expressed as grams of feed consumed per unit body weight gain (FCR) was given by;

$$\text{FCR} = \frac{Feed\ Intake\ in\ Grams}{Weight\ Gain\ in\ Grams} \times 100$$

Egg production performance

Egg production performance (laying percentage) was determined by the number of eggs produced per bird in each pen using the following formula;

$$\text{Laying Percentage} = \frac{Total\ Number\ of\ Eggs\ Collected\ in\ Pen\ Over\ Period}{ANOL\ X\ Number\ of\ Days} \times 100$$

Where ANOL is the average number of live birds in pen during the experimental period and is given by;

$$\text{ANOL} = \frac{Number\ of\ Birds\ at\ Beginning\ - Number\ of\ Birds\ at\ End\ of\ Period}{2} \times 100$$

This was calculated for each pen and eventually for each treatment.

Gross margin Analysis of feeds

Ingredients for experimental diets were purchased from farmers within the study area.The diets were analysed for economic viability by considering most current market prices and input costs involved in feed formulation .The cost of feeds alone was considered in this study for economic evaluation while other costs were assumed constant. The cost of the feeds were calculated using the prevailing market prices which were recorded when the feed ingredients were purchased. Incidence cost (IC) and profit index (PI) were calculated as follows:

$$\text{IC} = \frac{Cost\ of\ Feed}{Weight\ of\ Bird\ Produced}$$

$$\text{PI} = \frac{Value\ of\ Bird}{Cost\ of\ Feed}$$

Gross margin was calculated by subtracting the cost of formulated feeds from estimated value of bird;

Gross margin = $QP - Cost\ of\ feed$

Where

Q- Is the average live weight of chicken in Kgs

P- Is the prevailing market price per Kg live weight of chicken in Kenya shillings.

The market prices of the feed ingredients where they were procured in Siaya county were used in calculation of feed cost (Table 3.0).

Table 3.0: Mean annual prices of feed ingredients used in formulating experimental diets

Feed Ingredients	Price Per Kilogram (KSh.)
Brown sorghum (*Odhuwa*)	30.00±10
White sorghum (*Gadam)*	30.00±10
Maize	40.00±10
Soya beans	100.00±25
Mineral-Vitamin Premix	250.00±05

These prices were obtained over a period of six months after harvest and during the planting season in 2018/2019

Data Analysis

Data was subjected to analysis of variance (ANOVA) using Genstat version 14 (2014) to establish significant differences ($p<0.05$). Where there were differences, mean separation was carried out by least significant difference (LSD).

RESULTS AND DISCUSSION

Compositional analysis of feeds

There was significant difference ($p<0.05$) in the dry matter (DM) content across treatments for the sorghum variety *Odhuwa* (Table 4). For the variety *Gadam*, treatment V2T2 had a significantly higher DM content (89.87%) than the control and V2T3/V2T4 with 89.44 - 89.47% DM. Feed formulae containing *Odhuwa* had significantly ($p<0.05$) more DM compared to those made using *Gadam* or maize. There was significant difference ($p<0.05$) in the crude protein (CP) content across treatments for the sorghum variety *Odhuwa* (Table 4). For the variety *Gadam*, treatment V2T3 had a significantly higher CP content (20.49%) than the control and V2T2 with 19.13-19.07%, but was not significantly different from V2T4 with 20.28% CP. Feed formulae containing *Odhuwa* had significantly ($p<0.05$) lower CP compared to those made using *Gadam* or maize (control). There was significant difference ($p<0.05$) in the Ash content across treatments for both sorghum varieties (Table 4). For the variety *Gadam*, treatment V2T4 had the highest ash content of 5.81% which was significantly higher than the control and V2T2/V2T3 with 3.75-4.69%. Feed formulae containing *Odhuwa* V1T3 had the highest Ash content of 4.89% which was also higher than the control. There was significant difference ($p<0.05$) in the Digestible Energy (DE) content across treatments for the sorghum variety *Odhuwa* (Table 4). Feed formulae containing *Odhuwa* had significantly ($p<0.05$) lower DE compared to those made using *Gadam* or the control maize. There was significant difference ($p<0.05$) in the DE content across treatments for the sorghum variety *Odhuwa* (Table 4). For the variety *Gadam*, treatment V2T3 had a significantly higher DE content (3.24 Mcal/kg) than the control and V2T2/V2T4 with 3.11 - 3.18 Mcal/kg). Digestible energy content reduced as the amount of V1 added increased but was lowest at treatment V1T4. It was higher with variety 2 but similar in treatments V2T2, V2T3 and V2T4. The CP content as well as the ash and DE contents were within the KEBS standard requirements (KEBS, 2010) as found in most common commercial feeds like *Kienyeji* mash. V1T2 conforms closely to the minimum requirements but the rest of the treatments and the control are well above the required minimum.

Table 4.0 Nutrient composition of the experimental feeds

Nutrient Composition	Formulated Dietary Treatments - V1 (*Odhuwa*)				Formulated Dietary Treatments - V2 *(Gadam)*				Mean	KEBS Min
	T1	T2	T3	T4	T1	T2	T3	T4		
Dry matter (DM) %	89.90 ±0.13[b]	90.02 ±0.13[c]	90.39 ±0.13[e]	90.15 ±0.13[d]	89.45 ±0.13[a]	89.87 ±0.13[b]	89.47 ±0.13[a]	89.44 ±0.13[a]	89.84	88.00
Crude protein (CP) %	19.10 ±0.76[c]	15.03 ±0.76[a]	17.48 ±0.76[b]	17.42 ±0.76[b]	19.13 ±0.76[c]	19.07 ±0.76[c]	20.49 ±0.76[d]	20.28 ±0.76[d]	18.00	14.50
Ash %	4.40 ±0.26[c]	4.04 ±0.26[b]	4.89 ±0.26[d]	4.46 ±0.26[c]	4.37 ±0.26[c]	4.69 ±0.26[d]	3.75 ±0.26[a]	5.81 ±0.26[e]	4.72	4.00
Digestible Energy (DE) Mcal/kg	3.20 ±0.1[d]	3.02 ±0.1[c]	2.78 ±0.1[b]	2.48 ±0.1[a]	3.19 ±0.1[d]	3.11 ±0.1[d]	3.24 ±0.1[e]	3.18 ±0.1[d]	3.04	2.65

Means with different superscripts in the same row are statistically different at p<0.05. KEBS Min, the Kenya Bureau of Standards (KEBS) minimum requirements are based on recommendations of the American National Research Council (US) Subcommittee on Poultry Nutrition (NRC, 1984).

Chicken Nutrition and Growth Performance

On feed intake; V1T2 had the highest (54.2 g) while V2T2 (40.3 g) had the lowest feed intake rate (Table 5.0). Feed intake in variety V2 treatments varied significantly (p<0.05) in all the treatments at a mean of 44.58 g but was lower than in treatments containing sorghum variety V1, which were also statistically different.

Growth rate (weight gain) of growers was highest in the birds fed on the control diet (1096.1-1118.8 g) and reduced by about half in those fed on V1T4 (559.0 g). For sorghum variety V2; the birds fed on V2T4 had the least (961.45 g) but statistically similar growth rate to the V2T2 group while in treatment V2T3 the growth rate was statistically similar to the control V2T1. On average daily gain (ADG); V1T1 (control) had the highest (11.42g) while V1T4 had the lowest (6.30 g) daily weight gain. In variety V2 however, V2T3 had statistically similar gain to the control V2T1 (11.17-11.37 g/day) while V2T2 was statistically similar to that of V2T4. For specific growth rate (SGR), V2T3 had the highest SGR (0.413) while V1T4 had the lowest (0.308). For variety V1 (*Odhuwa*) rations, the treatments V2T4 and V2T3 were statistically similar (0.31) but lower than the control V2T1 (0.41). V1T4 had the highest relative growth rate (RGR) of 55.33 while V2T3 had the lowest (43.11) relative growth rate. Variety V1 treatments V1T3 and V1T4 had statistically similar RGR (55.33-54.59) but were lower than for the control V1T1. For variety V2, treatment V2T3 had the highest RGR of 0.44 which was also higher than the control V2T1 (0.41) and was statistically different (p<0.05) from V2T2 and V2T4 effects.

Table 5.0: Performance parameters for Improved *Kienyeji* chicken fed on 8 sorghum-based formulated diets

Nutrition/ Growth Parameter	V1T1	V1T2	V1T3	V1T4	V2T1	V2T2	V2T3	V2T4
Daily feed intake(g)	46.6 $\pm1.92^{d}$	54.21 $\pm1.92^{f}$	51.12 $\pm1.92^{e}$	39.30 $\pm1.92^{a}$	46.4 $\pm1.92^{b}$	40.30 $\pm1.92^{a}$	48.90 $\pm1.92^{d}$	46.61 $\pm1.92^{c}$
Total feed intake(kg)	2.82 $\pm0.14^{d}$	4.01 $\pm0.14^{f}$	3.78 $\pm0.14^{e}$	2.91 $\pm0.14^{a}$	2.71 $\pm0.14^{b}$	2.98 $\pm0.14^{a}$	3.62 $\pm0.14^{d}$	3.45 $\pm0.14^{c}$
Weight gain	1219.0 $\pm63.53^{e}$	965.55 $\pm63.53^{c}$	838.80 $\pm63.53^{b}$	558.95 $\pm63.53^{a}$	1219.1 $\pm63.53^{d}$	961.45 $\pm63.53^{c}$	1054.31 $\pm63.53^{d}$	952.75 $\pm63.53^{c}$
ADG (g/day)	11.42 $\pm0.64^{e}$	9.20 $\pm0.64^{a}$	7.91 $\pm0.64^{c}$	6.30 $\pm0.64^{b}$	11.37 $\pm0.64^{e}$	9.82 $\pm0.64^{d}$	11.37 $\pm0.64^{e}$	9.66 $\pm0.64^{d}$
AWG (g/week)	79.94 $\pm4.54^{e}$	64.4 $\pm4.54^{c}$	55.37 $\pm4.54^{b}$	44.1 $\pm4.54^{a}$	79.59 $\pm4.54^{e}$	68.74 $\pm4.54^{d}$	79.59 $\pm4.54^{e}$	67.62 $\pm4.54^{c}$
SGR (%)	0.41 $\pm0.02^{d}$	0.34 $\pm0.02^{b}$	0.31 $\pm0.02^{a}$	0.31 $\pm0.02^{a}$	0.41 $\pm0.02^{d}$	0.38 $\pm0.02^{c}$	0.44 $\pm0.02^{e}$	0.37 $\pm0.02^{c}$
RGR (%)	44.96 $\pm1.59^{b}$	51.38 $\pm1.59^{d}$	54.59 $\pm1.59^{e}$	55.33 $\pm1.59^{e}$	45.47 $\pm1.59^{b}$	47.99 $\pm1.59^{c}$	43.11 $\pm1.59^{a}$	48.59 $\pm1.59^{c}$
FCR gfeed/gwt	3.35 $\pm0.45^{a}$	6.24 $\pm0.45^{d}$	4.18 $\pm0.45^{b}$	6.70 $\pm0.45^{e}$	3.35 $\pm0.45^{a}$	4.19 $\pm0.45^{b}$	3.72 $\pm0.45^{a}$	4.19 $\pm0.45^{c}$
Survival Rate (%)	77.50 $\pm4.40^{c}$	70.54 $\pm4.40^{b}$	68.00 $\pm4.40^{b}$	61.30 $\pm4.40^{a}$	76.3 $\pm4.40^{c}$	93.43 $\pm4.40^{d}$	65.04 $\pm4.40^{a}$	94.10 $\pm4.40^{d}$

ADG-Average daily gain, SGR-Specific growth rate, RGR-Relative Growth Rate, FCR-Food Conversion Rate. Means with different superscripts in the same row are statistically different at $p<0.05$.

Feed conversion efficiency (FCR) was highest in V1T4 and generally higher in V1 treatments and lowest in V1T1/V2T1 meaning there was relatively low feed efficiency in V1 compared to V2 treatments with maize controls (T1's) having lowest FCR. This could be attributed to the anti-nutritive factor in the sorghum Variety V1.There is no significant (P>0.05) difference between the treatment groups in mean feed to gain ratio. The controls V1T1/V2T1 relatively have better feed conversion ratio as compared toV1T4 and V1T2. This result is in agreement with the report of Kumar et al. (2005)

Growth performance in treatments of V1 declined as the sorghum content was increased. Performance with variety V2 treatments was superior to that in treatments with variety V1. These could be explained by the anti-nutritive tannin content limiting its utilization thus affecting growth performance (Hassan et al., 2003). Variety V2 treatment responses were statistically different (p<0.05). However, beyond the optimum inclusion rate of 75% the cost of diets tends to rise as FCR ratio increases. This could be due to the fact that certain growth factors (as essential amino acids) in maize complement those in V2 to give a superior growth performance unlike when sorghum variety V2 is used as a single source of grain energy in the diet as reported by Combs (1968). Growth curves indicated low growth rate at the initial stage up to week 8 after which there was an exponential growth rate for all treatment diets (Figure 1). The period of low growth rate may be associated with acclimatization to the new feed types.

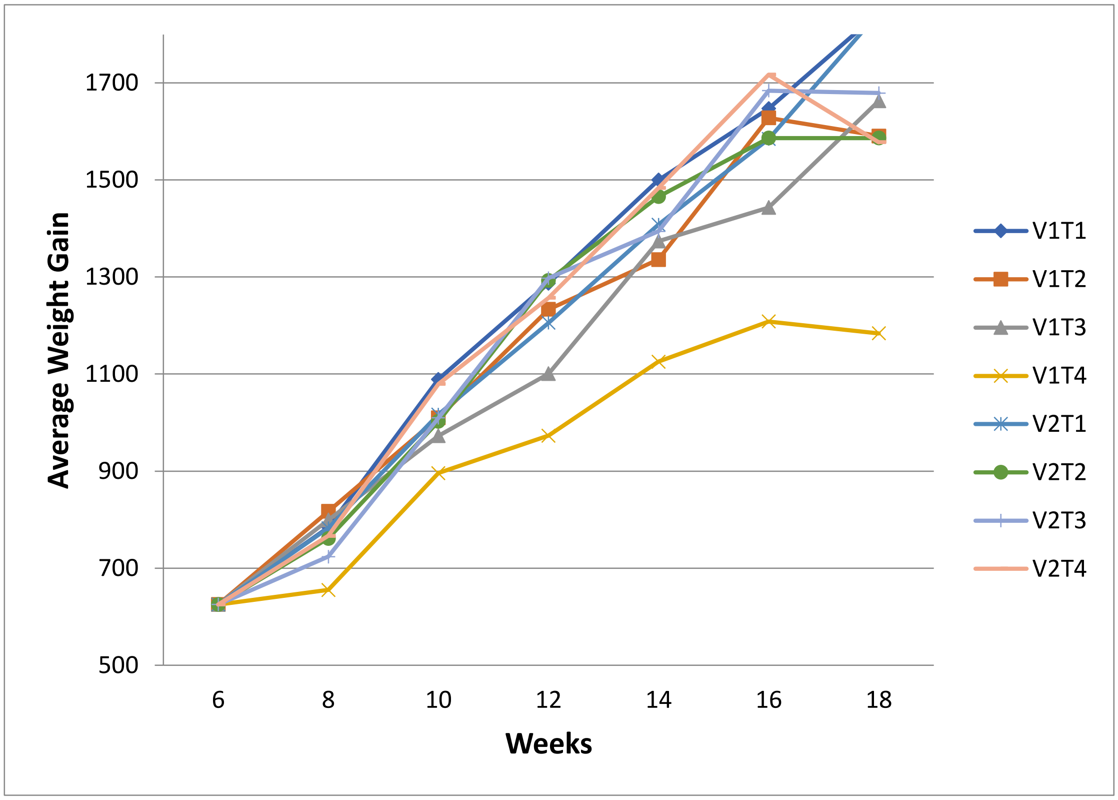

Figure 1.0: Trends in chicken weight gain over a period of 12 weeks of feeding grower chicken on different experimental diets.

Survival rate was highest (94.1%) under treatment V2T4 and lowest in V1T4 (61.3). VarietyV1 treatments recorded lower survival rates than the control and those of variety V2. This is most likely due to the negative effects of tannin, on protein digestibility and growth. Although the two sorghum varieties are rated as low tannin *(*Mugalavai and Onkware, 2018) colored sorghums like *Odhuwa* tend to have a relatively higher tannin content than white sorghum varieties (Sedghi et al., *2012*).

Gross Margin Analysis

Gross margin analysis based on feeds showed that control diets V1T1 (300.02) & V2T1 (307.90) had the highest gross margin while treatment V1T4 (135.47) recorded the lowest gross margin (Table 6.0). This could be explained by the relatively high weight gain in comparison with the cost of the feed. Feed cost per kilogram live weight gain increased as percentage inclusion of *Odhuwa* ingredient in the ration increased but remained constant as it reached 50%. As the percentage inclusion of *Gadam* as an ingredient increased the gross margin went up to an optimum inclusion rate of 75% where the cost started to rise as it could no longer be compensated by weight gain.

Table 6.0: Gross Margin analysis for one chicken for the formulated feeds

Parameter	V1T1	V1T2	V1T3	V1T 4	V2T1	V2T2	V2T3	V2T4
Feed cost/Kg (Ksh)	69.7	57.7	53.7	49.7	69.7	57.7	53.7	49.7
Total Feed Intake (kg)	3.730	4.011	3.781	2.908	3.70	2.982	3.619	3.448
Total Feed cost (KSh)	259.98	231.43	203.04	144.53	257.89	172.06	194.34	171.37
Weight gain	1219.0^{c}	965.55^{bc}	838.8^{b}	558.95^{a}	1219.1^{c}	961.45^{bc}	1054.3^{bc}	952.75^{bc}
FCR	5.00	6.25	7.14	10.00	5.00	6.25	1.85	2.00
Sale weight (Kg)	1.12	0.97	0.84	0.56	1.11	0.96	1.054	0.95
Chicken price/Kg (KSh)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Value of chicken (KSh)	560.00	485.00	420.00	280.00	555.00	480.00	527.00	475.00
Gross margins (GM) Ksh	300.02 ±23.99^{d}	253.57 ±23.99^{c}	217.0 ±23.99^{b}	135.5 ±23.99^{a}	297.11 ±23.99d	307.9 ±23.99^{d}	332.7 ±23.99^{e}	303.6 ±23.99^{d}

GM values are presented as mean±S.E.Values with different superscripts in the same row are statistically different at $p<0.05$.

Egg Production Performance

Egg production was highest in the control (13.3%) while the treatment V1T4 had the lowest laying percentage of 0.56% (Figure 2.0). Chicken raised on feeds formulated using the variety V1 had a relatively lower production mean (4.32%) than that of variety V2 treatments (6.85%). V1T3 and V2T3 each had the highest laying percentage for the respective varieties, apart from the controls.

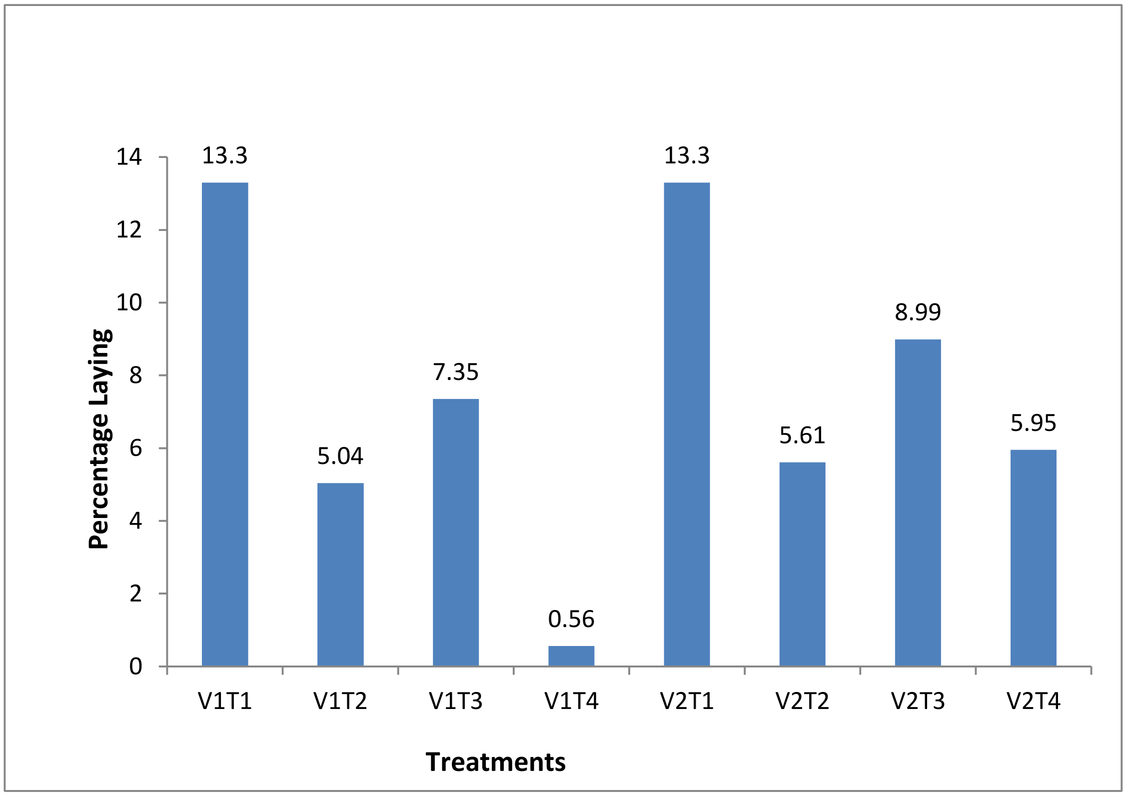

Figure 2.0: Mean egg production percentages across treatments

CONCLUSION

Based on the results, the 8 formulas contained DM, CP Ash and DE content within the accepted Kenya Bureau of Standards minimum limits for poultry feeds. However, it was noted that maize substitution with sorghum up to 75% (three quarters of the grain energy ingredient as illustrated in Table 2.0) for the variety *Gadam* and 50% (half of the grain energy ingredient as illustrated in table 2.0) for *Odhuwa* provides optimum response while total substitution tends to reduce the growth rate. Seventy-five percent (75%) maize substitution with sorghum variety *Gadam* had higher gross margin returns and therefore is more profitable than use of variety V1. However, use of maize alone as a single energy ingredient in formulas still gives better performance of chicken than either of the two varieties of sorghum.

To optimize cost of formulation and cost of feeding without adversely affecting growth, *Odhuwa* sorghum variety should be used at an optimum inclusion rate of 50% in the formulated diets while *Gadam* sorghum variety should be added to the rations at an optimum inclusion rate of 75%. These cost effective treatments were represented by treatments V1T2 for *Odhuwa* and V2T3 for *Gadam*.

The use of locally available, low cost, low tannin, sorghum grain energy resource in improved *Kienyeji* chicken homemade rations is a possibility that can be adopted by small scale sorghum farmers to improve poultry productivity. This has potential to broaden diets of the rural communities and reduce malnutrition and hidden hunger as they strive to improve their livelihoods through the sorghum-poultry enterprise.

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