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Assessment of growth, survival and cost of feeding IKC chicks distributed to farmers in the drylands of Western Kenya

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ABSTRACT

Rearing improved indigenous chicken (IKC) fed on locally available low cost, sorghum-based diets in the Western Kenya drylands could address the region's food insecurity resulting from low crop and livestock productivity. This study involved a sample of 50 poultry keeping/sorghum growing households across five wards considered to be semi-arid regions of Siaya and Busia Counties. It growth performance of IKC growers , survival performance and cost of feeding on sorghum-based diets. Most (69.4%) farmers used sorghum variety *Nyadundo*, together with maize, soybeans, and fishmeal (*omena)* and/or *omena* dust, in rations, because of availability on the farm (78%) and often, on the market (67%). *Nyadundo* is available throughout the year both on the farms and the market.. Most (55%) farmers keep chicken under free range. Most (75%) birds fed on home-made rations (HMR) where protein source was over 25% gained weight of 1.5kg. Most farmers (67%) who mixed maize with sorghum at 1:1 ratio incurred a marginally higher cost compared to those (33%) who included more sorghum at a ratio of 1:2 or 0:1. Most (79%) birds survived. The HMRs nutrient quality were quite comparable to commercial feeds on the market. Adoption of IKC production using sorghum-based feeds can help diversify chicken feed and broaden household diets to reduce malnutrition, hidden hunger, and food insecurity and alleviate poverty in the semi-arid regions of Western Kenya.

Keywords: Homemade rations (HMR), Improved *Kienyeji* Chicken (IKC), Kenya, Semi-arid regions, Sorghum-based diets

RÉSUMÉ

L'élevage de poulets indigènes améliorés (IKC) nourris avec des régimes alimentaires à base de sorgho à faible coût localement disponibles dans les zones arides de l'ouest du Kenya pourrait remédier à l'insécurité alimentaire de la région résultant de la faible productivité des cultures et du bétail. Une étude utilisant un échantillon de 50 ménages élevant de la volaille et cultivant du sorgho dans cinq circonscriptions considérées comme semi-arides des comtés de Siaya et Busia, utilisant huit poussins IKC de quatre semaines, formés aux meilleures pratiques de gestion et suivis pendant 16 semaines pour la croissance des poulets, la performance de survie et le coût de l'alimentation avec des régimes à base de sorgho. La majorité (69,4%) des agriculteurs utilisent la variété de

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sorgho Nyadundo, avec du maïs, des soja et des farines de poisson (omena) et/ou de la poussière d'omena, dans les rations, en raison de leur disponibilité à la ferme (78%) et souvent sur le marché (67%). Nyadundo est disponible toute l'année à la fois sur les fermes et le marché. La majorité (55%) des agriculteurs gardent les poulets en liberté. La plupart (75%) des oiseaux nourris avec des rations maison (HMR) où la source de protéines représentait plus de 25% ont pris un poids de 1,5 kg. La plupart des agriculteurs (67%) qui ont mélangé du maïs avec du sorgho dans un ratio de 1:1 ont encouru un coût légèrement supérieur par rapport à ceux (33%) qui ont inclus plus de sorgho dans un ratio de 1:2 ou 0:1. La majorité (79%) des oiseaux ont survécu. La qualité nutritionnelle des HMR était assez comparable aux aliments commerciaux disponibles sur le marché. L'adoption de la production IKC utilisant des aliments à base de sorgho peut aider à diversifier l'alimentation des poulets et à élargir les régimes alimentaires des ménages pour réduire la malnutrition, la faim cachée et l'insécurité alimentaire, et à alléger la pauvreté dans les régions semi-arides de l'ouest du Kenya.

Mots-clés : Rations maison (HMR), Poulets Kienyeji améliorés (IKC), Kenya, Régions semi-arides, Régimes alimentaires à base de sorgho

Introduction

Chicken production plays a key role in livelihoods of most smallholder farmers living in semi-arid regions of Western Kenya, contributing to human nutrition as a source of high value protein, income, and manure provision (Okello *et al.,* 2010; Behnke and Muthami, 2011). Strengthening this in the region can curb malnutrition and hidden hunger, and reduce poverty levels. Manure from chicken can be used to fertilize sorghum farms to increase productivity. Chicken are attractive to poor households because of advantages such as; quick adaptation to rural semi-arid environment, small space requirement, simple management practices and less startup capital requirements, survival on relatively low inputs, short lifecycles, frequent egg production, quick turnovers, conversion of low quality feed into high value protein (Kamuravel *et al.*, 2014), quick returns to investment and ready market outlets for products (KIPPRA, 2009). Drylands of Western Kenya occupy about 30% of the region's landmass and experience food insecurity which is a result of low crop and livestock yields due to characteristic low and erratic rainfall and relatively high ambient temperatures for most part of the year (Manuya *et al.*, 2020). Chicken productivity is negatively affected by inadequate nutrition due to unreliable quality and quantity of feed resources. Conditions here are not suitable for rain-fed agriculture (Muni *et al.,* 2018).

Human malnutrition, reported as the highest in Kenya and hidden hunger, which mostly affects children, are prevalent in the area; with relatively high levels of poverty (Kingori *et al.,* 2010; Mugothe *et al.,* 2012; Nwandalu and Nwzngi, 2013). These areas, are however suitable for certain crops like sorghum accounts for 60-70% of total production cost this contributes negatively to the poultry farmers' profit margin (Elnagar and Abdel-Wareth, 2014). Sorghum varieties that have low tannin and other readily available feed resources can be used in simple home-made chicken rations (HMR). According to Mohamed, (Magothe *et al.,* 2012) the ME and CP content of sorghum are 3270 kcal kg^{-1} and 12%, respectively, which is comparable with 3319 kcal kg^{-1} ME and 10.1% CP of maize, respectively (Muhendra, 2016). Therefore sorghum, needs to be explored despite its low commercialized production level and its anti-nutritive bio-chemicals, tannins. Sorghum will normally outperform other cereals under various environmental stresses and requires little input during growth, hence more economical to produce here (Meduga *et al.,* 2010). Maize has been the main source of grain energy in most manufactured poultry feeds in Kenya (Kingori *et al.,* 2010). It also the main staple

food in most rural communities, accounting for 65% of total staple food caloric intake and there is great competition for it as a resource for both animal feed and human food (Ariga *et al*., 2010). As a result, manufactured poultry feeds are expensive due to ever rising prices of maize and during times and in areas of shortage the feeds become unavailable. Since feeding accounts for 60-70% of total production cost this contributes negatively to the poultry farmers' profit margin (Elnagar *et al*., 2014).

Sorghum varieties that have low tannin and other readily available feed resources can be used in simple home-made chicken rations (HMR). According to Mohamed, (Magothe *et al.,* 2012) the main staple food in most rural communities, accounting for 65% of total staple food caloric intake and there is great competition for it as a resource for both animal feed and human food (Ariga *et al*., 2010). As a result, manufactured poultry feeds are expensive due to ever rising prices of maize and during times and in areas of shortage the feeds become unavailable. Since feeding accounts for 60-70% of total production cost this contributes negatively to the poultry farmers' profit margin (Elnagar *et al*., 2014). sorghum, though a subsistence food crop with a lot of cultural attachment for many food insecure people, has great potential as an alternative energy source in

feeds. Adoption of IKC, upgraded from indigenous chicken, mitigates the challenge of poor breed potential, while at the same time maintaining the characteristic resilience and disease tolerance of the Kienyeji chicken. The objective of this study was to assess growth, survival and cost of feeding of the IKC on locally available, low cost sorghum-based rations in the sorghum growing semi-arid regions of Siaya and Busia counties of Kenya.

Materials and Methods

The field survey was done in three wards in Siaya County and two wards of Busia County, which are within drylands of Western Kenya. The survey was done between April and August 2019. Fifty poultry keeping/sorghum growing households were purposively identified/selected and mobilized, 10 per ward from across five different wards, namely North Ugenya, West Ugenya and East Ugenya in Siaya County and Marachi and Matayos of Busia County. These farmers were trained and provided each with eight, 4-weeks -old, low-input, dual-purpose IKC of 'Rainbow Rooster' breed whose weights were monitored. Farmers were selected from groups that were initially recruited to grow improved sorghum cultivars in a McKnight funded project. Data as shown in Table 1 were collected and recorded, bimonthly. Farmer selection was based on; a) Previous experience with poultry rearing and growing of sorghum; b) Willingness to be trained, and c) Ability to keep records and monitor flock performance.

Data Collection and Analysis

Data were collected using a structured questionnaire and weight recordings made using a sensitive Data were collected using a structured questionnaire and weight recordings made using a sensitive electronic weighing scale corrected to three decimal points. corrected to three decimal points.

Table 1. Areas of survey addressed by poultry keeping farmers in Western Kenya

Parameter of interest	Measures recorded
Feeding regimes and rearing systems	Free range or confined Number of hours let out during day Land tenure
Feed resources	Types of feed resources preferred Feed ingredient's inclusion rates Cost of feed resources Feed supplementation
Chicken performance	Weight gains Survival rates

Analysis for cost was done using prevailing market prices. Feed availability was determined using farmers ease of access on the farm and on the market throughout the year. Weight gain was compared with data collected from an on-station feed trial at the University of Eldoret (Manuya *et al.,* 2020) and statistically analyzed and means compared using Chi square. Analysis of variance was carried out to examine if there was statistical significance of difference in the weight gain for farmers' birds, and the weight gain for 100% maize-based feeds.

Results

Housing and Production systems. Rearing systems were diverse with majority (65%) practicing different levels of free-range production, while 35% confined their chicken those who confined used portable folds like the traditional Osera to confine chicks and growers, in the owner's residence, or occasionally in separate house/structure outside their residences (23.54%) while others kept them in the house (41.23%) particularly at night or in constructed units (17.63%).

Table 2. Types of housing provisions used in confining chicken in Western Kenya

Category	Preference/Activity	Frequency	Percentage
Types of confinement	Traditional portable housing folds (*Osera*)	4/17	23.5
	Constructed poultry units	3/17	17.6
	Residential houses	7/17	41.2
	Fenced chicken run	3/17	17.6

Table 3. Source of grain energy resource and use in feed rations by farmers in western Kenya

Category	Energy Resource used	Frequency of farmers using resource	Percentage
Grain energy resource used	Sorghum & Maize	45/50	90
	Maize only	3/50	6
	Sorghum only	2/50	4
Source of the grain	Obtained from farm & market	23/50	46
	Obtained from farm only	16/50	32
	Obtained from market only	11/50	22
Crop acreage	Acreage of maize	50.75/93.75	54
	Acreage of sorghum	26.5/93.75	33
	Other crops	22.75/93.75	13

Some (25.0%) farmers confined them in a chicken run fenced with a chain link or chicken wire (Table 2). Over 90% of the farmers kept chicken on their own land while 10% keep them on leased property; 98% of the farmers on their own land practiced mixed farming but with a greater emphasis (87%) on maize and sorghum growing (Table 2).

Feeding regimes, feed supplementation, feed resource preference and feed cost analysis. Over 69.4% of the farmers use sorghum variety *Nyadundo* while the rest use other varieties like T30 (2.9%), C26 (23.5%), N57 (3.0%), T53 (0.5%) and *Gadam and Odhuwa* (0.7%) as shown in Figure 2. Sorghum (particularly high tannin *Nyadundo*) is plenty on these farms occupying an estimated 30% of their farms while maize occupies an estimated 54%. Over 90% of farmers used sorghum and/or maize as an energy ingredient in their homemade rations (Table 3)**.**

Farmers used what was available on the farm (78%) and quite often (68%) on the market as they did not produce all the feed ingredients (Table 3). Out of those interviewed, 4% added more sorghum than maize at any ratio; 67% used maize and sorghum at 1:1 ratio in their mixture, while 20% mixed lesser sorghum to maize at an estimated ratio of 1:2; the rest (9%) just mixed their feeds haphazardly without any proper measurement or formula (Figure 1).

Most farmers (68%) preferred, supplementing with Growers' mash and 'Kienyeji mash. The HMRs quality is quite similar and often better than commercial feeds, particularly for CP. Commercial feed costs are, however, higher than the home-made rations (HMR) costs as shown in Tables 4 and 5.

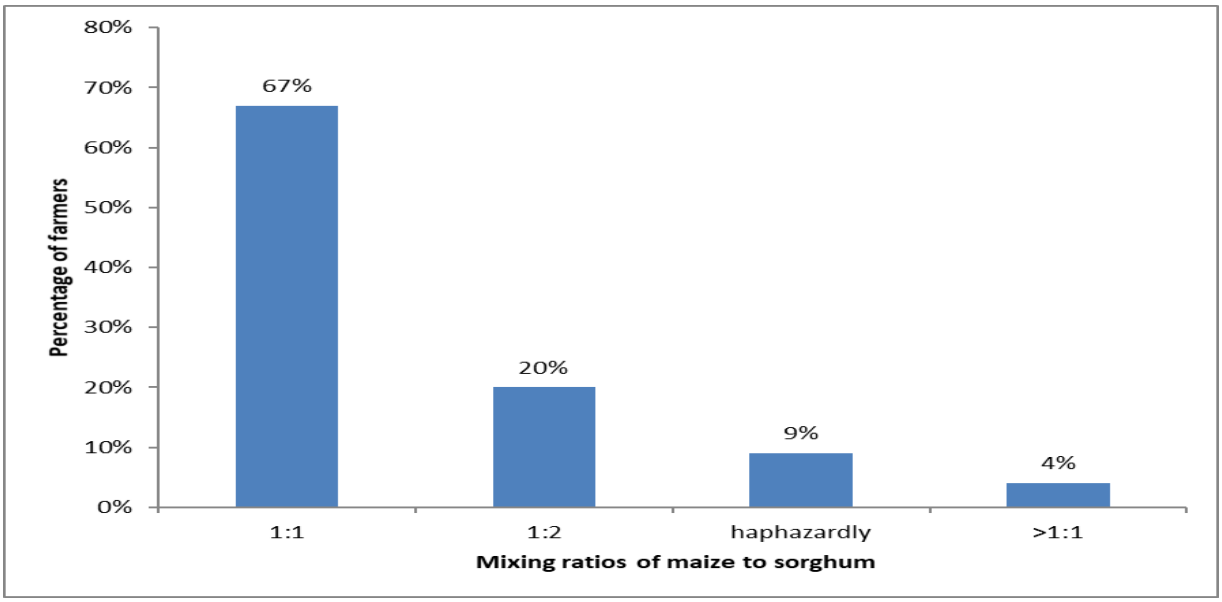

Figure 1. Percentage of farmers mixing different ratios of maize and sorghum as feed for Improved Kienyeji Chicken

Table 4. Types of commercial feeds used by farmers keeping improved Kienyeji chicken in Western Kenya

Type of feed	Farmers % proportion using feed	Estimated cost/ Kg. (Ksh.)
Grower's mash	36	75.00
Chick mash	20	75.00
Kienyeji mash	32	63.00
Do not buy	12	-

Table 5. Cost estimate per kilogram of various mixes of homemade rations in comparison with experimental and commercial feeds

Feed Formulas	Cost per kg of homemade feeds in maize to sorghum ratio (Ksh.)			
	1:0	1:1	1:2	0:1
Maize/sorghum/soybean mix	60.00	52.00	49.33	44.00
Maize/sorghum/soybean/omena mix	61.25	53.25	50.55	45.25
Maize/sorghum/soybean/omena dust mix	56.25	48.25	45.55	40.25
Maize/sorghum/omena mix	65.00	57.00	54.30	49.00
Maize/sorghum/omena dust mix	45.00	37.00	34.33	29.00
Maize/sorghum mix	50.00	40.00	36.66	30.00
Developed experimental feeds	69.70	57.70	53.70	49.70
Average cost of assorted commercial feeds	70.00	70.00	70.00	70.00

Table 6. Mean annual prices of feed ingredients used in chicken rations in Western Kenya

Feed ingredient	Months available	Price per kg (Ksh.)
Brown sorghum (*Odhuwa*)	Aug-April	30.00±10
White sorghum (*Gadam)*	Aug-April	30.00±10
Red sorghum *(Nyadundo)*	Throughout the year	30.00±10
Maize	Aug-Dec	50.00±10
Soya beans	Aug-April	100.00±25
Omena	Throughout the year	125.00±5.0
Omena dust	Throughout the year	25±5.0

These prices were obtained over a period of six months after harvest (August-December) and during planting season (March -April) in 2018/2019

Feed cost analysis based on these prices showed that farmers who mixed maize to sorghum at a 1:1 ratio incurred a higher cost and thus a lower gross margin, compared to those who mix at a ratio of 1:2 or 0:1 as shown in Table 5. With higher inclusion of sorghum, the feed prices reduced marginally and was much lower than that of commercial feeds. Supply of sorghum and other ingredients fluctuates seasonally with abundance after harvest and scarcity during planting season. Table 6 illustrates apparent price fluctuations of each ingredient annually

Growth performance and weight gain. From the eight growers given to the farmers the highest chicken weight gain was 1646.4g, while the lowest chicken weight gain was 378.6g giving an average of 1242g. The highest final weight was 2999g while the lowest final weight was 845g. Majority (75%) of the birds gained a weight of 1500g and above (Figure 2) while 25% gained a weight of less than 1500g.

Mean weight gain for farmers chicken increased at a lower rate than that of the on-station experimental birds from 10 to 14 weeks of age but gradually increased and equaled at 18 weeks where the growth rate was similar and attained a significantly similar final mean weight (1219g vs 1242g) at 22 weeks (Figure 3).

Of those that gained over 1500g, 80% were managed by female farmers; however, the highest gained weight of 2999g was from a male managed farm. Results indicated that 85% of the totally confined birds, 45% of those released for 1-4 hours in a day and 5% of those allowed out to free range the whole day gained weight of 1500g and above (Table 7).

Table 7. Impact of improved indigenous chicken rearing system on weight gain and survival rate

Rearing system	Weight gain (g)	Birds, %	Survival rate %
Confined100%	>1500	85	98
Semi-free range	>1500	45	85
Free range	>1500	5	54

For those who included protein source at 25%, 75% achieved weight gain of more than 1500g and of those who included it at less than 25%, 19% achieved weight of more than 1500g (Table 8 and Figure 2 and 3) .

Table 8. Effect of protein inclusion level in Improved Kienyeji Chicken diets on weight gain

Protein inclusion level	Weight gained (g)	Birds attaining that weight, %	Remarks
25%and above	>1500	75	40% of farmers made protein inclusion level of 25% and above
	<1500	25	
Below25%	>1500	19	60% of farmers made a protein inclusion level of below 25%
	<1500	81	

Table 9. Proportion of farmers recording mortality rates in Improved Kienyeji Chicken

	Confined	Semi-Free range	Free range	Total
Farmers	17/50	2/50	31/50	50/50
Birds Mortality rate	8/400	15/400	61/400	84/400
Birds lost due to disease	8/400	60/400	14/400	82/400
Birds lost due to predation	nil	nil	2/400	2/400
Farmers with 100% loss	nil	Nil	1/50	1/50
Farmers with 0% loss	1/50	1/50	18/50	20/50
Farmers doing vaccinations	4/50	1/50	1/50	6/50

Discussion

Bird mortality. Out of the 50 farmers sampled, 40% still had all 8 birds surviving after the survey; 58% had less than 8 birds surviving; 2% had lost all their birds through predation or disease particularly Coccidiosis and New Castle Disease. However, 79% of birds were still surviving after 12 weeks, a good sign of their resilience (Table 7). On mortality, relatively more birds were lost from the free-range than the confined systems. Almost all birds (98%) lost were lost due to disease and only 2% through predation or theft was reported. Disease mortality was as prevalent in the free-range birds as was in the confined birds. A very limited part of the households (12%) used vaccines and drugs as part of their chicken health management strategy.

Housing and production systems. Rearing systems differed diversely and gave a wide range of results on the performance of the chicken with most farmers preferring free-range or semi-free-range systems of production due to lower investment cost and low engagement. The choice of a particular system depended on land availability and the objective for rearing the chicken. Farmers who preferred confinement did it to protect birds from predation, theft, and disease as well as the ease of collecting manure. Those who preferred the free-range system cited free range as less involving and less costly in terms of feeding, construction, and associated costs.

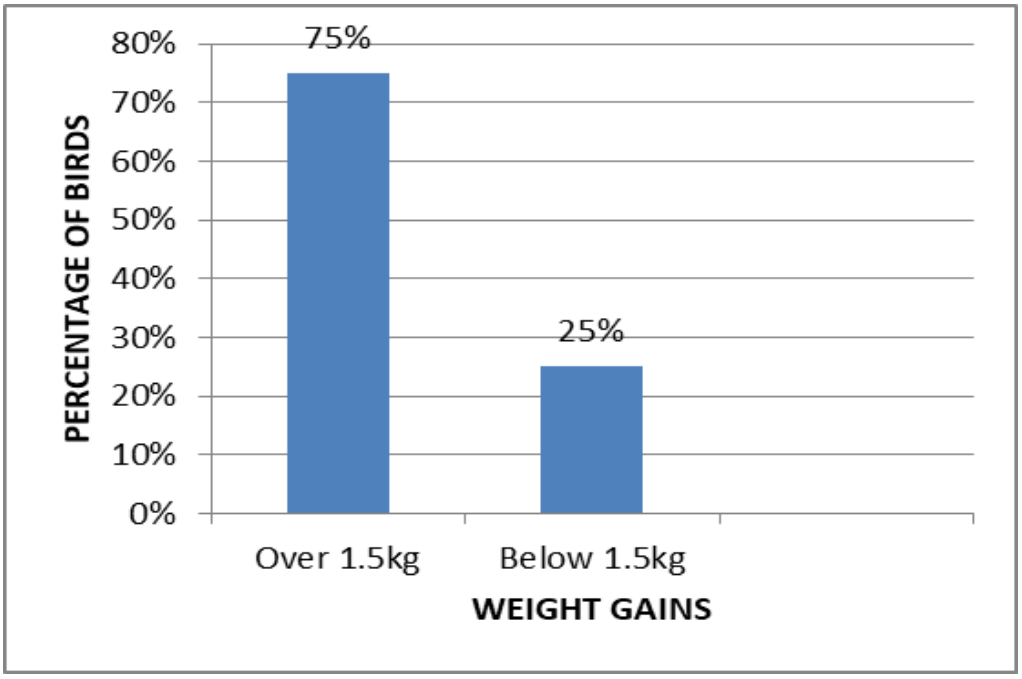

Figure 2 . Proportion of birds in different weight gains categories

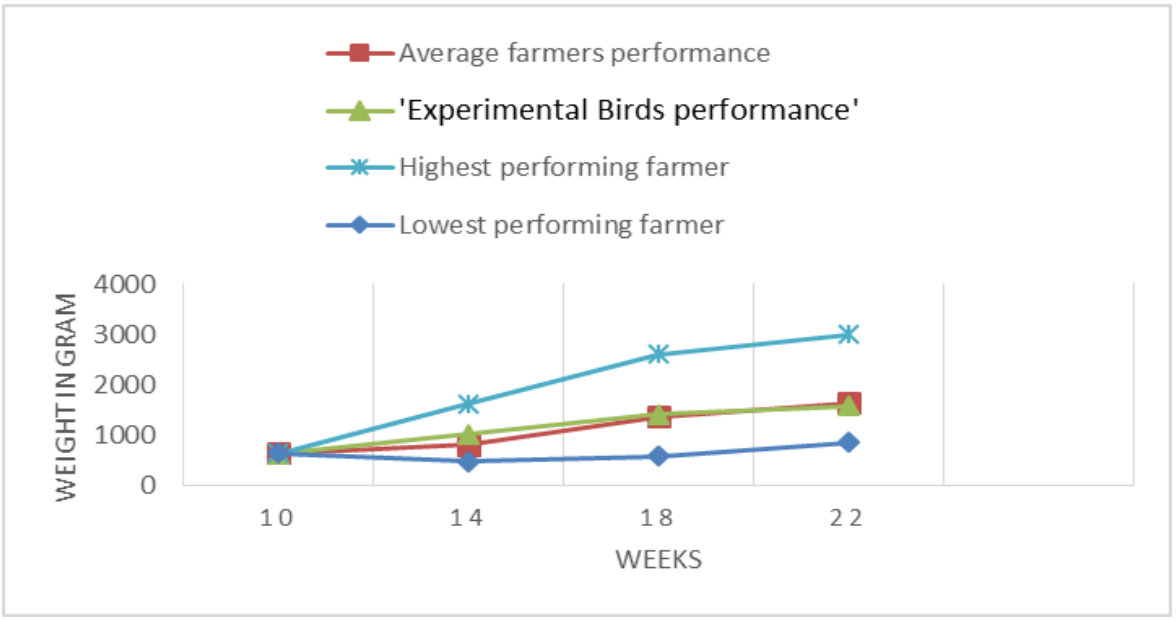

Figure 3. Weight gain trends comparisons of IKC reared on-station and by farmers in Western Kenya

The rate of investing in inputs is low leading to low production cost and therefore the cost per unit of egg or meat is nearly negligible (10). Free range system gives birds enough space to move around, opportunity to pick and feed on insects, weed seeds, sand, and grit, exercise and reduce stress, in an environment clear of their dropping. However, the farmers practiced a wide range of levels of confinement depending on seasons and available options and resources. The confined birds performed than those under free-range in weight gain and survival. This could most probably be explained by the fact that confined birds converted most of their energy into more weight gain rather than spending it scavenging around the home. Disease followed by predation are the most significant causes of mortality and outflow (17) as extensive or free-range production systems make the chickens vulnerable to harsh environments that increase likelihoods of infection and transmission of diseases (Magothe *et al.*, 2012).

In free range systems chicken are barely provided with proper housing. Most households did not deliberately house the chicken except for simple confinements inside the family residence especially during the night. During the daytimes, the birds are then released to open and unpredictable environment. During cropping seasons, birds are sometimes confined and supplemented with maize, swill and other available feed resources. The land tenure system favours chicken rearing even by youth and women who quite often do not own land or other productive resources.

Feeding regimes, feed supplementation, feed resource preference and inclusion and feed cost analysis. Smallholder farmers have limited chances of selecting feeds since they use what is readily available . It is notable that a negligible number of farmers (0.7%) used the recommended low tannin sorghum varieties of Gadam and Odhuwa (Manuya *et al.,* 2012) as most farmers plant their sorghum for subsistence and cultural purposes and it is generally high tannin red/brown seed types. Cereal grains will normally account for 60-80% of a typical chicken diet and it serves as a principal source of carbohydrate energy source for poultry (Elnagar *et al*., 2014). Soybean was preferred as a readily available source of protein because it does well in Siaya and Busia Counties and is often intercropped with sorghum to enhance yield. Similarly, omena and omena dust were preferred due to their availability though costing more than soybeans. It has been estimated that through scavenging, indigenous chicken are able to acquire 8.5g/kg/day of their total 11.7g/kg/day of protein requirement and thus require supplementation of 3.5g/kg/day (Gitonya, 2014). Although energy requirement information for the scavenging chickens in Kenya is scarce, they require about 286 Kcal/day according to other studies (Magothe *et al*., 2012). Farmers buy a variety of processed commercial feeds like Growers' mash (36%), 'Kienyeji mash' (32%), 'Chick mash' (20%), from input suppliers on the market to supplement home-made rations to either boost nutrient content or during scarcity of sorghum. Most farmers prefer supplementing with Growers' mash and 'kienyeji mash because of its availability and relatively lower prices throughout the year as compared to Chick and Layers mash. The scavenging feed resource base (SFRB) for the birds is variable depending on the season and rainfall. Therefore, strategic supplementation of birds according to age and production status can be a suitable solution. Even though, sorghum presents an alternative source of locally available, low cost, grain energy for home-made IKC feed ration (HMR), its viability has not been established. Sorghum is valuable as it has numerous utilizations of each part of the plant in different agricultural systems often used as forage, for building, weaving or firewood. Sorghum is not a highly commercialized crop (Muni *et al.,* 2019), grown more as a cultural food crop and therefore limiting its incentives for increased production, though available throughout most of the year. The use of sorghum as an alternative energy source to maize in formulated diets is popular and its adoption is a possibility which still gives good nutritional and productive performance of IKC comparable to that given by maize-based diets. Its nutritive value, cost and availability in semi-arid regions makes sorghum grain the most likely alternative to maize in poultry feeds (Elnagar and Abdel-Wareth, 2014). Sorghum-based feeds are evidently marginally cheaper than maize -based feeds in the semi-arid areas particularly during harvest time. With greater inclusion of sorghum, the feed prices are reduced. A Farmer making his own feed can save between KSh18-38 for every kilogram of feed, depending on the ratio of mixing of maize and sorghum. They also have a nutritional advantage over the commercial feeds as well as being quite comparable nutritionally (Table 10) to the maize-based feeds (Tarus *et al.,* 2019). Farmers also use greens like kales and cabbages (which they say improves yolk coloration), blood-meal, termites, ants, and food leftovers (swill).

Table 10. Mean nutrient content of specific commercial feeds and Home-made rations (HMR)

FEED TYPE	NUTRIENT LEVELS (%)		
	DM	CP	ASH
Kienyeji Mash	91.5±0.4	9.57±2.91	13.84±4.05
Chick Mash	92.8±0.32	12.73±1.46	27.45±0.76
Growers Mash	92.52±0.08	10.88±2.38	14.16±2.04
Home-made rations (HMR)	92.35 ± 0.20	13.72± 0.47	9.95± 2.36

Source:(22)

Table 11: Different levels of chicken weight gains fed on sorghum and maize-based feeds

Weight gain (g)	Experimental sorghum-based birds	Farmers birds	100% maize-based feeds birds
Highest final weight	2025[a]	2999[b]	3225[b]
Mean weight gain	888.7[a]	1242[b]	1333.13[c]

Availability and cost of feed determined choice of sorghum varieties and other feed ingredients**.**

Growth performance and weight gain of chicken. The wide differences in growth performance is due to broad diversity of feeding regimes and rearing systems used; where 75% of the birds gained weight of 1500g and above, while 25% gained weight of less than 1500g, a good market-oriented growth indicator. since most indigenous chicken are marketed at a mean weight of 1000g (Kingori *et al*., 2010). With an increased inclusion of protein resource in the diet growth performance was enhanced. It is also evident that sorghum inclusion in diets did not give significantly different growth performance as compared to maize-based diets. Neither was the performance inferior to that of the experimental on-station birds. Statistically, weight gain was dependent on both the rate of protein resource inclusion and level of confinement. Chicken on free range is normally fed in the morning before releasing to scavenge. The more the confinement the greater the weights gain. The mean weight gains compared well with that of birds fed on 100% maize-based rations in the earlier on-station feed trial experiment where the highest weight gain was 2600g, while the lowest was 1051g giving a mean of 1219g. Confinement also gave better results than free range birds in terms of weight gain, as they spend more energy to gain weight instead of scavenging. It is evident from Table 10 that farmers' birds had the highest mean weight of 1242 grams which was slightly higher than mean 1219 grams for 100% maize-based feeds birds.

The results shows that highest and lowest weight gain for experimental birds and farmers' birds are not statistically different also highest final weight for farmers' bird and 100% maize-based feeds are not statistically different from each other. In addition, mean weight gain for experimental bird and 100% maize-based feeds are not statistically different from each other. The highest final weight was 3225g. Generally, however the weights were lower than those of the maize-based feeds. Overall weight gain trend for the farmers' chicken was quite similar in comparison to the on-station experimental chicken . The farmers' birds mean weight gain was better (1242g) than that for maize-based feeds (1219) and the on-station experimental birds (888.7) (Table 11).

Chicken mortality. Disease followed by predation are the most significant causes of mortality and outflow. Extensive or free-range production systems expose chickens to harsh environmental conditions that increase likelihoods of infection and transmission of diseases thus resulting into high mortalities. The most common diseases are Newcastle

Disease (NCD), Chronic Respiratory Disease (CRD), Fowl Pox, Coccidiosis, Fowl Typhoid, Salmonellosis, Infectious coryza and Pullorum. Of these, NCD is the most devastating, causing severe losses as other studies have also shown (Magothe *et al.,* 2012). Western Kenya, for instance, with high population concentrations for humans and poultry, low hygiene standards, and a culture that promotes close contact with chicken poses very high biosecurity challenges especially during avian disease outbreaks. Aila (2012) asserts that there are usually humanized relationships between humans and poultry since small poultry flocks are kept by farmers and consequently humans and poultry often live in the same house. Generally, rural farmers rarely control diseases and parasites according to Magothe (2012). Outbreaks of NCD are the order of seasons and usually decimate the chickens. Herbs are sometimes used to treat sick birds, with the most used herb being Aloe vera.

Conclusion and Recommendations

From the results we conclude that the chicken diets developed by farmers meet the threshold standards for poultry feeds particularly for improved kienyeji chicken in as far as energy and crude protein nutrient composition is concerned. The use of sorghum as an alternative energy source to maize in formulated diets enhances performance of improved kienyeji chicken. Sorghum-based feeds are presumed to be marginally cheaper than maize-based feeds and generate a better cost-benefit gross margin than the maize-based feeds in the semi-arid areas. They also have a nutritional advantage to the commercial feeds as well as being quite comparable to the maize-based feeds. Inclusion of sorghum as an alternative energy source to maize in formulated diets is popular and is a possibility which can be enhanced and encouraged as it still gives good nutritional and productive performance of IKC and sometimes better than that given by the conventional maize diets.

Improved kienyeji chicken rearing is feasible in the Western Kenya semi-arid regions considering their favorable growth performance, low mortality rate and high preference. It is popular with the small-holder farmers particularly of the female gender who are more passionate and whose performance highly surpasses that of the male farmers. The more youthful farmers do not engage in chicken rearing as well in comparison with the adult farmers. The importance of IKC in provision of quality animal protein and wealth creation at national and household levels has been well recognised before and obviously its adoption with some farmer capacity building will help diversify and broaden household diets incorporating a wider range of foods and feeds to reduce malnutrition and hidden hunger and food insecurity and alleviate poverty.

The use of sorghum as an alternative energy source to maize in formulated diets is recommended. More farmers should be motivated to grow more of the low tannin sorghum (particularly Gadam and Othuwa) and soybeans as commercial feed resources, through the availing of affordable inputs like seeds to ensure production of enough volumes for chicken feed processing. More farmers should be encouraged to adopt a semi-free range (SFR) system of production to ensure both fast growth of chicken and/at an affordable housing cost. The low performance of chicken can be improved through changes in traditional management practices and thus contribute to improved household incomes as reported in Bangladesh (Magothe *et al.,* 2012). Individual and national/ regional efforts that take into account the whole chicken production value chain is thus recommended (Kumaravel *et al.,* 2014). Training and education should be tailored to both sexes with emphasis on women as they play a significant role and are more passionate and perform better in rearing chicken. The vaccination and disease control measures for the chickens should be strengthened, to contain diseases which kill large

numbers of chicken during outbreaks. They can also form registered organizations and marketing groups to take advantage of economies of scale to improve on their marketing strategies and volumes. These organizations as observed by Magothe (Kumaravel *et al.,* 2014) will also help them fetch good prices for their products. All youth should be encouraged to rear poultry as it requires minimal land and other collateral ownership and they can earn an income according to Mahendra (Kyule *et al*., 2014).

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Statement of No-Conflict of Interest

The authors declare no conflict of interest in the paper.

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