Vol. 18(8), pp. 586-593, August, 2022
DOI: 10.5897/AJAR2022.16004
Article Number: 1013DC869491
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

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African Journal of Agricultural Research

Full Length Research Paper

Use of termites as protein supplement for indigenous chicken on smallholder farms in Siaya County, Kenya

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Received 8 March, 2022; Accepted 20 July, 2022

Smallholder indigenous chicken (IC) production systems have been associated with low productivity thereby contributing to food insecurity and reduced livelihoods. Despite this scenario, smallholder IC producers have been harvesting and feeding termites supplementarily. This study determined the demographic characteristics that influence the use of termites as protein supplement for indigenous chicken by smallholder farmers and evaluated the nutrient composition of the most commonly used termite species. Household surveys were conducted to collect data on the socio-demographic characteristics of the farmers and on the use potential of termites as protein supplement to IC. Chi-square tests and logistic regression were used to analyze the collected data using R (version 4.0.2) statistical software. The commonly used *Agoro termites (Macrotermes subhylanus)* were harvested using trapping method, sun-dried and subjected to proximate analysis. A total of 72.7% of the farmers use termites as a protein supplement to feed IC. Chi square tests for association showed that occupation and education level of the respondents had significant association with termite usage (χ^2 =7.319, p-value = 0.042) and (χ^2 = 15.241, p-value = 0.004), respectively. *Agoro termites* were found to be rich in protein (37.7%) and calcium (38.625mg/100g) and could be used as protein supplement for IC.

Key words: Indigenous chicken, crude protein, supplement, Siaya, Kenya.

INTRODUCTION

Indigenous chickens (IC) are the most widely kept and also widely distributed livestock species in the whole world (Moreki et al., 2012). They also play an important role in the provision of both income and food to both rural and urban households. Indigenous chicken in Kenya account for about 76% of the total poultry population and produce about 55 and 47% of the total meat and eggs respectively (Kingori et al., 2010). Furthermore, they have several advantages, including quick returns on investment, relatively simple management practices and have many market outlets for products. However, IC are characterized by low productivity due to poor nutrition, prevalence of diseases and poor management (Kingori et al., 2007). In most cases, they are left to scavenge for

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insects, food waste, green grass, leafy vegetables and scattered grains (Kingori et al, 2003). IC is occasionally offered supplemental feed in form of food leftovers when available whereas housing and disease control are not provided regularly. Nutrient intake by IC under free range system is apparently sufficient only for maintenance and low production (Kingori et al., 2007). However, for improved productivity and production, additional inputs are required (Wondmeneh et al., 2016).

In Kenya average annual egg production in the traditional free and semi-free range systems is about 40-100 eggs/hen laid in 3-4 clutches each consisting of 12-20 eggs (Kingori et al., 2007). The eggs weigh 25-49 g which is within the range reported for other African countries (Kingori et al., 2010). According to Gad et al. (2015) there is potential for increasing production and productivity of IC. This can be achieved through improved housing, disease control, nutrition and genetics. With these improvements, egg production in IC can be increased to about 150 eggs per hen per year (Kingori et al., 2003). There is need to generate information on local feed resources available to IC in order to improve their performance under free range production systems. This will permit the evaluation of their nutritional requirement and formulation of appropriate feed ration. Kingori et al.(2007) observed that IC, under free systems, has a crude protein deficit of 3.2 g/bird/day which retards their growth and productivity. This deficit can be met through supplementation and can increase their growth rate by about 2.7 times their current rate (Kingori et al., 2003).

Termites are considered highly nutritive to both human and animals and are commonly consumed in Sub-Saharan Africa (Kinyuru et al., 2009). They are widely used by smallholder farmers as supplementary feed for poultry in Sub-Saharan Africa (Kenis and Hien, 2014). Termites play a key role in traditional poultry nutrition as a source of protein to chicken and guinea fowls (Sankara et al., 2018). Pomalégni et al. (2017) reported in a study that 72% of the farmers in South-Western Burkina Faso use termites collected from the bush to feed poultry. A study revealed that in traditional northern Ghana, each farmer has several termitaria that are harvested very early in the morning and afternoon depending on availability on a daily basis to supplement the protein requirements of the chicken and fowls (Anankware et al., 2015). This practice not only provides nourishment to the birds but also prevents the birds from roaming far away from home.

Different studies have shown variations on the termite species used for poultry feeding. For example, Boafo et al. (2019) showed that the most frequently used species in northern Ghana include species of the genera Macrotermes, Odontotermes and Trinervitermes. The use of Cubitermes, Amitermes and Microtermes was mentioned to a lesser extent. Amitermes was cited by more than 50% of the farmers in the Northern region but much less in other regions. Important variations were observed in the genera collected in the different regions. The genus most cited in all the regions is Trinervitermes, with more than 90% of all farmers citing this genus. Perhaps, Trinervitermes is used the most due to the abundance of their mound and the ease of obtaining workers by breaking mounds. In Burkina Faso, some species of *cubitermes* are reported to be toxic to chicks but not to guinea fowl and ducks (Dao et al., 2020). In Benin, a study revealed that a humivorus species of the genius *Noditermes* was toxic to both poultry species.

Termites are not always available; the quantity available depends on the season, availability of termite mounds and the termite species. A termite mound can provide about 50kg of termites per year (Duijn et al., 2018). Several studies have been done on the effect of termite diet on poultry. In Burkina Faso, Dao et al., (2020) substituted fish meal with fresh termite of the genus *macrotermes* in chick diets and showed that the daily weight gain was not affected though the feed conversion ratio was significantly higher with termites as compared to fish meal. Similarly, a study in the Democratic Republic of Congo showed that chick feed portions with 12% of termite *Kalotermes flavicollis* resulted in significant results in terms of weight gain and were economically much more profitable than commercial feed (Mutungi et al., 2019).

Siaya county, where the study took place, has an estimated human population of 1,005,816 (528,196 females and 477,620 males). It has 33.8 % of its population living below the national poverty line. It has few cash crops and most of the people depend on remittances from relatives residing outside the county (GOK, 2012). For on-farm generation of income, households rely on the sale of livestock particularly indigenous chicken (IC) and their eggs. Most of the studies on poultry in Kenya have targeted exotic commercial poultry rearing while few studies targeting IC are reported from other countries such as Ghana and Ethiopia. There is therefore a paucity of knowledge with regard to the IC and the use of termites as a source of protein supplement. This study was undertaken to determine the demographic characteristics that influence the use of termites as protein supplement for indigenous chicken by smallholder farmers, and evaluate the nutrient composition of the most commonly used termite species in indigenous chicken feeding.

MATERIALS AND METHODS

Study site

The study was done in West Alego and Township wards, Alego Usonga Sub-County, Siaya County, Kenya. Siaya County lies

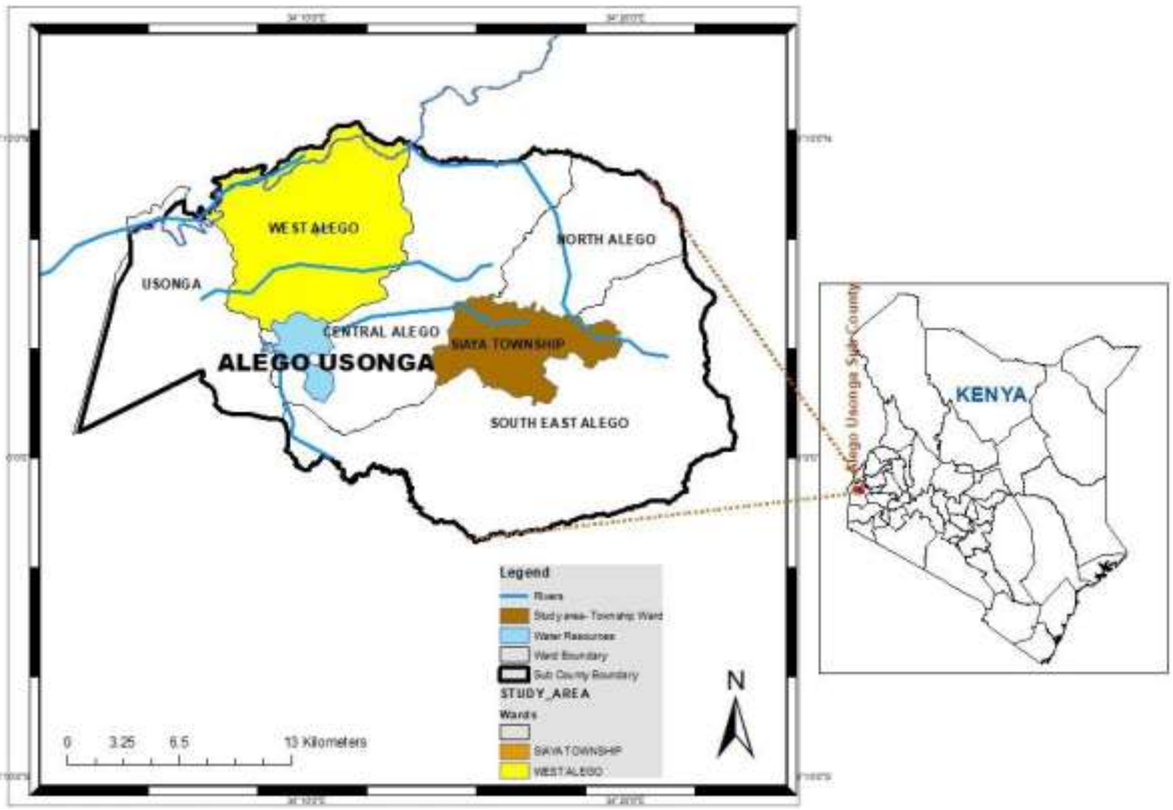

Figure 1. Map of Alego Usonga sub county in Siaya showing study area.
Source: Majuma Kenya GIS consultancy group.

approximately between latitude 0° 26´ South to 0° 18´ North and longitude 33° 58´ and 34° 33´ East. Alego Usonga Sub-County has a total area of 623.6 km^2 out of which 503.3 km^2 (80%) is cultivatable land. 120.3 km^2 (20%) out of the dry land is non-arable. 503.3 km^2 is arable to moderately suitable land for farming activities. Ecologically, the Sub-County spreads across agro-ecological zones LM_1, LM_2 and LM_3.The altitude range is 1140 to 1420 m above sea level. The rainfall range is 800-1600mm per annum. Generally, the Sub-County has bimodal rainfall pattern with long rains falling between March and June and short rains between September and December. The temperature ranges between 18 and 30°C with a mean annual temperature of 24°C. The evaporation rate is 1800-2000 mm per year (MoALF, 2015) (Figure 1).

Soil fertility ranges from moderate to low with most soils unable to produce without either organic, inorganic or as in most cases both fertilizers. The main soil type is ferrosols with sandy properties and underlying heavy murram.

Ferrosols and gleysols combined constitute the greater part of Alego Usonga soils, an implication of poor performance of crops grown in the region. The main water sources are Lake Kanyaboli, rivers Yala, Nzoia, several other streams and swamps. Most food crops and vegetables are grown in the Sub-County. Cotton and sugarcane are the main cash crops grown. Horticultural vegetables are partly grown under irrigation while bananas under rain fed are considered as a security as well as a cash crop. Root crops such as cassava and sweet potatoes are widely grown as security crops (MoALF, 2015).

Sample size determination

The target population was farmers who reside in Alego Usonga Sub-County and keep indigenous chicken. The sampling frame was the list of farmers with IC and who were trained by the department of livestock production on poultry management. This list was obtained from the Livestock Department, Alego Usonga Sub-County Administration. According to the Department's data, a total of 479 farmers of IC had been trained on poultry management in Township (264) and West Alego (215) wards of Alego Usonga Sub-County. These farmers were purposively targeted for this study due to the fact that they were knowledgeable on IC nutrition. The sample size from the population was determined using the formula developed by (Israel, 2009):

$$n = \frac{N}{1 + Ne^2}$$

Where;
n is the desired sample size
N is the population size
e is the desired level of statistical precision (0.05)

The sample size was thus calculated as follows:

$$n = \frac{479}{1+479(0.05)^2} = \frac{479}{1+1.1975} = 217.97$$

$$n \approx 218$$

Sample size for Township Ward:

$$n_1 = \frac{264}{479} \times 218 \approx 120$$

Sample size for West Alego Ward:

$$n_1 = \frac{215}{479} \times 218 \approx 98$$

In total, 120 farmers were interviewed from Township Ward while 98 were from West Alego Ward, giving a total of 218 farmers.

Data collection and analysis

A semi-structured questionnaire was designed and pre-tested in the study villages after which it was then revised and finally administered to determine the demographic characteristics that influence the use of termites as protein supplement for indigenous chicken by smallholder farmers. Data collected included: household characteristics (family size, farmland holding and chicken flock size per household); productivity of chicken in terms of eggs lay per year; chicken management practices including (feeding; feed availability, types and frequency of feeding). The interviewed farmers were categorized into two groups' *viz*., termite users and non-users. Data was analyzed using R version 4.0.2 (RCore Team, 2021) statistical software. Both descriptive and inferential statistics were used to summarize the data. In addition, Chi-square statistics was used to test for association between termite usage and the socio-demographic variables such as age, location, gender, education level and occupation.

$$\chi^2 = \frac{\sum_{i=1}^{n}(O_i - E_i)^2}{E_i}$$

Where;
χ^2 – is the Chi-square statistics tested at 95% confidence level
O_i– the observed values (frequencies) sampled from i = 1, …, n
E_i – the expected values (frequencies)

A binary logistic regression was fitted to assess the significant effect of socio-demographic variables on termite usage. The model was picked based on the nature of the response (termite user/non-user). The model specification was as follows:

$$Y = \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon_{ij})$$

Where;
Y – is the response variable, termite usage (User/Non-user)
β_0 – is the intercept
β_i– the estimates of the regression parameters (slopes) for i = 1,…, n
X_1 – are the independent variables, sociodemographic variables (ward, gender, age, occupation, and education level and farm size in acres).

Sample collection and nutrient analysis of the termites

A nutrient content test was done on Macrotermes subhylanus. They are commonly known as *Agoro* termites in the study region. The termites are wingless, and are the most widely used in indigenous chicken feeding in the study area. The termites were collected from both Township and West Alego Wards using trapping method.

Under this method, the harvester first spots trails of the termites in a field. A pit of 1 foot by 1.5 feet and 6 inches deep is then made and cleaned to eliminate safari ants. Dry maize stalks were placed at the bottom of the pit, and the pit was then covered using polythene bag to stop rain water. This was then left overnight. On the following day, soil was poured on top of pit to block the pit and prevent termites from escaping. The termites were then collected together with the plant materials and the soil. The plant materials were discarded and the termites rinsed with water to remove the soil.

The termites were then sundried, placed in a plastic container for laboratory analysis. Total Nitrogen was determined through the Kjeldahl (1883) method and crude protein calculated as Total nitrogen × 6.25. Minerals were analyzed according to the AOAC (2000) procedures. The mean values between the two study sites were compared using ANOVA and means separated using least significant difference at 95% confidence level.

RESULTS AND DISCUSSION

Of the 218 respondents surveyed, 213 (97.7%) gave a response to the question on whether they used termites or not whereas 5 (2.3%) didn't respond to this question. The response rate was thus 97.7% and hence the validity of the study.

Socio-demographic characteristics

The study was dominated more by females 64.7% compared to the males 35.3%. Half of the participants had primary level education whereas 33.3% had secondary education. Majority of the participants depended on agricultural production of crops as main source of income 82.6% and livestock production was mentioned by 41.7% as the other source of income. Majorly, the ownership of chicken was by women at 48.6%, followed by men at 23.9% whereas the joint ownership took a share of 25.5%. Most of the respondents were less than 36 years at 38.1%, followed by age 36 – 50 years and above 50 years at 75 (34.4%) and 60 (27.5%), respectively. The age group dominance signifies the most active or productive years in human life.

Extent of use of termites as feed to I.C.

The respondents were first categorized into users and non- users of termites. Users were those who harvest and feed termites to their IC while non-users neither harvest nor feed termites to the IC. A total 142(66.7%) of the participants were categorized as users while 71(33.3 %) as non- users. A study by Sankara et al. (2020) showed that 78% of the farmers interviewed in Burkina Faso used termites as feed to poultry. The findings of this study are slightly shy off the findings of the study in Burkina Faso. A lot still needs to be done for termite feeding to be fully adopted as a complementary protein source for poultry.

Out of the 142 users of termites, 72.7% cited termites being a source of protein as the main reason for using it to feed their poultry, while 24.8% cited its availability. The study reveals that majority of the respondents are aware of the need to include protein to IC diet. There exist other sources of protein for poultry such as fishmeal and other commercialized feeds but these are too expensive for the small-scale farmer. Termites, being both easily available and essentially cost-free, then fill this gap. This finding is in agreement with Dao et al., (2020) who indicated that termites may be the only source of proteins available to IC.

Most the farmers who utilize termites, 83.1% give them to all ages of the IC and only 10.5% discriminate on age and feed the chicks only. Once the termites are harvested, the whole harvest is poured on the ground and all IC are allowed to feed on the harvest. This finding contradicts with the finding by Kenis and Hien (2014) which indicated that most farmers in West Africa mainly collect and feed termites mostly to chicks.

Majority of the farmers fed IC once per day in the mid-morning just before scavenging, 60.1%, while 25.7% give termites two times a day-both morning and evening. This feeding frequency corresponds to the time the IC is released to go scavenge and the moment dusk comes that they need to get back to the poultry unit in the evening for shelter and protection. The feeding pattern could also be attributed to the quantity of termites harvested for feeding and the availability of the caretaker as mostly farmers leave in the morning for farm work and report midmorning to feed livestock then resume farm work and report back later in the afternoon or even evening. Additionally, the harvesting takes place in the morning and evening and in most cases the feeding is done immediately after harvesting. However, a study by Kenis and Hien (2014) showed that IC is fed thrice per day in order to provide the required protein and to prevent the IC from wandering far away from the homes hence preventing predation. Feeding IC once per day may not provide the required protein to promote growth of the IC.

Association between utilization of termites as feed for IC and socio-demographic variables

The Chi-square tests for association indicated that location (χ^2 = 3.402, p = 0.065), gender (χ^2 = 1.023, p = 0.312) and age (χ^2 = 3.03, p = 0.219) had no significant association with termite usage as signified by p-values greater than 0.05. Albeit females dominate in IC rearing, both genders use termites as an alternative source of protein for IC and thus an association between feeding IC and gender could not be made. The same can be said of the age distribution since variation in proportions of rearing IC and feeding termites are insignificant. Township ward and West Alego ward share same climatic conditions and thus not much difference in terms of termite availability and usage.

On the other hand, the respondent's occupation (χ^2 = 7.319, p = 0. 042) and level of education (χ^2 = 15.241, p = 0.004) had a significant association with termite usage. For detailed information, Table 1.

Effects of social demographic variables on termite usage

Table 2 validates the tests of association. It clearly indicates that location, age, gender and land size do not affect utilization of termite as indicated by the insignificant p-values (p = 0.267, p = 0.356, p = 0.426 and p = 0.102, respectively). However, occupation and level of education affect the utilization of termites as indicated by the p-values less than 0.05 (Wald = 4.898; p = 0.027 and Wald = 5.603; p = 0.018 respectively). Respondents who had other occupations other than farming were more likely to be non-users of termites. This confirms the assertion that harvesting and feeding termites is labour intensive and time consuming thus not conducive to those who had other jobs apart from farming. Education level also had an association with use of termites. The respondents with higher levels of education above primary were less likely to use termites. This may be attributed to the fact that most had commercial chicken production in addition to the IC whose scale of production could not allow for the utilization of termites. Dao et al. (2020) also indicated in their study that harvesting and utilization of termites become a challenge with a big flock size.

Chemical analysis of termite samples

The results in Table 3 indicate that the *Agoro* termites are rich in moisture, crude fibre and crude protein but low in crude fat. Generally, West Alego performs well nearly in all the tests except for Moisture and Crude Protein content where Township surpasses it. On the other hand, mineral analysis indicates that *Agoro* termites are high in calcium but low in phosphorus. Comparing the two regions, Township and West Alego, there was a significant difference in the chemical components: ash, dry matter, moisture, crude protein, phosphorus and calcium. This is as signified with a p-value less than 0.05. However, the termite chemical composition, crude fibre and crude fat did not vary significantly (p-value > 0.05) across the two regions (Table 3).

Table 1. Association between termite usage and socio-demographic variables.

Parameter	Termite usage No N(%)	Termite usage Yes N(%)	Totals	χ^2 (df)	P-value
Ward					
Township	44(62.0)	69(48.6)	113	3.402(1)	0.065
West Alego	27(38.0)	73(51.4)	100		
Gender					
Male	22(31.0)	54(38.0)	76	1.023 (1)	0.312
Female	49(69.0)	88(62.0)	137		
Age of the farmer					
Less than 36 years	22(31.0)	61(43.0)	83	3.03 (2)	0.219
36 - 50 years	26(36.6)	46(32.4)	72		
Above 50 years	23(32.4)	35(24.6)	58		
Occupation					
Farmer	69(97.2)	121(85.2)	190	7.319 (3)	0. 042*
Teacher	0(0.0)	1(0.7)	1		
Business Person	2(2.8)	15(10.6)	17		
Employed	0(0.0)	5(3.5)	5		
Education level					
None	11(15.5)	6(4.2)	17	15.241 (4)	0.004*
Primary	39(54.9)	66(46.5)	105		
Secondary	17(23.9)	60(42.3)	77		
College	2(2.8)	9(6.3)	11		
University	2(2.8)	1(0.7)	3		

*****Means significant at 5% level indicating the presence of an association.
Source: Data from the current study

Table 2. Summary of logistic regression results on the effects of socio-demographic variables on termite usage.

Variable	B	Std. Error	Wald	df	Sig.	Exp(B)
Ward	-0.374	0.337	1.233	1	0.267	0.688
Age of the respondent	-0.189	0.205	0.853	1	0.356	0.827
Gender	-0.250	0.314	0.633	1	0.426	0.779
Occupation	1.020	0.461	4.898	1	0.027*	2.774
Highest level of education	0.517	0.219	5.603	1	0.018*	1.678
Size of farm land holding in acres	-0.155	0.095	2.675	1	0.102	0.856
Constant	-0.950	0.564	2.839	1	0.092	0.387

***** Means significant at 5% level of significance, B – log of slope parameter, Exp(B) – exponent of B, Wald – the test statistic and Sig. – p-value. Both Wald and sig. are critical values tested against the 5% level of significance.
Source: Data from the current study

Nutrient Content of *Agoro termites*

Results of proximate analysis show that *Agoro* termites are an important nutritive feed resource to IC. In this study, *Agoro termites* averagely contain crude protein levels of 37.7% which is relatively higher than most

Table 3. Chemical composition of the *Agoro* termites (Mean±SE**)** from the two study sites.

Location	Ash	Dry Matter	Moisture	Crude Fibre	Crude Fat	Crude Protein	Phosphorus	Calcium
	Mean±SE	**Mean±SE**	**Mean±SE**	**Mean±SE**	**Mean±SE**	**Mean±SE**	**Mean±SE**	**Mean±SE**
Township	17.8±0.3[a]	90.5±0[a]	9.5±0[a]	24.0±0[a]	4.5±0.42[a]	39.4±0.2[a]	1.74±0[a]	33.6±0.7[a]
West Alego	22.1±0.1[b]	92.5±0[b]	7.5±0[b]	24.5±0.7[a]	4.6±0[a]	36.1±0.3[b]	1.95±0[b]	43.6±0.5[b]
P-value	0.00269*	<2e-16*	<2e-16*	0.423	0.771	0.00587*	0.00895*	0.00389*

*implies significant at 5%. Means sharing the same lsd (least significant difference) letters are not significantly different (p-value>0.05).
Source: Data from the current study

studies done on termites. A study by Akullo et al. (2018) found out lower crude protein levels of 23.1% for *Macrotermes falciger* compared to this study. According to Banjo et al. (2006), *Macrotermes bellicosus* has crude protein levels of 20.4% while *Macrotermes natalensis* has crude protein of 22.1%. A study by Moreki and Tiroesele (2012) reported crude protein content (% dry matter) of termites in Botswana as 46.3%. *M.nigeriensi* was found to contain 20.94% protein in a study carried out by Igwe et al. (2012) in Nigeria. A study by Solomon et al. (2020) showed that insects edible to both man and animals are good sources of protein and can meet the amino acid requirements of the consumers and are also rich in trace elements and vitamins. Edible grasshopper for example was found to contain crude protein of between 36-40% while that of raw *Macrotermes* species was found to be 42.3% (Ssepuuya et al., 2017).

There are notably some differences between this study and the findings of other researchers. The variations could be attributed to different ecotypes, age, sex, feed among other. In this study, the *Agoro termites* were found to also contain calcium and phosphorus mineral elements. This corelate well with Akullo et al. (2018) who also found out the presence of both Calcium and Phosphorus levels at 9.34mg/100g and 49.55 mg/100g respectively in *Macrotermes falciger*. Another study by Moreki and Tiroesele (2012) found out the following as the mineral content of termites: Sodium- 0.20 (g/100 g), Calcium - 0.23 (g/100 g), Potassium - 0.38 (g/100 g), Phosphorus - 0.38 (g/100 g), Magnesium - 0.15 (g/100 g). In this study, *Agoro termites* were found to contain averagely 38.625 mg/100 g Calcium and Phosphorus level of 2.71 mg/100 g. A study by Igwe et al., (2012) on chemical analysis of *M. nigeriensis* found out the phosphorus levels of 14.90 mg/100 kg.

Birds and all animal species require minerals for basic functions of formation and replacement of skeleton. Calcium and phosphorus are additionally needed for the formation of eggshell in laying birds, for example, a laying bird deposits in eggshell about 40 times the Calcium present in its own skeleton in one year of production (Elwinger et al., 2016). With the Calcium levels of 38.625 mg/100 g as found out by this study, *Agoro termites* can supply the Calcium requirements of the IC especially the laying ones. *Agoro termite*s in this study also contain averagely 4.6% crude fat; this is slightly lower as compared to a study by Moreki and Tiroesele (2012) who through proximate analysis found out higher figures of 7.3% in termites.

Proximate moisture composition of termites shows that *Agoro termites* are highly perishable due to the high moisture content at a mean of 8.5%. The dry matter content of *Agoro termites* as per this study was 91.5%, however, a study by Moreki and Tiroesele (2012) in Botswana got dry matter content for termites to be 96.4%. The average ash content of *Agoro termites* harvested from the two study areas gave higher figures - 19.95% as compared to other studies (Moreki and Tiroesele, 2012). Utilisation of termites as feed could improve food security and improved household incomes by providing a cheaper source of poultry feed.

CONCLUSIONS AND RECOMMENDATIONS

Occupation and education level of respondents determine whether they harvest and feed termites to indigenous chicken while age, location and gender of the respondents do not. From the findings of this study, it is evident that termites, especially *Agoro* termites have sufficient protein for IC feeding. There is a possibility therefore that *Agoro* termites could be fully utilized as a source of cheap protein to IC since it has 37.7% protein. There is need however for further studies on the use of termites as feed to indigenous chicken on other ecological regions and the safety of its use. Moreover, further study should be done to determine the reasons for the significance difference in chemical components of *Agoro t*ermites from the two wards.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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