COST OF INPUTS INFLUENCING INDIGENOUS CHICKEN EGG PRODUCTION IN THARAKA SUB-COUNTY, THARAKA NITHI COUNTY, KENYA

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ABSTRACT

Poultry farming contributes to Kenya's food and economic security. It provides a living for 70% of Kenyans by providing meat, eggs, and income. Indigenous chicken (IC) dominates poultry production in Kenya and is primarily kept in rural areas due to low economic rearing costs. Yet, IC's egg production is low, laying 45 eggs/hen/year compared to its potential of 165 eggs/hen/year. Low and poor-quality feeds and disease management practices have been associated with low egg production. This study used a cross-sectional survey to establish the impact of the cost of inputs on IC egg production in Tharaka Sub-County, Tharaka Nithi County, Kenya. A structured questionnaire was used to collect primary data from a clustered simple random sample of 246 IC farmers from Gatunga, Mukothima, Nkondi, Chiakariga, and Marimanti wards of Tharaka Sub-County. The data were analysed using descriptive and inferential statistics using STATA software version 17. Descriptive statistics were means, standard deviations, and proportions. A Stochastic Frontier production model was fitted to predict the influence of the cost of inputs on IC's clutch sizes. The results showed that higher treatment expenditure ($\beta = 0.0003$, $t = 29.01$, $p < .001$) and commercial feeds ($\beta = 0.005$, $t = 46.80$, $p < 0.01$) were associated with higher clutch at a 1% significance level. IC produced an average clutch size of 18.6 with commercial feeds compared to 16.6 with local feeds. Poultry diseases adversely influence chickens' physiological processes, such as impaired growth and feed utilisation decreasing egg production. Commercial feeds have nutrients such as protein, for egg yolk and albumen formation, calcium, and phosphorus essential for eggshell formation. Contrarily, local feeds may not have the balanced nutrients. Therefore, low cost of commercial feeds and disease treatment decreases the cost of egg production. Thus, IC farmers should use commercial feeds to increase egg production. Besides, the county should support IC farmers to control diseases through financing to improve egg production.

Keywords: Cost of inputs, Clutch sizes, Egg production, Indigenous chicken, Poultry farming; Tharaka Nithi.

INTRODUCTION

In Kenya, Chicken contributes about 6.1%, 2.3 %, and 0.7% of the livestock, Agricultural, and national GDP, respectively (Mbugua *et al.,* 2018). By selling their poultry or eggs, farmers can access a source of income that enables them to cope with unexpected costs such as medical bills and enhance their quality of life. Poultry meat and eggs substantially alleviate malnutrition, enhance food security, are a source of income and increase living standards among low-income households (Eissler *et al.,* 2020; Food and Agriculture Organization [FAO], n.d.).

According to a technical note by the Kenya Agricultural and Livestock Research Organization [KALRO] (2016)., indigenous chickens have several advantages over exotic breeds. They are well adapted to the local environment, can survive harsh conditions, have high resistance to diseases and parasites, require low inputs, and can scavenge for food. As a result, it is often practised in rural areas where most households are low-income earners (Nduthu, 2015).

Despite being the majority of the poultry population in Kenya, indigenous chickens have low production levels. In Kenya, an IC is estimated to produce an average of about 45 eggs annually against its potential of 165 eggs/hen/per year (Dong *et al.,* 2017; Mutua, 2018).

How feeds and disease management practices influence IC egg production is little known. Yet, indigenous chickens are kept predominantly by free-ranging systems in Tharaka Nithi County. The current study examined the effect of the input expenditure on egg production in indigenous chicken in Tharaka Sub-County, Tharaka Nithi County.

MATERIALS AND METHODS

The study was conducted in Tharaka Nithi County in the Central region of Kenya. The County lies between Latitude of 00^o 07' Noth and 00^0 26' South and 37^o 19' West and 37^o 46' East (Figure 1). Tharaka-Nithi has a tropical wet and dry or savanna climate. It records an annual temperature of about 21.0ºC, about -1.54% lower than Kenya's average.

The temperatures range from 13.2ºC in July to a maximum of 27.5ºC in March. Tharaka-Nithi receives about 148.0 millimetres (mm) of precipitation, with the wettest months being April (366.7mm) and the driest January (35.7 mm) (Tharaka-Nithi, Kenya climate, 2023).

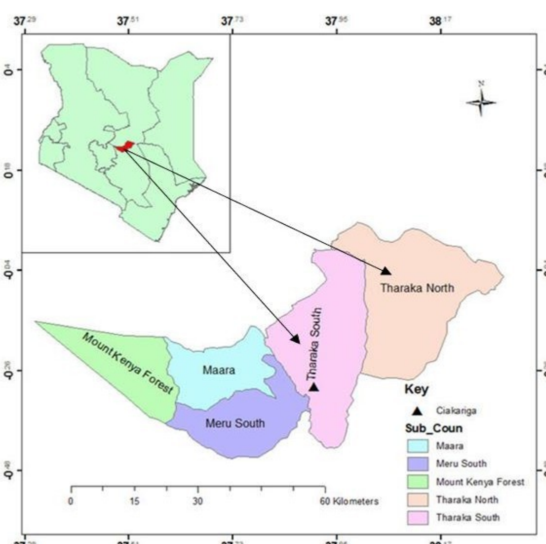


Figure 2: Map of Kenya showing Tharaka Nithi CountySource: Geocurrents (2016)

Tharaka North and South Sub-Counties in Tharaka Nithi County were purposively selected since it receives relatively low rainfall compared to Maara and Meru South sub-counties. The sample is clustered in four wards of the Tharaka Nithi Sub-County; Gatunga, Mukothima, Nkondi, Chiakariga, and Marimanti wards. The highlands (upper zones) comprising Chuka and Maara Sub-Counties receive adequate rainfall for agriculture but are poorly distributed in time and space. The semi-arid (lower zone) covering lower Igambang'ombe, Tharaka South, and North Sub-Counties receive poor rainfall of less than 300.0mm, as indicated in Figure 2 (Meteorological Department, 2021).

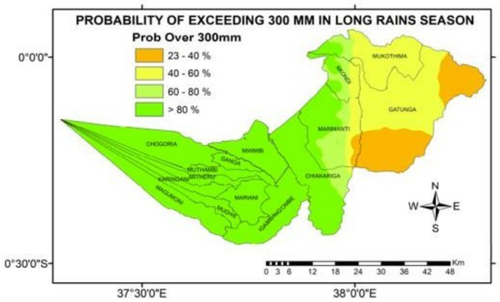


Figure 3: Rainfall Intensity in Tharaka Nithi Counties During October -December Rainy Season.
Source: Kenya Meteorological Department, 2021

The study adopted a cross-sectional survey design administered in May 2023 in Tharaka Sub-County wards: Gatunga, Mukothima, Nkondi, Chiakariga, and Marimanti wards. A semi-structured questionnaire was used to collect data from 227 (Two hundred twenty-seven) respondents through oral interviews. The questionnaire included cost of inputs (controlling diseases and feeds), and production measured by clutch sizes. The questions were validated by Agricultural economists using face, content, and criterion validity. The questionnaire was pretested in the Siakago ward in Mbeere North Sub-County, Embu County.

STATA 17 software was used to carry out the analysis. Coded data were analysed using descriptive statistics, including measures of central tendency (mean, median, and mode) and measures of dispersion (standard deviation and range). The Cobb-Douglas stochastic frontier model was used to evaluate the study objectives. The stochastic production frontier model was fitted to examine the impact of the cost of diseases and feed supplements on IC egg production following Equation 1.

$$Y = \alpha + \sum_{i=1}^{5} \beta_i Ln X_i + y \qquad (1)$$

Where;

Y = number of eggs per clutch Ln = Natural logarithm
α = model intercept
X_i Is a vector of the cost of disease control metrics: the cost of medicine, veterinary officer fees, vaccination, commercial feeds, and local feeds.
βi = Regression coefficients of each of the covariates, LnX_i
ε is the composite error term computed as Vi- Ui, parameters described in Equation 3.

The stochastic production frontier model was postulated by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977). It is based on linearity assumption, and the variable is assumed to be strictly nonnegative components. In this analysis, the variables are assumed to follow a half-normal distribution. The model parameters are estimated using the maximum likelihood estimation method.

RESULTS AND DISCUSSIONS

Participants

Most IC farmers were female having less than a secondary school education (Table 1).

Table 14: Farmers' Characteristics of Smallholder Indigenous Chicken Farmers

Characteristic	Level	Frequency [N = 227]	Per cent
Gender	Male	90	39.65
	Female	137	60.35
Level of Education	No formal education	7	3.08
	Primary education (incomplete)	81	35.68
	Primary education (complete)	82	36.12
	Secondary education (incomplete)	11	4.85
	Secondary education (complete)	22	9.69
	College	20	8.81
	University education	4	1.76
Household Head	Husband	174	76.65
	Wife	53	23.35

The IC farmers' ages ranged between youthful and advance age and the household sizes between single person and dozen people (Table 2)

Table 15: Descriptive Statistics of Household Size and Age, Land Size, And Experience

Variable	N	Mean	SD	Min	Max
Age	227	42.10	8.64	26	77
HS	227	5.58	1.99	1	12
Experience	227	7.97	5.83	0	23
Land size	227	4.11	2.97	0.25	13

Production Statistic

Most Tharaka South Sub County farmers are small-scale farmers, with 1 to 40 IC, of which 0 to 37 are IC laying eggs. The eggs per clutch are generally low between 10 to 20 (M = 17.2, SD = 2.05). The results are comparable to those in empirical studies. In Ethiopia, Mengesha, Kebede, and Getachew (2022) established that IC lays 10 - 15.7 eggs monthly. The eggs per clutch are generally lower than typical exotic breeds (Mengesha et al., 2022), Table 3.

Table 3: Descriptive Statistics of Indigenous Chicken and Egg Production

Variable	N	Mean	SD.	Min	Max
Number of IC	227	13.07	9.487	1	40
Number of IC laying eggs	227	9.242	8.6	0	37
Eggs per Clutch	220	17.2	2.049	10	22

Inputs Expenditure

Poor IC management practices could contribute to the low egg production among ICs in Tharaka Sub-County. The inputs expenditure explored in this study was on feeds and medication. The results are presented and discussed below.

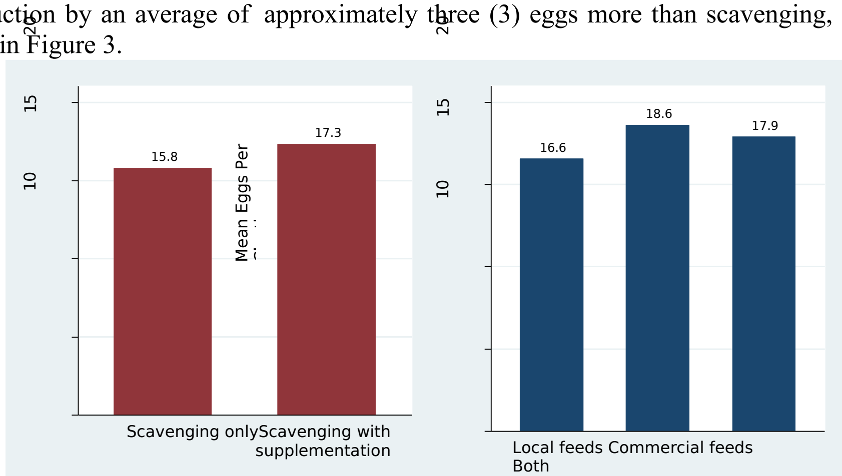
Feeds

Table 4 summarises the study's results on indigenous chicken farmers' feeding behaviour. Table 4: Tabulation Of Feeding Behaviour of Indigenous Chicken Farmers

Variable	Levels	Frequency	Percentage
How do your birds feed?	Scavenging only	20	8.81
	Scavenging with supplementation	207	91.19
	Total	227	100
If scavenging with supplementation, which feed supplements do you use?	Local feeds	102	49.76
	Commercial feeds	28	13.66
	Both	75	36.59
	Total	205	100
If commercial feeds, at what interval do you feed your birds?	Daily	43	41.35
	Weekly	61	58.65
	Total	106	100

All IC farmers scavenge their chickens and supplement them with local or commercial feeds, mostly weekly. Generally, 80% of farmers keep poultry under extensive free-range systems in most low-income countries in Africa, such as Rwanda (Mahoro *et al*., 2017) and Benin (Adoligbe *et al*., 2020) and Asia (FAO, 2004), where the birds scavenge for food. The IC is adapted to harsh environments and can survive with minimal inputs (Desta, 2021). Therefore, IC chicken farming is mostly based on scavenging and local feed supplements.

Scavenging may cause low egg production in ICs because they may not get enough nutrients and energy from the feed they find. Egg production needs protein, calcium, phosphorus, vitamin D, and other minerals and vitamins for egg yolk, albumen, and shell formation (Broehm, 2023). Scavenging feeds may not have the right nutrients for egg production in ICs. In this study, the IC farmers let their chickens scavenge with little low-protein feed supplementation such as maise, sorghum, and pearl millet ("*Mwere*"). Contrarily commercial layer feeds typically have balance and higher levels of protein, calcium, and other nutrients, including enzymes that improve the digestibility and efficiency of the feed. Contrarily, commercial layer feeds have more protein, calcium, and other nutrients and enzymes that help improve the digestibility and efficiency of the feed (Alagawany, Elnesr, & Farag, 2018). Therefore, commercial feed supplementation boosts egg production. In this study, supplements increase egg production by an average of approximately three (3) eggs more than scavenging, as shown by the average clutch sizes in Figure 3.



igure 4: Average Clutch Size Based on The Feed Types

Variable	N	Mean	SD	Min	Max
Quantity of local per day (Kgs)	206	2.02	1.34	.5	10
Cost of local feeds per Kg (Kshs)	207	161.62	68.03	50	500
Quantity of commercial per day (Kgs)	102	2.26	1.21	.5	5
Cost of commercial feeds per Kg (Kshs)	99	203.74	114.31	50	500

Table 5 presents the descriptive statistics of quantities and costs of local and commercial feeds on IC. Table 5: Descriptive Statistics of Quantity and Cost of Local and Commercial Feeds

The study shows that local and commercial feed usage per day (Kg) are similar. However, commercial feeds are generally higher, by about 1.26 times, than local feeds. Commercial feed costs may limit farmers' use, affecting their egg production. Commercial feed costs more than local feed because it has specific nutrients such as protein levels, calcium, and minerals for different chickens, such as egg-layers, meat birds, and chick mash, that affect how the chickens grow, stay healthy, and produce more eggs (Alagawany, Elnesr, & Farag, 2018). The commercial feed may also have medication, organic, or fortified ingredients such as grains, soybean meal, and fish meal that local feed lacks. These ingredients can boost the chickens' health and immunity. Contrarily, local feeds are cheaper than commercial feeds since they are home-grown.

Medication

Table 6 presents the study results on poultry disease incidences and management practices among IC farmers in Tharaka Sub-County.

Table 6: Frequency Distribution of Poultry Disease Incidences and Management

Variable	Levels	Frequency	Per cent
Which is the most common disease affecting your indigenous chicken?	Newcastle	70	30.8
	Coccidiosis	30	13.2
	Both	127	56
	Total	227	100
Do you vaccinate your birds against Newcastle?	No	45	19.8
	Yes	182	80.2
	Total	227	100
Who normally carries out vaccination? (Newcastle)	Yourself	79	44.4
	Veterinary Officer	54	30.3
	Both	45	25.3
	Total	178	100
How effective is the treatment?	Effective	79	35
	Partially effective	105	46.5
	Not effective	42	18.6
	Total	226	100

Do you vaccinate your birds against Coccidiosis	No	45	19.8
	Yes	182	80.2
	Total	227	100
Who normally carries out vaccination (Coccidiosis)	Yourself	79	43.9
	Veterinary Officer	55	30.6
	Both	46	25.6
	Total	180	100
How effective is the treatment?	Effective	79	35
	Partially effective	103	45.6
	Not effective	44	19.5
	Total	226	100

Both Newcastle and Coccidiosis are prevalent IC in Tharaka sub-county. Poultry diseases, especially Newcastle and Coccidiosis, are widespread and affect indigenous chicken production in Africa. For example, in South Western Ethiopia, almost all farmers (96%) faced poultry diseases as a production challenge, including Newcastle (Yadessa *et al*., 2017). In Kenya, Newcastle (18.5%) and Coccidiosis (16.4%) were also the main disease constraints for indigenous chicken farmers in Busia and Machakos counties (Muleke *et al*., 2022).

Vaccinating chickens is vital to protect them from diseases that harm their egg production, quality, and welfare. Marek's disease, Newcastle disease, and fowl pox are some diseases. By preventing these diseases, vaccination also reduces the need for antibiotics, which can lead to the emergence of antibiotic-resistant bacteria. Therefore, vaccinating chickens is beneficial for the productivity of IC. Most IC farmers (80%) vaccinated their indigenous chicken against Newcastle and Coccidiosis, two common and deadly poultry diseases. Only 19.82% of the farmers did not vaccinate their chickens, exposing them to the risk of infection and mortality. Most farmers (44.38%) performed the vaccination by themselves, while some (30.34% for Newcastle and 30.56% for Coccidiosis) relied on their veterinary officers. Vaccination is an important practice to ensure the health and productivity of indigenous chickens.

Table 7 summarises the costs of disease management practices.

Table 7: Descriptive Statistics Input Costs of Disease Management Practices

Variable	N	Mean	SD	Min	Max
Cost of Newcastle vaccination	165	530.1	850.3	0	5000
VO Pay for Newcastle vaccination	143	1038.8	1404.5	0	5000
Newcastle Vaccination Frequency	224	2.4	2.0	0	15
Newcastle Treatment Cost	191	1017.6	1012.7	100	4000
Coccidiosis Vaccination Frequency	224	2.4	2.0	0	15
Cost of Coccidiosis Vaccination	167	525.0	834.9	0	5000
VO pay for Coccidiosis vaccination	144	1037.9	1397.7	0	5000
Coccidiosis Treatment Cost	198	1063.9	1082.2	100	6000
Vaccination Cost	165	1056.6	1689.0	0	10000
Medicine Cost	167	2084.0	1560.8	400	7200

Veterinary fee	143	2078.3	2806.6	0	10000

Notes: VO =Veterinary Officer; Vaccination cost = Cost of Newcastle vaccination + Cost of Coccidiosis Vaccination; Medicine Cost = Newcastle Treatment Cost + Coccidiosis Treatment Cost; Veterinary fee = VO Pay for Newcastle vaccination + VO pay for Coccidiosis vaccination.

Poultry vaccination is a complex process that depends on various factors, such as the type, dose, route, timing, and frequency of the vaccine, as well as the age of the birds. This study found that the frequency of coccidiosis vaccination was low among the farmers, averaging only three times a year. This could explain why the vaccines were ineffective in preventing the disease. However, vaccination does not guarantee complete protection or elimination of the disease pathogens, even if done correctly. Therefore, other measures, such as biosecurity and hygiene, are also essential to control coccidiosis in poultry.

Most farmers were not fully satisfied with the treatments for Newcastle (ND) and coccidiosis disease, two common and deadly poultry diseases. For Newcastle treatment, only 34.96% of the farmers said it was effective, 46.46% said it was partially effective, and 18.58% said it was ineffective. For Coccidiosis treatment, the results were similar: 34.96% effective, 45.58% partially effective, and 19.47% ineffective. These findings suggest that the treatments are unreliable in curing the diseases or preventing their recurrence. The study finding is consistent with empirical evidence demonstrating that vaccinated chickens can still contract ND. For instance, Kim and Samal (2016) established ND prevalence of 77.0% among vaccinated poultry. Thus, IC farmers should minimise predisposing factors like dump environments and stressors like diet changes (Obasi, Ifut, & Offiong, 2006). Besides, more research and development are needed to improve the treatments and increase their efficacy.

Effect of the Inputs Expenditure on Egg Production in Indigenous Chicken

Table 8 presents the stochastic frontier model based on Cobb Douglas production predicting IC egg production based on the cost of diseases and feed supplements.

Table 8: A Stochastic Production Frontier Model Predicting Eggs Per Clutch Based on The Cost of Feed Supplements and Control of Newcastle and Coccidiosis Diseases

					95% Confidence Interval		
Eggs Per Clutch	Coefficient	SE	t-value	p-value	Lower	Upper	Sig
Medicine Cost	0.00029	0.00001	29.010	0.000	0.00027	0.00031	***
Veterinary fee for vaccination	0.00007	0.00017	0.400	0.691	-0.00026	0.00040	
Vaccination Cost	0.00031	0.00022	1.400	0.162	-0.00013	0.00075	
Local feed cost per kg	-0.00658	0.00006	-110.09	0.000	-0.00670	-0.00646	***
Commercial feed cost per kg	0.00458	0.00010	46.80	0.000	0.00439	0.00477	***
No of IC	-0.02095	0.00186	-11.25	0.000	-0.02460	-0.01730	***

Constant	18.35008	0.01955	938.58	0.000	18.31177	18.38840	***
σ_v^2	-31.8385	377.906	-0.080	0.933	-772.52	708.843	
σ_u^2	1.2912	0.3086	4.18	0.000	0.68631	1.89603	***

*Note. N = 21; Chi-square (6) =2247036117.452, p < .001; Akaike crit. (AIC) =75.598; *** p<.01, ** p<.05*

The model violates the heteroskedasticity assumption based on the Likelihood-ratio, $\chi^2(01) = 10.65$, $p < .01$. A conditional heteroskedastic half-normal model, with the number of IC included as a control variable since medicine cost, veterinary fee, and vaccination cost may increase with increasing flock size. The model was statistically significant, $\chi^2(6) = 2247036117.4$, $p < .001$.

Medicine cost has a significant positive effect on clutch size ($\beta = 0.00029$, t = 29.01, p < .001). The results support H1a: High expenditure on medication is associated with higher IC egg production. The results suggest that medication expenditure positively correlates with clutch size, meaning farmers who invest more in treating their chickens have higher egg yields. Diseases are a major factor that affects egg production in IC. Treating Newcastle and Coccidiosis is crucial, as these diseases affect the chickens' physiological processes that influence egg production. Newcastle disease virus (NDV) can cause poor weight gain, reduced egg production, and a high mortality rate in chickens (Nisa *et al.,* 2019). Coccidiosis can also impair chickens' intestinal health and nutrient absorption, lowering egg quality and quantity (Abebe *et al.,* 2018). Therefore, effective and timely treatment of these diseases is essential for improving the productivity and profitability of poultry farming.

The findings are coherent with existing empirical literature that has reported that poor management practices and diseases, such as Newcastle and Coccidiosis, are associated with low egg production in IC in South Western Ethiopia (Yadessa *et al*., 2017). Assefa *et al*. (2019) show that 93.8% of indigenous chicken owners report chicken disease, including Newcastle and Coccidiosis, which causes low egg production. These diseases impair the physiological processes of the chickens that are essential for egg production, such as nutrient absorption, hormone regulation, and reproductive function. Therefore, treating these diseases can improve the clutch sizes of the chickens by enhancing their health and productivity. Disease treatment is important to increase IC farmers' egg yield and income.

Veterinary fee for vaccination ($\beta = 0.00007$, t = 0.400, p = 0.691) and vaccination cost ($\beta = 0.00031$, t = 1.400, p = 0.162) had insignificant effect on clutch size. The results do not support this. H1b: High expenditure on vaccination is associated with higher IC egg production. Vaccination is mainly for disease prevention and may not directly impact egg production. However, vaccination does not guarantee complete protection from the disease, as some chickens can still get infected even after being vaccinated. For example, a study by Kim and Samal (2016) found that 77.0% of the poultry vaccinated against ND tested positive for the virus. This shows that vaccination alone is insufficient to control ND, and other measures, such as biosecurity and hygiene, are also needed. Therefore, vaccination is a necessary but insufficient condition for improving poultry health and productivity.

Regarding feeds, local feed cost per kg (β -0.0066, t = -110.09, p < 0.001) has a significant negative effect on clutch size, whereases commercial feed cost per kg ($\beta = 0.00458$, t = 46.80, p < 0.01) had a significant positive effect on clutch size. The results support H2: High cost of commercial feeds enhances the egg production of IC. The results suggest that the feed type and quality significantly affect IC's clutch size. Expensive local feeds are associated with low clutch sizes, while expensive commercial feeds are associated with high clutch sizes. This could be explained by the difference in their nutritional content, which is essential for egg production.

Local feeds may have low or imbalanced nutrients, which could impair the physiological functions of the IC that support their egg production. Egg production requires a lot of energy and nutrients, such as protein (for egg yolk and albumen formation), calcium (for eggshell formation), phosphorus, vitamin D, and other minerals and vitamins (Broehm, 2023). Commercial feeds are designed to provide these nutrients in optimal amounts and ratios, which could enhance the health and productivity of the IC. Comparatively, Local feeds may lack the nutrients needed for egg production. They may contain non-layer feeds, such as maise, sorghum, and pearl millet, which do not provide optimal nutrition for laying IC. Low-protein feeds may reduce egg production and increase feather growth. Commercial layer feeds have balanced and higher protein levels, calcium, and other nutrients and enzymes that improve feed digestibility and efficiency (Alagawany et al., 2018). Therefore, commercial feed supplementation improves IC farmers' clutch size and income.

This study shows that IC farmers can increase their egg production and profitability by using commercial layer feeds. The results revealed that commercial feed supplementation can boost the egg yield by one to three eggs more than local feeds. Although this difference may seem small, it can be significant if scaled up by high-scale IC production. Therefore, IC farmers should consider adopting commercial layer feeds or improving the quality of local supplements to enhance their productivity and income.

CONCLUSION AND RECOMMENDATION

The current study concludes that the cost of inputs does influence indigenous chicken egg production in Tharaka Sub- County, Tharaka Nithi County. Therefore, it is recommended that IC farmers use commercial feeds in feeding their chickens and carry out disease management practices for increased egg production in Tharaka Sub-County, Tharaka Nithi County.

ETHICS STATEMENT

The study adhered to the ethical principles for human research, as stipulated by the Declaration of Helsinki in relation to methods, informed consent, and confidentiality. The Chuka University Ethics Committee, a National Commission for Science and Technology and Innovation, approved the current study. Informed consent was sought from the respondents before administering the questionnaires. Data were processed as confidential and anonymised.

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