*Original Research Article*

# Effects of substituting sunflower seed cake with copra cake on growth performance and economic value of broiler


## ABSTRACT

An experiment to determine the effects of substituting sunflower seed cake with copra cake on growth performanceand cost value of broilers was conducted at Sokoine University of Agriculture. A total of 260 broilers were assigned to five dietary treatments designated as (T1, T2, T3, T4, T5), containing 0, 15, 30, 45 and 60% of copra cake, respectively. The experimental diets were fed for 6 weeks i.e. 8-49 days of age. During the experiment the birds were group fed and feed intake was measured daily whereas live weight changes were measured weekly. After seven weeks; 12 chickens from each treatment were slaughtered and carcass yield and dressing percentage were determined. Proximate analysis of the individual feed ingredients and experimental diets was done. The results showed that Crude protein (CP) and metabolizable energy (ME) were not significantly different between the treatments. Dry matter intake (DM) was significantly lower for T4 and T5 during the 3$^{rd}$ and 4$^{th}$ week of the experiment. Total DM intake per bird was lowest for T4 (3354.9g) and highest for T2 (3926.2g). FCR and FER in T4 were significantly lower (1.95) and higher (0.52) respectively. Significant differences on growth performance were observed, with higher cumulative weight gain in T1 (1870.1g) and lower for T5 (1704.4g). However, dietary treatment had no significant effect on carcass yield and dressing percentage except for the liver. When cost was correlated to return from marketable bird it was shown that highest gross margins were obtained from T4. From the current study it was concluded that copra cake can replace sunflower seedcake meal up to 45% without affecting the performance of birds.


*Keywords:Broiler feeding; Carcass yield; Copra cake; Performance; Sunflower seed meal*



## 1. INTRODUCTION

Poultry production is a very important business used for income generation and poverty alleviation in Tanzania. The population of chickens in Tanzania currently stands at 83,280,000 comprising of 38,770,000 indigenous chicken and 44,510,000 exotic chickens [1]. Feed is the major cost component in poultry production, usually comprising 70–80% of the total production cost all over the world [2]. Previous studies have shown the inclusion levels of common ingredients in poultry diets to be maize meal (40%), maize bran (25%), fishmeal (5%) and oil seed cakes like sunflower seed cake, and cotton seed cakes (15%) [3, 4, 5, 6, 7].Based on the inclusion level of these ingredients, the estimated amount of individual ingredient used per year as an animal feed in Tanzania is about 5600 tons of maize meal, 3500 tons of maize bran, 700 tons of fishmeal, 2100 tons of sunflower seed cakes, and

700 tons of cotton seed cake. The major poultry feed ingredients have been facing market competition with human food demand in developing countries like Tanzania.

Poultry producers always aim to maximize production with minimum expenditure on nutrient sources so as to economize their feeding practices [8, 9, 10, 11]. High price of compounded feeds is the critical limitation for poultry production in Tanzania. Additionally, seasonal fluctuations of feed prices due to variation in price of ingredients and cost of feed processing often result into high feed cost that makes the production unit unprofitable [10,12]. Furthermore, over 90% of the feed in Zanzibar is imported from Mainland Tanzania. This eventually increases the cost of production to the poultry keepers and decreases the profit of the poultry projects, especially for small holders, who account for about 95% of all poultry keepers in Zanzibar.

The main sources of protein for poultry in Tanzania are blood meal, fish meal and oil seed cake meals. These products in most cases are expensive and their supply is not reliable [13]. Reduction in cost can be achieved by using relatively cheap available sources of protein supplements such as copra cake.Coconut palm (*Cocosnucifera*) is one of the most useful tropical trees with multiple uses such as food, beverage, shelter and livestock feed [14]. It is widely grown all over Zanzibar and coastal areas of Tanzania i.e. Tanga, Bagamoyo, Pwani, Lindi and Mtwara. Copra cake is a product of dried meat or kernel from the ripen coconut which is obtained after oil being extracted either by mechanical or solvent methods. The extraction of oil by crushing the dried kernel (copra) produces about (65-72%) oil and the by-product known as copra cake (35-38%) which is mainly used as feed for livestock [15, 16, 17]. In 2010 the world production of copra was estimated at 5.2 million tons and copra meal/copra cake production was 1.86 million tons, while copra meal production in Tanzania was only 12000 tons per year [18].

Copra cake can be used as an animal feed to replace expensive broilers [19].Although copra meal is expensive, studies have shown that it can be used to feed animals and poultry with good results [20] as it is a good source of energy and protein. However, Copra cake cannot be stored for more than six months due to high fat content which causes rancidity and lowers the quality of feeds. Copra meal contains high levels of non-starch polysaccharides (NSP) content and notably ß-mannan and galactomannan which are known to have anti-nutritional properties in monogastrics species hence are not easily digested by poultry [21].Thus the presence of these substances together with anti-nutritional properties limits the use of copra meal in poultry diets. Feeding copra meal in some cases has been observed to result in poor growth of chickens because the amino acid profile is not optimal for poultry due to relatively low levels of lysine and sulphur amino acids.The problem can be overcome through dietary supplementation with good quality protein and these amino acids[22, 23]. It is therefore important to determine the optimal inclusion level of copra cake when preparing poultry feed.

Zanzibar and other coastal areas of Tanzania could benefit by using copra meals over the other major oil meals, since the other meals such as soybean meal, groundnut meal and cotton seed meal are not locally produced. Thus, the current study was undertaken to assess the effect of substituting sunflower seed cake with copra cake in broiler diets. The overall objective of the study was to evaluate the nutritive potential of copra cake as a protein supplement in broiler diets in Zanzibar.

## 2. MATERIALS AND METHODS

### 2.1 Study area

The study was conducted at the poultry unit of the Sokoine University of Agriculture (SUA) in the Department of Animal, Aquaculture and Range Sciences (DAARS). The University is situated between $6^o$ to $7^o$ S and $37^o$ to $38^o$ E. SUA is located about 3 km far away from Morogoro town and it lies on the foot of the slopes of Uluguru mountain between elevation of about 500-600m above sea level.

### 2.2 Experimental diets and preparations

Copra cake meal was collected from Zanzibar (Unguja Island) while other feed ingredients i.e. maize bran, sunflower seed cake, fish meal, maize meal, mineral premix, vitamin premix, salt, limestone, methionine and blood meal were purchased from TANFEED; a feed mill company in Morogoro Municipality. All feedstuffs were stored at room temperature. Five dietary treatments (T1, T2, T3, T4 and T5) containing different levels of copra cake and sunflower seed cake were compounded and used in the feeding experiment. T1 was used as a control and contained 100% sunflower seed cake while T2, T3, T4 and T5 contained copra cake at 15%, 30% 45% and 60% inclusion level respectively as shown in Table 1. All feedstuffs were mixed by a vertical mixer at feed mill company except for sunflower and copra cake which were added and mixed in the diet manually at SUA experimental unit. This was done to ensure that all treatments (T1-T5) contained equal amounts of the other feedstuff excluding copra cake and sunflower seed cake. After thoroughly mixing of all the ingredients, feeds were packed in 50 kg bags and were marked accordingly i.e. (T1–T5). Samples of formulated diets were taken to the laboratory for chemical analyses.

## 2.3 Birds, experimental design and management

Two hundred and sixty (260) day-old broiler chicks from Interchick Company were brooded together for one week. Brooding temperature was maintained at 35°C through provision of artificial heat from 200 watts electric bulbs and during this time chicks were offered the same diet (i.e. control diet). After one week, chicks were transferred to the rearing experimental units and were randomly allocated to the five dietary treatments, making 52 chicks per treatment. Each treatment was replicated four times and each replicate had 13 birds. After the 1$^{st}$ week all chicks were given their respective treatment diets (Table 1) throughout the experimental period. Broiler chicks were kept on deep litter floor system and rice husks were used as a litter material.

**Table 1.**Physical composition of the experimental diets (%)

| **Ingredient** | **Levels of copra meal in the diet (% as fed basis)** | | | | |
|---|---|---|---|---|---|
| | **T1** | **T2** | **T3** | **T4** | **T5** |
| Copra cake | 0 | 3 | 6 | 9 | 12 |
| Sunflower cake | 20 | 17 | 14 | 11 | 8.0 |
| Maize | 49 | 49 | 49 | 49 | 49 |
| Maize bran | 18.5 | 18.5 | 18.5 | 18.5 | 18.5 |
| Fishmeal | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| Blood meal | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Limestone | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 |
| Bone meal | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |

| | | | | | |
|---|---|---|---|---|---|
| Premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Salt | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| methionine | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| Total | 100 | 100 | 100 | 100 | 100 |
| Calculated CP % | 19.60 | 19.24 | 18.46 | 18.52 | 18.16 |
| Calculated Energy (ME) Kcal/kg | 2679.38 | 2690.42 | 2701.46 | 2712.50 | 2723.54 |

During the day, sunlight was used as a source of light while at night electrical bulbs were used to illuminate and provide heat to chicks throughout the experimental period. On the seventh day of age all chicks were vaccinated against Newcastle disease and this was repeated on the 21st day of age. Vaccination against Gumboro was done on the 14th day of age.

### 2.4 Experimental procedure and measuring parameters

The performance of broiler chicks was assessed using change in body weight (growth rate), feed intake and feed conversion ratio.

#### 2.4.1 Growth rate

Individual chicks were identified by placing a tag number on the wing. Initial weight of individual chicks was taken before the chicks were introduced to the brooding pen. Weighing of chicks was done on a weekly basis to determine the weekly weight of each bird.

Growth rate was calculated as follows:-

$$W = \frac{Wt2 - Wt1}{t2 - t1} \quad \text{.......................................................}(1)$$

Whereby:

W = average daily weight gain g/d (growth rate)

$Wt_1$ = Live weight at time $t_1$

$Wt_2$ = Live weight at time $t_2$

### 2.4.2 Feed intake and feed conversion ratio

The amount of feed offered and feed refusal in each pen (replicate) was weighed and recorded daily. Feed intake per pen was obtained by calculating the differences between the total weight of feed given and weight of feed refusal. Feed conversion ratio (FCR) was calculated to determine the efficiency of the diet by dividing the total feed intake with the total weight gain of all birds in each pen.

### 2.4.3 Carcass and non-carcass component

After seven weeks, three broiler chickens were randomly selected from each replicate for slaughter. Slaughter was done by cutting off the head at the head neck using a sharp knife. The slaughtered chickens were put in hot water at 70°C followed by removal of feathers. The feet were carefully cut off at the tibia femur joint, the abdomen was incised at mid ventral using a sharp knife and the entire gastro intestinal tract was removed. Edible organs (liver, heart, gizzard and spleen) were separated from the gut and weighed per group. The gizzard was longitudinally split so as to remove the contents and the inner membrane before weighing. The percentage of the component was calculated as weight of the component over the live weight as shown in the formula:

$$\%\ \text{weight of component} = \frac{\text{Weight of component}}{\text{Live weight}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

After removal of all internal organs the carcass weight of each chicken was measured.

Dressing out percentage was calculated as follows:

$$\text{Dressing}\ \% = \frac{\text{CW}}{\text{L W}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Whereby;

CW= carcass weight; LW= live weight.

### 2.4.4 Chemical analysis of feed stuff, dietary treatments

Samples of feed ingredients and experimental diets were analysed for their content of DM, CF, CP, EE, AA, ME, Ca and P according to AOAC [24].

### 2.4.5 Comparative cost of dietary treatment

Based on the current prices of the feed ingredients used in the formulation of the dietary treatments, economic analysis of the diets was determined. The cost in Tsh per gram carcass weight was calculated as input-output ratio and was compared between the dietary treatments. The following formulas were used to determine economic analyses of the experimental diets:

Gross Margin (GM) = Gross sale per bird – Total feed cost............................ (4)

Total feed cost per bird = Total feed intake per bird x unit price per kilogramme of treatment diet........................................................................................................ (5)

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross Margin}}{\text{Total feed cost per bird}} \quad \ldots\ldots\ldots\ldots\ldots (6)$$

## 2.5 Data processing

Collected data from each treatment were entered into the computer data base (excel sheet) ready for statistical analysis.

### 2.5.1 Statistical analysis

The obtained data were analysed using 2 models. Dietary treatments were an independent variable whereas weight gain, feed intake, FCR, carcass and non-carcasscomponents were dependent variables. The data were analyzed using the General Linear Model (GLM) procedure of Statistical Analysis System [25].The Statistical model1 used for analysis of growth carcass and non-carcass, whereas model 2 used for analysis of feed intake.

**Model 1:**

$Y_{ijk} = \mu + Ti + S_j + (TS)_{ij} + b\,(X_{1ijk} – X_2) + e_{ijk}$

Where; $Y_{ijk}$= Response variable (weight gain and carcass characteristics)

$\mu$ = General mean effect

$T_i$ = Effect due to the $i^{th}$ dietary treatment (I =1, 2, 3, 4, 5)

$S_j$ = Effect of $j^{th}$ sex on $i^{th}$ dietary treatment

$(TS)_{ij}$ = Interaction effect of sex and treatment

b = Regression coefficient of initial weight of bird on subsequent performance

$X_1ijk$ = Initial group mean weight

$X_2$ = Final group mean weight

$e_{ijk}$ = Random error

**Model 2:**

$Y_{ij} = \mu + T_i + P_j + e_{ij}$

Where; $Y_{ij}$= Measurement on the $j^{th}$ pen from $i^{th}$ treatment

$\mu$ = General mean effect

$T_i$= Effect of $i^{th}$ (dietary) treatment (*i* =1,2,3,4, 5)

$P_j$= Effect of $j^{th}$ pen from $i^{th}$ treatment

$e_{ij}$= Random error

## 3. RESULTS

### 3.1Chemical composition of experimental diets

The chemical composition of the experimental diets is presented in Table 2. No significant differences were observed for DM content in the diet. The result showed that as the inclusion level of CC increased in the diet percentage of DM, CP, EE and CF content slightly decreased. T1 was slightly higher in DM, CP, EE and CF content than T5. Energy level was similar between the dietary treatments with exception of a slightly higher level in T4. An increase in mineral content by about 40-50% was noted when CC was added to the diet. The effect of dietary treatment on amino acids was insignificant although a slight increase in lysine content with increasing level of CC was noted.

**Table 2.**Chemical composition on dry matter bases of dietary treatments

| Nutrients | Dietary treatments | | | | |
|---|---|---|---|---|---|
| | **T1** | **T2** | **T3** | **T4** | **T5** |
| DM (%) | 89.7 | 89.5 | 88.9 | 88.6 | 88.9 |
| CP (%) | 18.4 | 17.7 | 17.5 | 16.9 | 16.5 |
| EE (%) | 9.1 | 8.4 | 8.5 | 8.7 | 8.6 |
| CF (%) | 9.1 | 6.9 | 6.8 | 6.2 | 5.9 |
| ME (kcal/kg DM) | 3029 | 3019 | 3072 | 3115 | 3029 |
| Lysine (%) | 0.78 | 0.79 | 0.78 | 0.82 | 0.87 |
| Tryptophan (%) | 0.21 | 0.21 | 0.20 | 0.20 | 0.20 |
| Met/Cyst (%) | 0.72 | 0.68 | 0.66 | 0.63 | 0.67 |
| Ca (%) | 0.27 | 0.47 | 0.46 | 0.53 | 0.44 |
| P (%) | 0.26 | 0.50 | 0.50 | 0.52 | 0.49 |

*KEY: DM = Dry Matter; CP = Crude protein; EE = Ether extract; CF = Crude fibre; ME = Metabolizable energy; Met/Cyst = Methionine/ cystine; Ca = Calcium; P = Phosphorus.*

## 3.2Effect of dietary treatments on dry matter intake, feed conversion efficiency and feed conversion ratio

The least square means on weekly DM intake are presented in Table 3. An increase in DM intake with age was noted in all dietary treatments. Significant differences for DM intake were only observed in the 3rd and 4$^{th}$week of age where T1, T2, and T3 outperformed T4 and T5. A similar trend was noted for TDMI.

**Table 3.**Least square means on weekly Dry matter intake (g/bird)

| Age (wk) | **Dietary treatments** | | | | | **SEM** | **P-value** |
|---|---|---|---|---|---|---|---|
| | **T1** | **T2** | **T3** | **T4** | **T5** | | |
| 2 | 237.2 | 228.1 | 236.6 | 218.2 | 215.5 | 6.3 | 0.0912 |
| 3 | 388.9$^{a}$ | 394.9$^{a}$ | 384.7$^{a}$ | 319.9$^{b}$ | 332.1$^{b}$ | 9.8 | 0.0003 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | 542.1[a] | 535.5[a] | 533.9[a] | 484.7[b] | 490.1[b] | 14.4 | 0.0364 |
| 5 | 771.5 | 758.9 | 777.4 | 747.2 | 751.2 | 27.7 | 0.9230 |
| 6 | 893.5 | 1038.1 | 979.8 | 901.1 | 898.8 | 50.7 | 0.2348 |
| 7 | 923.6 | 968.9 | 943.1 | 683.6 | 882.6 | 89.8 | 0.2318 |
| T DM I (g/b) | 3756.9[a] | 3926.2[a] | 3855.5[a] | 3354.9[b] | 3665.5[b] | 122.6 | 0.0485 |

*[a,b]Least square means with different letter script within the same row are significantly different (P<0.05); .*

Feed conversion ratio (FCR) is an important indicator on how efficient a feed can be converted to meat. Feed Conversion Efficiency (FCE) and FCR of the experimental diet are shown in Table 4. The results showed significant differences (P<0.05) for FCR and FCE between the experimental diets. FCR was lowest in T4 and highest in T5 and T2. A similar trend was noted for DMI but FCE was highest in T4 and lowest in T5 and T2.

**Table 4.**Effect of dietary treatments on feed efficiency ratio and feed conversion ratio

| | **Dietary levels** | | | | | |
|---|---|---|---|---|---|---|
| **Parameters** | **T1** | **T2** | **T3** | **T4** | **T5** | **P-value** |
| Average daily gain (g/day) | 38.2±0.61[a] | 38.1±0.61[a] | 37.6±0.61[a] | 35.0±0.61[b] | 34.9±0.61[b] | <0.0001 |
| Mean DMI (g/day) | 76.7±2.66[a] | 80.1±2.66[a] | 78.7±2.66[a] | 68.5±2.66[b] | 72.9±2.66[ab] | 0.0545 |
| FCE (g gain/g DMI)*100 | 0.49±0.20 | 0.47±0.2 | 0.48±0.2 | 0.52±0.2 | 0.46±0.2 | 0.2637 |
| FCR (g DMI/kgBW) | 2.03±0.07 | 2.13±0.07 | 2.10±0.07 | 1.95±0.07 | 2.17±0.07 | 0.2252 |

*[a,b] Least square means within the same row with at least one common letter script do not differ significantly (p>0.05). FCE are in percentage*

### 3.3 Effect of dietary treatments on growth performance

Table 6 shows the least square means for cumulative weight gain of broiler chicken fed the experimental diets. The results showed that there were significant differences (P<0.05) in growth performance of broiler chicken among the dietary treatments. Cumulative weight gain was higher for T1 and lower for T5 throughout the experimental period. The inclusion level of copra cake resulted in decreased growth rate of broiler chickens.

The trend for live weight and weekly live weight gain are shown in Fig. 1 and Fig. 2. The result showed that live weight gain was highest in T1 and lowest in T5 throughout the experimental period and the differences were significant. Live weight in T2 and T3 was close to T1 from $4^{th}$ to $7^{th}$ week (Fig. 1). However, the rate of gain in T1 and T3 declined at the $6^{th}$ week (Fig. 2), and there were significant differences in live weight gain on the $7^{th}$ week of age.



**Table 5.**LSM means (+SEM) for cumulative weight gains in gram (g) of birds fed diets containing different level copra cake

| **Age** | **Experimental diet** | | | | | **P-value** |
|---|---|---|---|---|---|---|
| **(Weeks)** | **T1** | **T2** | **T3** | **T4** | **T5** | |
| 2 | 205.2± 4.3 | 197.8±4.2 | 193.1±4.3 | 190.5 ± 4.2 | 191.3 ± 4.1 | 0.0913 |
| 3 | 413.1 ±9.0$^{a}$ | 398.3 ±9.0$^{ab}$ | 385.0±9.1$^{b}$ | 358.2±9.0$^{c}$ | 359.2±8.8$^{c}$ | <0.0001 |
| 4 | 702.9±14.6$^{a}$ | 679.7±14.5$^{ab}$ | 653.0±14.7$^{b}$ | 604.7±14.5$^{c}$ | 601.3±14.2$^{c}$ | <0.0001 |
| 5 | 1118.5±22.6$^{a}$ | 1068.0±22.5$^{a}$ | 1060.7±22.9$^{a}$ | 971.2±22.5$^{b}$ | 965.9±22.1$^{b}$ | <0.0001 |
| 6 | 1515.7±26.9$^{a}$ | 1491.2±26.9$^{ab}$ | 1434.0±27.3$^{b}$ | 1347.4±26.9$^{c}$ | 1338.9±26.4$^{c}$ | <0.0001 |
| 7 | 1870.1±31.5$^{a}$ | 1851.2±31.4$^{a}$ | 1840.2±31.9$^{a}$ | 1720.1±31.4$^{b}$ | 1704.4±30.8$^{b}$ | 0.0001 |

*$^{a,b,c}$, Least square means with the same letter script within the same row do not differ significantly (p>0.05).*

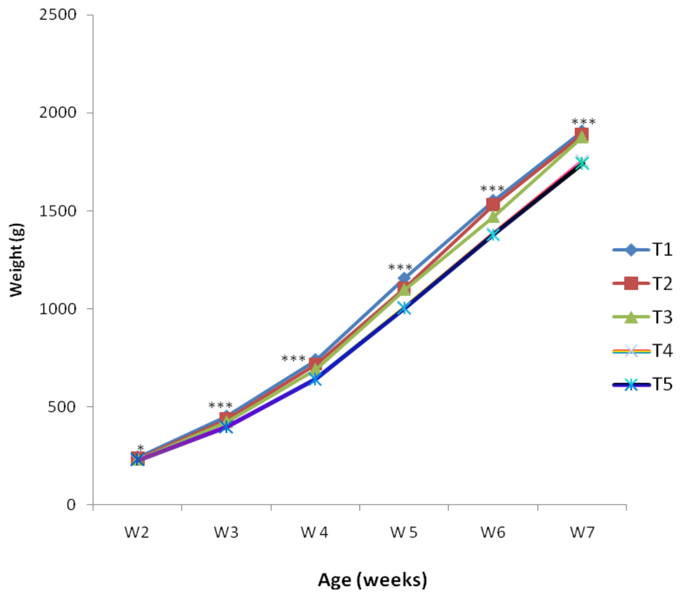


**Fig.1. Effect of dietary treatments on live weight**

*NOTE: *=p<0.05; ***= p<0.001*

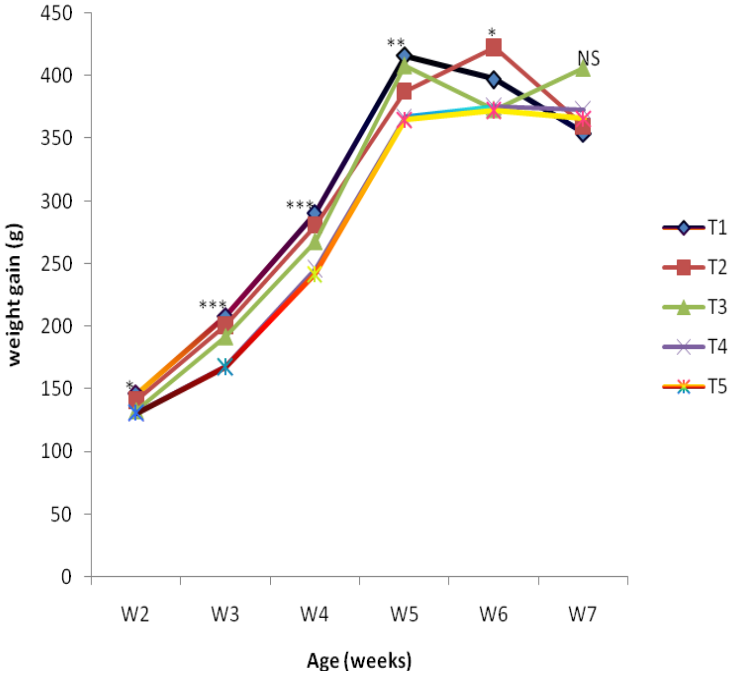


**Fig.2.Effect of dietary treatments on weekly live weight gain**

*NOTE: * = p<0.05; **=p<0.01; ***= p<0.001,*

## 3.4Effect of dietary treatments on carcass and non–carcass component of broiler chicken

Table 6 shows least square means for carcass and non-carcass component of broiler chickens fed diet containing different levels of copra cake. The inclusion of copra cake did not affect dressing percentage, carcass and non-carcass components i.e. gizzard, heart, spleen, wing, thigh, drumstick, breast, head and feet. However, a significant effect was only observed for the liver. Chicken in T4 had heavier liver compared to other treatments.

**Table 6.**Effect of dietary treatments on carcass and non-carcass components at 7 weeks of age

| Variables | Dietary treatment | | | | | P-value |
|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | |
| Final Live weight(g) | 1 908.6±31.5$^{a}$ | 1 889.7±31.4$^{a}$ | 1 778.7±31.9$^{b}$ | 1 758.4±31.4$^{b}$ | 1 742.9±3.1$^{b}$ | 0.0001 |
| Dressing (%) | 72.1±0.6 | 71.7±0.64 | 70.4±0.6 | 70.3±0.9 | 70.7±0.74 | 0.1964 |
| Carcass wt(g) | 1305.8±10.3 | 1300.2±11.7 | 1276.3±11.2 | 1275.1±16.3 | 1281.4±13.7 | 0.2035 |
| Head (%) | 2.1±0.1 | 2.2±0.1 | 2.1±0.1 | 2.0±0.1 | 2.1±0.1 | 0.2388 |
| Feet (%) | 3.6±0.2 | 3.9±0.2 | 3.7±0.2 | 3.3±0.2 | 3.7±0.2 | 0.5406 |
| Gizzard (%) | 2.4±0.1 | 2.4±0.2 | 2.3±0.2 | 2.4±0.2 | 2.3±0.2 | 0.8424 |
| Liver (%) | 1.8±0.1$^{bc}$ | 1.7±0.1$^{c}$ | 1.8±0.1$^{bc}$ | 2.4±0.1$^{a}$ | 2.0±0.1$^{ab}$ | 0.0008 |
| Heart (%) | 0.4±0.0 | 0.4±0.0 | 0.4±0.0 | 0.4±0.0 | 0.4±0.0 | 0.5248 |
| Spleen (%) | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.1±0.0 | 0.6940 |
| Wing (%) | 7.2±0.2 | 7.1±0.2 | 7.0±0.2 | 7.1±0.2 | 7.0±0.2 | 0.8616 |
| Thigh (%) | 9.6±0.2 | 9.6±0.2 | 9.5±0.2 | 8.5±0.3 | 9.4±0.3 | 0.1201 |
| Breast (%) | 19.7±0.6 | 19.1±0.7 | 18.5±0.6 | 19.8±0.9 | 18.6±0.8 | 0.6339 |
| Drumstick (%) | 11.9±0.5 | 11.4±0.5 | 11.0±0.5 | 10.6±0.7 | 11.3±0.6 | 0.5035 |

*[a,b,c]. Least square mean within the same row with at least one common letter script do not differ significantly (p>0.05).*

*NOTE: Values are expressed as a percentage of live weight.*

3.5 Comparative cost of dietary treatments

The cost for the experimental diets is shown in Table 7. The present study showed that the feed cost per kilogram of broiler meat was highest in T2 and lowest in T4. When cost was related to return of the marketable carcass weight it was noted that gross margins and BCR was highest in T4 and lowest in T3 (Table 7).

**Table 7.**Comparative cost of dietary treatments per unit carcass weight

| **Cost item** | **Dietary treatment** | | | | |
|---|---|---|---|---|---|
| | **T1** | **T2** | **T3** | **T4** | **T5** |
| Days to slaughter | 49 | 49 | 49 | 49 | 49 |
| Average carcass weight/bird(g) | 1305.8 | 1300.2 | 1276.2 | 1275.1 | 1281.4 |
| Price of feed /50kgs (Tsh) | 34783.7 | 34708.7 | 34633.7 | 34558.7 | 34483.7 |
| Total feed consumed /bird (kg) | 4.19 | 4.39 | 4.34 | 3.79 | 4.12 |
| Cost of feed /kg (Tsh) | 695.6 | 694.1 | 692.6 | 691.1 | 689.6 |
| Total feed cost/bird (Tsh) | 2914.9 | 3047.4 | 3006.2 | 2619.5 | 2841.4 |
| Price for broiler-1500g (Tsh/g) | 4 | 4 | 4 | 4 | 4 |
| Gross sale per bird (Tsh) | 5223.2 | 5200.8 | 5105.1 | 5100.4 | 5125.8 |
| Gross margin per bird (Tsh) | 2308.3 | 2153.3 | 2098.8 | 2480.8 | 2284.3 |
| Benefit cost ratio | 0.79 | 0.70 | 0.69 | 0.94 | 0.80 |

## 4. DISCUSSION

### 4.1 Chemical composition of feed ingredients

The chemical compositions of the feed ingredients used in the present study were within the range reported in other studies [3, 4, 13].However, most of the chemical components in copra cake meal i.e. DM, CP, CF, ASH, EE, and ME were higher than the values reported by Wallace et al.[26]and Dairo and Fayusi [27]. Similarly, the chemical composition of the sunflower seed cake with the exception of CF (27.2%) was higher than those reported by Laswaiet al. [28] CP was lower than the values reported by Moorthy and Viswanathan[16].The variations in nutrient composition of the feed ingredients might be due to differences in varieties, growing conditions and methods used for the extraction of oil as reported by Ramachandranet al.[29].

Oil is extracted from seeds or fruits by either pressing (mechanical method) or with using solvents (chemical). The mechanical method involves high temperature during oil extraction process compared to solvent extraction process which involves low temperature. High temperature may lead to nutrient losses or destruction especially vitamins and amino acids e.g. lysine and sulphur. These nutrient losses consequently lead to low nutritive values of oil cakes/oil meals [30].Thus, oil meal such as copra meal, resulting from solvent extraction have very low fat content and higher protein compared to a similar product obtained by the screw expeller process(mechanical process)[16, 20].The copra and sunflower seed cake meal used in the present study were by-products of mechanical extraction.

### 4.2 Chemical composition of experimental diets

The chemical composition of the dietary treatments was mostly a reflection of feed ingredients used. The experimental diets were initially intended to contain about 18 to 19.6% CP (Table 1). The higher energy level in T4 compared to the other dietary treatments was unexpected and the reason for this observation is unclear. However, the range of energy content in experimental diets was similar to that reported by Hatta and Sundu[31].Chemical analysis of the experimental diets (Table 2) showed that the target was not totally achieved in CP level due to variation of the actual and estimated/calculated nutritive value of the feedstuffs used. As stated in the methodology section all feed ingredients were purchased and compounded in feed mill company. The differences between the calculated and the actual values were a reflection of the variation which exists in feed composition and improper sampling when taking sample for laboratory analysis. Additionally, various studies stated that the variation of nutritive value of feed ingredients could be due to location, plant breed, soil fertility, stage of maturity, agronomic practices and efficiency of processing method [28, 32].

The observed low CP content of the feeds in this study has been documented in other research as well. This serves as an indicator that there is a lack of accessible high-quality protein sources for formulating broiler diets in the majority of tropical countries [33]. Nevertheless, low protein diets (18-16%) can support growth performance equal to high protein diets when highly digestible ingredients are used [33].The study of Rostagnoet al.[34]and Azarniket al.[35]concluded that protein level had no significant effect on performance of broiler hence supplementation of amino acid in low CP diets can partially correct the depression of growth performance.

The CF of T1 was higher (9.1%) compared to other experimental diets. This difference was probably due to the high fibre content found in sunflower seedcake; since the inclusion level of sunflower seedcake in T1 was high (20%) (Table 1). The CF and EE levels of the experimental diets were higher than that recommended for the broiler diet i.e. 3-4% CF and 3-5% EE [4].High CF and EE may result to increased bulkiness and high energy content of the diets which might affect palatability and feed intake.Calcium levels were lower than the recommended value of broiler diets probably due to low levels of calcium in the feedstuffs used. Low calcium content in broiler diets in most cases may result into leg problems although, these conditions were not observed in the current study.

### 4.3 Effect of dietary treatments on dry matter intake, feed efficiency and feed conversion ratio

Chickens in T4 had significantly lower feed intake than those in other treatments. This was probably due to the high energy content and low methionine in T4 (3114.5 kcal/kg DM) compared to other treatments.

Poultry are known to be sensitive to energy concentration in the diets [21, 36].The major dietary factor affecting feed intake is the concentration of energy in the diet. Recommended energy intake for broiler is about 3000 kcal/kg [4]. Therefore, if the energy concentration in the diet is increased without changing the concentration of other nutrients the birds will normally tend to eat less hence a drop in the intake of other nutrients. The insignificant differences between the dietary treatments after the fourth week of age, was probably an indication that the effect of CC on feed intake was less obvious in older chickens. Similar findings were observed by Sunduet al.[37, 38] who associated the decline in feed intake when CC was increased in the diet, probably due to its high water holding capacity and bulkiness. This effect is high in young animals and low in older birds. The decline in intake during the seventh week of the experiment (Table 3) probably resulted from drastic changes in climatic conditions i.e. rise in ambient temperatures which in most cases leads to decreases in feed intake and increased water consumption. Towards the end of the experimental period the ambient temperature was between 29-30°C. Temperature has a big influence on feed intake. Low temperatures stimulate feed intake whereas, high temperatures (> 28°C) limit the voluntary feed intake [4].

The present study showed that, T4 had lowest FCR and lowest FCE probably due to low feed intake. Values for FCR mainly depend on two factors, the growth rate and feed intake and both are mostly affected by the quality of the diet. High FCR is obtained when feed intake is high and growth rate is low as would happen with an unbalanced diet [39].The study of Magalaet al.[40] observed that higher dietary energy with low protein results into slow growth of the chicken and hence decreased weight gain. This is probably due to a decrease in intake of other nutrients such as amino acids which are essential for growth in broiler chickens. The normal range of FCR for broiler is 2 but, this value depends on many factors, including age of birds, feed quality and duration of lighting [41].Therefore, FCR obtained in this study was within the expected range.

### 4.4 Effect of dietary treatments on growth performance

The mean live weight of 1.7-1.9 kg/bird at 7 weeks observed in the present experiment was lower than 2.13 kg reported by Khanongnuchet al.[42].The low weight in the present study was a reflection of low

CP and amino acids in the experimental diets and somehow high environmental temperatures. Reduction of cumulative weight gain was probably due to decreased feed intake as already shown in Table 3. A decrease in feed intake consequently decreases the amount of nutrients ingested and this leads to decreased growth and body weight. Physical properties of copra cake like bulkiness, low calorific value, water holding capacity and the presence of anti-nutritional factor NSP may contribute to the poor performance of broiler chickens fed diets containing this feed ingredient [37, 38, 43].

The non-significant differences for live weight gain observed on the 7$^{th}$ week (Fig. 2) indicated that the effect of CC is less apparent in older birds compared to the young chicks. Similar finding were reported bySunduet al.[37]and Bastoset al.[44] who observed that, effect of CC is small in older animals due to a gradual increase in feed intake and growth. A decline of weight gain after the 6$^{th}$ week (Fig. 2) was due to low feed intake which was caused by change of climatic conditions (rising of temperature) but also, a reflection of the growth pattern of broiler birds. Chicken growth is described as a sigmoid curve with an initial exponential development phase, an intermediate or transitory phase, and a final phase of inhibited growth that consists of a gradual reduction in the growth rate following an asymptotic increase in the BW [45]. Characteristically young chicken and most young animals require high concentration of nutrients in the diet during the early stages of growth so as to support multiplication of tissues and maintenance. The demand of nutrients declines towards attainment of maximum growth; consequently the demand of nutrients for growth decreases[46]. Therefore, when the maximum growth of broiler is attained the feed /nutrients are mainly used for body maintenance only or fat deposition.

### 4.5 Effect of dietary treatments on carcass and non–carcass component of broiler chickens

The dressing percentage of between 70 and 72% (Table 6) was within the expected levels for broilers. The insignificant differences in dressing percentage between treatments observed in this study were probably due to similar levels of amino acids in the experimental diets. The effect of dietary treatments on liver weight was not consistent although the liver in T4 and T5 were heavier than in the other treatments. Increased liver weight was probably due to increased energy to protein ratio (ME:CP) of the experimental diets. Similar findings were reported by Hosseiniet al. [47] when comparing growth performance and carcass characteristics of broiler chicken fed diets with various energy and constant energy to protein ratio. Additionally, Mushiet al.[48] found that higher supplementation of concentrate resulted to increased percentage of liver weight in goats due to higher accumulation of glycogen, which binds water and fat in liver. The significant effect for dietary treatments and sex interaction for the liver observed whereby, male liver had more weight than female liver could have a reflection of heavier body weight of male birds [49]. The weights of the liver in present study for all treatments were within the normal range.

### 4.6 Comparative cost of dietary treatments

Feed cost represents the major part of poultry meat production. Reduction of feed cost without affecting broiler growth performance and carcass yield will increase the profitability of enterprise. In the present study feed cost, gross margin and cost benefit ratio per unit carcass weight, were used to measure the economic efficiency of broiler production as influenced by dietary level of copra cake and sunflower seed cake meals.  The results showed that the inclusion of copra cake in the diet reduced feed cost/bird due to the relatively cheaper price of the feed and therefore increasing benefit cost ratio per bird. So in this study, the broiler chicken on T4 (Diet with copra cake substituting 45% of sunflower seed cake inclusion) gave the highest gross margin and benefit cost ratio (BCR) when the saleable price of chicken was per unit carcass weight. The profit and BCR on feed cost analysis indicated that the copra cake was cost effective at 45% of sunflower inclusion. Nworgu[50] and Zamanet al.[51] observed that, BCR might be used as a measure of assessing profitability and they pointed out that the treatment that expressed higher BCR were more profitable to the farm enterprise. Therefore, it can be concluded that, the use of copra cake at 45% of replacing sunflower seed cake inclusion had a good economic benefit as a feed ingredient for broiler chicken production.

## 5. CONCLUSIONS

i. The increase of copra cake level in broiler diets moderately decreased the final live weight and feed intake while feed conversion efficiency increased.

ii. Inclusion level of copra cake had no effect on carcass yield and carcass components as percentage of live weight except for the liver.

iii. Incorporation of CC at 45% of sunflower seedcake replacement in broiler diets (equivalent to 9% inclusion level of copra cake in the diet) was more profitable since the returns per unit cost expenditure were higher by 1.29 Tshs. However, total weight gains per bird were slightly lower at that inclusion level. Above and below 45% copra cake inclusion produced low returns per unit cost expenditure.

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