ORIGINAL ARTICLE

Effect of feeding cactus (*Opuntia ficus indica*) fruit meal as a partial replacement of maize on feed intake, growth performance and carcass characteristics of Cobb 500 broiler chickens

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ABSTRACT

A study was conducted to investigate the effect of feeding cactus (*Opuntia ficus indica*) fruit meal as a partial replacement of maize on perormance of Cobb 500 breed of broilers.A total of 160, 18- days old unsexed chicks with equal mean weight were randomly assigned to 4 treatment diets in completely randomized desgn with 4 replicats. The tratments contained 0% CFM (Cactus Fruit Meal)(T_1), 2.25% CFM (T_2), 4.5% CFM (T_3) and 6.75% CFM (T_4) as replacement of maize.. At the end of the experiment, one male and one female chick per replicate were slaughtered to evaluate carcass characteristics. The results obtained showed that there were no significant differences ($P>0.05$) between all the treatments in dry matter intakes. The intake of ash, crude protein, ether extract and crude fiber increased but, metabolizable energy decreased ($P<0.05$) with increasing levels of CFM in the diet. The daily weight gain significantely increased ($P<0.05$) with increasing levels of CFM. Weight at slaughter, drumstick, thigh, commercial carcass and total edible weight of male chicks were heavier ($P<0.05$) than the female counter parts whereas there was no significant difference between sexes in other edible carcasses. The wing weight for T1 was higher ($P<0.05$) than that of T2 while T3 and T4 had a similar value. The drumstick weight for T4 and T1 was greater ($P<0.05$) than that of T2. The thigh weight for T4 was higher ($P<0.05$) than that of T2. T2 had lower ($P<0.05$) dressing percentage than that of T1. There was no significant difference in other non edible carcasses. Hence, cactus fruit meal could be used as alternative source of energy in areas where maize is scarce and unavailable for feeding Cobb 500 broiler chickens (see the comment on separate page).

Keywords: *Opuntia ficus-indica*, growth performance, feed intake, carcass characteristics, *nutrient intake*

INTRODUCTION

Poultry production has important role due to the short production season, quick turn over on investment and a source of high biological protein value products. Especially, broiler chickens production has an integral part to achieving sustainable and rapid production of high quality protein to meet up the increasing demand of the developing countries (Raja *et al*., 2014). Poultry meat is highly desirable, palatable, digestible, relatively low fat content and, nutritious for all ages. In Ethiopia poultry population is estimated to be 56.87million. With regard to breed 95.86 percent, 2.79 percent and 1.35 percent of the total poultry are reported to be indigenous, hybrid and exotic, respectively (CSA, 2015). Fisseha *et al*. (2010) stated that chicken are a source of food and income in Ethiopia and also one way of improving the livelihood of the poor household. Traditional poultry production system is the vital source of national output of poultry meat and eggs.

Mahmoudnia *et al.* (2012) reported that broiler production has increased rapidly in tropical and subtropical regions in the past and sustained growth are forecast for the future. Feed cost is crucial factor in determining the economic success of broiler production. The major sources of energy in poultry diets in the tropics are cereal grains especially maize due to its high content of energy (Tadelle *et al*., 2002). However, there is a dynamic increment in cost of cereal grains and human competition impose a challenge on economic viability and overall sustainability of the present poultry production system as well as limited access to land for production of maize for poultry feed (Shapiro *et al*.,2015). Beside this, Millions of people in Africa, particularly in Ethiopia depend on maize for their daily food (Enyisi *et al*., 2014; Mandefro *et al*., 2002).

Hunduma *et al*. (2010) stated that in commercial poultry production system feed expense accounts for about 60% of the total cost of production but in village poultry production system it is difficult to calculate. The study by (Fisseha *et al*., 2010; Shapiro *et al*., 2015) showed that feed shortage is one of the biggest challenges to the development of the poultry sub-sector in Ethiopia.

Currently energy feeds are the most expensive part of feedstuffs for monogastrics and huge amounts of cereal grains are used for this purpose throughout the world. Because of this it is difficult to access at small scale and household level (Adugna Tolera, 2008). For this reason lower energy value feeds are used in ration formulation. Therefore, there is a need to find alternative energy feed sources which the farmers can get with a reasonable cost and available at household level. One of such feeds is cactus (*Opuntia ficus indica*) fruit. Cactus fruit is source of human food, forage, raw material for industrial products (cosmetic product, medicine and the like), as live fence and soil conservation purposes (Mitiku *et al*., 2002; Nefzaoui, *et al*., 2010). The fruit of cactus is moderate in crude protein (CP) content (12.5-25% of DM) low in phosphorus, high in fiber and ash. Cactus cladodes and fruit are highly digestible source of energy (Firew Tegegne, 2001; Firew *et al*., 2007; Hernández-Urbiola *et al*., 2011; Chiteva and Wairagu, 2013).

Cactus is a'Bridge of life' for dry areas because it's multi- purpose tree and efficiently converts water into biomass. Cactus is the most widespread of the long-domesticated plant (Saenz, 2000). Maize and cactus have been reported to contain similar energy values. Maize has 14.2MJ/kg of metabolisable energy value while cactus fruit has 14.95MJ/kg of metabolisable energy value (Firew Tegegne, 2001; McDonald, 2010). Maize contains carbohydrate (starch) similar with cactus (*Opuntia ficus indica*) fruit. However, maize is not available unlike cactus in the arid and semi-arid area as well as during the rainy season. Research results indicates that cactus is acceptable, palatable, rich source of carbohydrate and calcium for sheep for better growth performance (Firew *et al*., 2005, 2007; Aliyu and Mustapha, 2007). However, there is little research carried out on cactus fruit as poultry feed as a partial replacement to maize. The objective of this research was to assess the effect of feeding cactus fruit meal as a partial replacement of maize on feed intake, growth performance and carcass characteristics of Cobb 500 broiler chickens.

MATERIALS AND METHODS

The study area

The study was conducted at Agarfa Agricultural and Technical, Vocational and Educational Training (ATVET) College poultry farm, which is found in Bale zone of the Oromia Regional State. Agarfa ATVET College falls at 7$0^{0}$17'N Latitude and 39^{0}49'E Longitude. Agarfa ATVET College is located at 458 km south east of Addis Ababa. The minimum and maximum temperature is 10^{o}Cand 25^{o}C, respectively. The average annual rainfall is 800ml whereas 400ml and 1200ml is the minimum and maximum annual rainfall recorded in the area, respectively (ABoFED, 2009).

Cactus fruit meal preparation

The fruit parts of cactus were used in the experiment as partial replacement of maize in broiler chicken ration. The whole fruits of cactus were collected, in March 2015 G.C from Agarfa ATVET College and the surrounding area. They were chopped in small pieces and were spread on plastic sheet, and dried with sun light for two weeks. Turning was carried out two-three times a day to prevent mold growth. Then after, the fruits were ground with mortar and pestle finally sieved to produce Cactus Fruit Meal (CFM). (See the comment given on separate page)

Laboratory Chemical Analysis (See the comment given on separate page)Representitive samples of the feed ingredients, the treatment rations and refusal feed were dried in an oven at 60^{o}C for 48 hours and ground to pass through 1mm mesh screen and stored in air tight bags until used for laboratory chemical analysis. Dry matter, ether extract, crude fiber and total ash were determined following the methods of AOAC (1995). Nitrogen was analysed using kjeldahl method. Crude protein was obtained by multiplying the N concentration by 6.25. Metabolizable energy (ME) of the experimental diets was calculated by indirect method according to Wiseman (1987) as follows: ME (kcal/kg DM) = 3951+54.4EE-88.7CF-40.80Ash. All the samples were analyzed in duplicates at Animal Nutrition Laboratory of Hawassa University. Experimental diets formulation The dietary ingredients were composed of noug cake (*Guizotia abyssinica*), maize (white), wheat bran, soybean seed (roasted), cactus fruit meal (CFM), lime-stone, dicalcium phosphate (DCP), common salt, vitamin premix, lysine and methionine. All ingredients except CFM were obtained from Goba-Robe and Addis Ababa. The soybean seed was roasted for 5 minutes (to deactivate trypsin inhibitor) prior to inclusion. Each ingredient was ground separately using feed miller machine before mixing. Finally 4 treatment rations shown in Table 1 were formulated based on the result of the laboratory analytical data.During the formulation attempts were made to make the treatment iso-nitrogenous and iso-caloric and contained mean crude protein of -----% and mean metabolizable emergy of Cactus fruit meal was included into the treatment rations to replace about 0, 2.25, 4.5 and 6.75% of maize as shown in Table 1.

Table 1: Composition of the treatment rations used in the current study

Feed ingredients	Treatments			
	Control (T1)	T2	T3	T4
Maize	45.0	42.75	40.50	38.25
Nougseed cake	4.40	4.40	4.40	4.40
Wheat bran	18.0	18.0	18.0	18.0
Soya bean	28.0	28.0	28.0	28.0
Cactus fruit meal	0.0	2.25	4.50	6.75
Limestone	2.0	2.0	2.00	2.00
Salt	0.50	0.50	0.50	0.50
Vitamin premix	0.50	0.50	0.50	0.50
Lysine	0.90	0.90	0.90	0.90
Methionine	0.70	0.70	0.70	0.70
Total	100	100	100	100
CP%	17.50	18.47	19.0	20.46
ME/kcal/kg	3427	3395	3363	3337

According to NRC (1994) the standard requirements of energy in a ration of broilers chickens is as follows 3,200 kcal ME/kg and crude protein 23% for a 1-21 day old chick and 20% for 21-42 days.

Managment of the Experimental Chicken

(A total of 250 day-old unsexed Cobb 500 broiler chicks were purchased from Alema private limited company, Debrezeit. The chicks were reared under brooder for two weeks and placed on commercial starter rations. At the end of the two weeks, 160 chicks with similar body weight were randomly selected, leg tagged, weighed individually on a digital balance. These were randomely divided into 16 groups with 10 chicks each. Each group were transferred to an experimental pen with 1.5 m x 1.5 m wire mesh partitioned pens. Each pen was cleaned & disinfected in advance of the arrival of chicks. The floor was covered with wood shavings of 4-5cm deep. The houses were well equipped with feeder and waterer. . All chicks were vaccinated against Marek's disease, Newcastle disease, and Gumboro (IBDV) as recommended. Anticoccidiostat (20-40 g/100 l of water), oxytetracycline (20 g/100 l of water) and multivitamin tablets were given with drinking water when clinical symptoms were observed. All the remaining routine management activities were carried out following standard procedures. Finally the four treatment rations shown in Table 1, were randomely allocated to the expermental chicks in completely randimized design with 4 replicates for a feeding periog of 42 days.

The experimental feed was offered twice a day 8:30 am and 5:30 pm throughout the experimental period. The amount of feed offered was increased by 10% than previous day intake. At the morning of every day feed left over was measured to calculate feed consumed uring the day. Water was provided *ad-ibitum.* Feed intake was calculated from the difference between the feed offered and refusal. Body weights of the individual chicks were recorded using electronic digital balance at weekly intervals through out the study period. Feed conversion was calculated as the ratio between feed consumed and body weight gain during the experimental period (gram feed consume/gram weight gain). Body weight gain was estimated as the difference between the final and initial weight during the trial.

Evaluation of carcass characteristics

At the end of the experiment period, two chicks (one male + one female) which are close to mean live weight were selected from each replicate. These chicks were slaughtered manually to evaluate the carcass characteristics. The chicks were starved of feed overnight before slaughter. Chicks were slaughtered by severing the jugular vein, allowed to bleed completely, plucked manually and weighed to determine blood and feather weight. After defeathering they were, eviscerated and cut up using the standard procedures to assess the different carcass parts. The individual parts and organs were weighed using a digital electronic balance and recorded. Data on pre-slaughter live weight, weight of blood, weight of shank, neck, head, breast meat, drumstick, thigh, digestive tract, wing, gastrointestinal and reproductive organs, the visceral organs including heart, kidneys, spleen, lungs, and liver weight were recorded. Morphological characteristics such as intestinal length were recorded by measuring tape. Total non-edible carcass (TNE) included feathers, blood, head, shank and claw, esophagus, crop, proventiculus, spleen, pancreas, kidneys, heart, lungs, intestines, gonad, cloacae, and abdominal fat. The edible carcass weight was determined by summation of back, wing, neck, drumsticks, thighs, wings and breast including skin, gizzard and liver. Dressing percentage was calculated using the following formula:

$$\text{Dressing \%} = \frac{\text{Carcass weight}}{\text{Slaughter weight}} \times 100$$

Statistical data analysis

Data collected from the experiment was subjected to Analysis of variance, using SAS 2004, version 9.1. Significant levels of differences among means were determined by using the Duncan Multiple range test.

The following model was used:

Yij=μ+Ti+Eij; Where Yij=individual values of the dependant variables in the experiment; μ=over all mean of response variable; Ti=the effect of treatment;

Eij=random error

Whereas, the effect of Cactus fruit as partial replacement of maize on carcass traits was analyzed by using two ways ANOVA. The following model was used for the analysis:

Yijk = μ + Ti + Tj + Eijk; Where, Yijk = individual value of the dependant variable; μ = overall mean of response variable; Ti = the effect of i^{th} treatment in the response variable; Tj= effect of sex; Ti*j= treatment by sex; Eijk = random error in the response of individual chicks

RESULTS

Chemical composition of experimental diets and feed ingredients

Nutrients composition and calculated metabolizable energy (ME) values of feed ingredients and treatment diets are presented in Table 2. The ME content of cactus fruit meal (CFM) was low compared to the other ingredients.

Table 2. Chemical composition of feed ingredients and treatment rations used in the experiment (See comments given on sepatate page)

Feed ingredients	Nutrients						
	DM %	Ash	CP	EE	CF	NFE	ME (kcal/kg DM)
CFM	96.2	15.4	10.6	7.5	19.2	43.5	2027.6
Maize	96.6	1.4	9.6	5.3	5.2	75.1	3720.9
Soybean (roasted)	97.2	3.1	33.1	12.8	7.6	40.6	3846.0
Nougseed cake	96.8	3.8	32.2	11.3	20.2	29.3	2618.9
Wheat bran	97.6	4.4	15.6	8.7	7.6	61.3	3570.6
Starter ration	97.5	7.3	22.4	5.9	6.0	55.85	3442.0
T1	93.5	6.4	17.5	4.32	5.65	59.61	3427.0
T2	93.9	7.0	18.47	4.41	5.75	58.37	3395.0
T3	93.3	7.5	19.0	4.56	6.0	56.28	3363.0
T4	93.8	7.8	20.46	4.68	6.2	54.65	3337.0

NFE = DM-(CP+EE+CF+Ash), DM = dry matter; CP = crude protein; EE = ether extract; CF = crude fiber; NFE = nitrogen free extract; ME = metabolizable energy; CFM = cactus fruit meal; T1 = diets without cactus fruit meal; T2 = diets containing 2.25% of cactus fruit meal; T3 = diets containing 4.5% of cactus fruit meal; T4 = diets containing 6.75% of cactus fruit meal as a replacement to maize.

The crude protein, ash, and crude fiber levels showed a slight increase as the inclusion rate of cactus fruit meal increased. Metabolizable energy was slightly higher for T1 and lower for T4 whereas T2 and T3 were in between.

Nitrogen free extract (NFE) values decreased with an increase in CFM level.

Nutrient and energy intakes

The nutrient and metabolizable energy intakes of the experimental chicks are presented in Table 3. There were no significant (P>0.05) difference between all the treatments groups in DM intake. The intake of ash, CP, EE, and CF showed proportional increase with the increased levels of CFM in the diet.

Table, 3. Nutrient (g/head/day) and metabolizable energy (kcal/head/day) intakes of the experimental chicks fed the treatment rations (see the comments given on sepaate page)

Nutrients	Treatments					
	T1	T2	T3	T4	SEM	P
Dry matter	123.40	123.53	123.98	123.58	0.36	NS
Ash	7.99[a]	9.35[b]	9.89[c]	10.45[d]	0.23	*
Crude protein	23.42[a]	24.69[b]	25.51[c]	26.91[d]	0.32	*
Ether extract	5.77[a]	5.92[b]	6.05[c]	6.19[d]	0.04	*
Metabolizable energy	3343.80[d]	3227.40[c]	3162.70[b]	3122.00[a]	21.65	*

[a, b, c ,d] Means within the same row bearing different superscript letters are significantly different (p<005) *; T1 = diets without cactus fruit meal; T2 = diets containing2.25% of cactus fruit meal; T3 = diets containing 4.5% of cactus fruit meal; T4 = diets containing 6.75% of cactus fruit meal; SEM = standard error of the mean.

Growth performance of the experimental chicks (see the separate comments)

The average final body weight, daily body weight gain, feed conversion ratio of the experimental chicks are presented in Table 4. The daily weight gain significantly increased (P<0.05) with increasing levels of CFM.

Table, 4. Growth performance of the experimental chicks fed the treatment diets (See the comments given on separate page

Parameters	Treatments					
	T1	T2	T3	T4	SEM	P
Initial body weight (g/h)	242	243	242	242	1.83	NS
Final body weight (g/h)	1779^{a}	1797^{b}	1824^{c}	1847^{d}	8.49	*
Total weight gain (g/h)	1537^{a}	1554^{b}	1582^{c}	1604^{d}	8.23	*
Daily weight gain (g/h)	36.6^{a}	37.0^{b}	37.7^{c}	38.2^{d}	0.19	*
Feed conversion ratio	3.41^{c}	3.32^{b}	3.26^{b}	3.19^{a}	0.03	*

^{a,b,cd} Means within the same row bearing different superscript letters are significantly different p * ($p<0.05$),T1 = diets without cactus fruit meal as partial replacement to maize; T2 = diets containing2.25% of cactus fruit meal; T3 = diets containing 4.5% of cactus fruit meal; T4 = diets containing 6.75% of cactus fruit meal; SEM = standard error of the mean

The results indicated that both male and female birds showed a significant ($p<0.05$) increase in body weight at a higher rate throughout the study (Figure 1). However, the males showed better body weight gain as compared to the females.

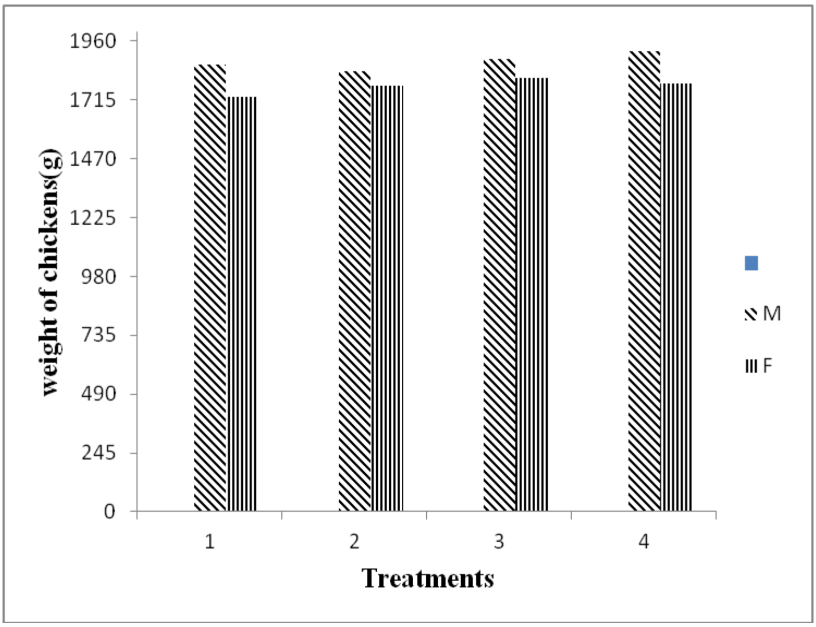

Figure 1 . Comparative growth performance of male and female experimental chicks fed on the treatments (There is no figure1, See the separate comments).

Carcass Characteristics of experimental chiks

The results of commercial carcass characteristics of the experimental chicks placed on the treatment rations are shown in Table 5. Weight at slaughter, drumstick, thigh, breast muscle, commercial carcass and total edible weight of male chicks were significantely heavier (P<0.05) than the female counter parts whereas there was no significant difference between sexes in the other edible carcasses. The wing weight of the treatment groups fed on T1 was significantely higher (P<0.05) than those fed on T2 while the treatment groups fed on T3 and T4 had comparable wing weight. The drumstick weight of the group fed on T4 and T1 was greater (P<0.05) than those fed on T2. The thigh weight of the groups fed on T4 was higher than those fed on T2. The treatment groups fed on T2 had lower (P<0.05) dressing percentage than those fed on T1.

Table 5: Edible commercial carcass characteristics of the experimental chicks fed on the tretment containing different levels of CFM (See separate comments)

Carcass characteristics (g)	Sex		Treatments				SEM	P
	M	F	T1	T2	T3	T4		
Slaughter weight	2063.0^{b}	1806.8^{a}	1917.7	1855.9	1967.5	1998.7	83.0	NS
Neck	48.0	44.5	42.8	45.2	47.3	50.3	2.7	NS
Wing	73.0	67.4	74.3^{b}	63.6^{a}	72.0^{ab}	70.9^{ab}	3.0	*
Drumstick	187.8^{b}	158.9^{a}	183.3^{b}	156.7^{a}	170.2^{ab}	183.3^{b}	8.0	*
Thigh	204.9^{b}	176.4^{a}	198.3^{ab}	171.2^{a}	191.6^{ab}	201.5^{b}	9.2	*
Breast muscle	339.4^{b}	300.7^{a}	321.8	298.3	327.9	332.3	17.9	NS
Breastbone	172.0	158.8	162.8	160.6	177.8	160.4	9.2	NS
Backbone	162.2	144.3	153.9	153.2	149.4	156.7	8.5	NS
Liver	54.0	46.0	47.9	43.3	54.7	54.4	3.8	NS
Gizzard	41.6	39.9	41.8	36.3	39.9	45.1	3.1	NS
Skin	122.0	114.7	118.5	111.3	129.7	114.3	8.8	NS
Edible offal	217.7	200.9	208.3	190.8	224.4	213.8	12.5	NS
Commercial carcass	1187.8^{b}	1051.1^{a}	1137.4	1048.8	1136.4	1155.4	51.6	NS
Dressing percentage	68.1	69.3	70.1^{b}	66.8^{a}	69.2^{ab}	68.5^{ab}	0.8	*
Carcass weight	1405.5^{b}	1252.3^{a}	1345.6	1239.6	1360.7	1369.2	61.8	NS

$^{a,\ b\ ,c\ ,d}$ Row means within the same category with different superscripts letters are significantly different p * (p<0.05),NS =Non significant; T1 = diets without cactus fruit meal; T2 = diets containing2.25% of cactus fruit meal; T3 = diets containing 4.5% of cactus fruit meal; T4 = diets containing 6.75% of cactus fruit meal; SEM = Standard error of the mean; DP% =Dressing percentage; Edible offal = (skin, gizzard and liver), Carcass weight = (commercial carcass + edible offal), Dressing percentage = (Weight of carcass/slaughter weight)*100.

DISCUSSIONS

Nutrient and energy contents of the experimental diets

The CP content of CFM (10.57%) in the present study is lower than the previous reports (13.1%) by Firew *et al*. (2001) and Chiteva and Wairagu (2013). The variations in CP content could be due to factors like soil, season of harvest, and agro-ecology (Firew, 2001). It is indicated that cactus fruit meal has a moderate amount of crude protein. The CP contents of wheat bran and noug seed cake is in line with the finding of Adugna (2008). The CP value of maize (9.6%) obtained in this study is within the range (4.5-9.7%) reported by other researchers (Mandefro *et al*., 2002; Adugna, 2008; Enyisi *et al*., 2014).

Cactus fruit meal used in the current study had a crude fiber level of 19.28% against the 4% reported by Chiteva and Wairagu (2013). The high level of CF obtained from CFM in the current study is in agreement with the report of López-Cervantes *et al*. (2011) and El-mostafa *et al*. (2014). Cactus fruits when used with its seeds has high CF content. The ash content of CFM (15%) is comparable to the results (19.89%) reported by (Firew, 2001; Firew *et al*., 2005). The CF content of the experimental diets varied between 5.65 and 6.20%, which was slightely less than the maximum CF (7%) requirement of broiler diets (Varastegani and Dahlan, 2014). Accordingly the experimental chickens fed on different levels of CFM diet showed improvement in appetite. The increasing trend of EE across the treatments with an increase in cactus fruit meal in diets may be explained by the high oil content cactus fruit. This, together with CF and ash content seems to have contributed to the differences in metabolizable energy content of the diets The metabolizable energy content of CFM in the current experiment (2027 kcal/kg) was lower than that (3770 kca/kg) reported by Chiteva and Wairagu (2013). The variation might be due to harvesting season, mode of CFM preparation and age of cactus fruit. Amata (2014) reported that cactus plant is high in soluble carbohydrates. The metabolizble energy content was slightly lower in T4 (3337) as compared to that of T1 (3427), but higher than the recommended energy level (3200 kcal ME/kg DM) for broilers by NCR (1994). The metabolizble energy content of CFM used in this study was lower than that of maize. However, cactus is grown in harsh environmental condition mostly in arid and semi arid area where maize is less productive. In such areas cactus fruit meal could be used as alternative source of energy for broiler chickens.

DM and Nutrient Intakes of Broiler Chickens

The total DM intake was similar across all the treatment groups. This might be attributed to comparable digestibility nature of cactus fruit meal and maize. It has been shown that incorporating cactus peal instead of wheat bran in diets of sheep improved DM intake (Firew, 2001; Firew *et al*., 2005). On the other hand, Costa *et al.* (2012) indicated that inclusion of cactus peal as a replacement to maize increased DM intake in sheep feeding.

Shammalah (2007) showed that cactus cladodes are very palatable to rabbits. As reported by Henn *et al* (2014) Cobb 500 broilers at 38 days of age consumed 175.5 g DM/d. the value of which is similar to the current DM intake of 178.8 g/d. The high DM intake could be attributed to high passage rate, energy density of the feed and nature of cactus fruit meal. Giachetto *et al*. (2003) indicated that broiler chickens consume enough feed to satisfy their energy requirements. For this reason, high OM, CP and EE intakes were exhibited in the diets which contained higher levels of CFM compared with the control group. In the current experiment, at higher levels of CFM the energy density was lower than the control group.

The low crude protein intake for the groups fed on T1 (23.4) as compared with that of T3 (25.51) and T4 (26.9) could be due to the low content of crude protein in maize than cactus fruit meal. High CP intake could lead to an increase in body weight gain. In contrast Banerjee *et al*. (2013) showed that increase in the level of protein in the diets did not significantly influence the overall body weight gain. The ether extract intake was higher in T4 (6.19) than T1 (5.77) which could be related to high cactus fruit meal inclusion in T4.This finding support the fact that cactus fruit has high amount of oil (Saenz, 2000). Crude fiber intake was slightly higher in T4 than T3, T2 and T1 which could be due to the high crude fiber content of cactus fruit meal than maize. Crude fiber has an advantage to improve DM intake of chicken by increasing fecal bulk and speed up the passage of feed through the digestive tract and keeps the health of gastro intestinal tract if it is at optimum level (Melkamu, 2013). The level of crude fiber in poultry-feed must be kept below 7%. A crude fiber level above 7% has negative effect on the production performance of chicken (Varastegani and Dahlan, 2014). The low metablalizable energy intake of the groups fed on T4 as compared to those fed on T1, T2 and T3 might be due to the low metabolazable energy content of T4.

Growth Performance and Feed Conversion Ratio

The high average daily body weight gain of chicks fed on T4 (38.19 g) as compared to those fed T1 (36.59 g) is in full agreement with results of Parker *et al.* (2014) who indicated that total extract of the edible fruit of the prickly pear cactus had a beneficial effect on chick performance in terms of improving average daily gain. This might be due to the fact that cactus product stimulate chaperone activity, and thus reduce the deleterious effects caused by stress. On the other hand, the work of Firew *et al.* (2008) showed that cactus peal has a great importance in maintaining the live weight of animals rather than improve growth performance. This difference might be due to species difference and the parts of cactus used during the experiment.

The weight gain obtained from the current experiment is higher than the value (20.5 - 29.4 g/day/bird) reported by Befikadu *et al*. (2008) in Cobb 500 broiler chickens fed Azolla (*Azolla filiculoide*). The current result could be explained by the low FCR and high protein intake from T4. Both energy and protein are essential for growth. For this reason, the weight of the chicks increased with an increase in the level of cactus fruit meal. This means that 6.75% cactus fruit meal might be adequate in order to exhibit their effects in promoting better growth performance in broilers. However, further research is required to determine the optimum level of CFM that could safely be included into broilers ration. The improvement in body weight gain recorded in this study is consistent with the finding of Hossain (2009) who reported that cactus fruit meal improved performance (body weight gain and feed conversion ratio) of broiler.

Despite low ME content and intake, the weight gain of the groups fed on T4 was higher than the others. This result is supported by the report of Rabie (2010) and Vincek *et al.* (2011) which indicate that chickens fed low ME diets (2700 kcal/kg) were more efficient in converting energy to body weight gain than those who received high ME diets. Contrary to the results of the current experiment Giachetto *et al*. (2003) reported no significant difference in weight gain between the birds fed with different energy levels (3,200 kcal ME/kg vs. 2,900 kcal ME/kg). Costa *et al*. (2012) showed that increasing cactus meal in sheep ration reduced daily body weight gain. Poultry has an ability to use ME efficiently than ruminants (Mc Donald *et al*., 2010). In the current experiment the chickens attained body weight of 2.2 kg during 42 days of feeding. The groups fed on the treatment containing 6.75% CFM had higher final body weight than the others. This result is in-line with the report of Hristakieva *et al*. (2014) who showed that Cobb 500 broiler chickens achieved 2.2 kg after 42 days of feeding trial. It indicates that substitution of cactus fruit meal by maize could bring the expected final body weight of Cobb 500 broiler chickens. The results of this study is also consistent with the result of Hascik *et al*.(2010) who showed that the broiler chickens may come to a final weight of 2.0-2.2 kg after 42 days of feeding. The result of the current experiment shows that male chicks gained more than the females during the experimental period and consequently achieved a higher final body weight at the end of the feeding trail. This is consistent with the finding of Henn *et al.* comparable to those fed T1. The results showed that replacement of about 6.75% of maize with cactus fruit meal has no any negative effects on thighs and drumsticks weight. This indicates that in (2014) who showed that Cobb 500 broiler male chickens has superior growth rate than female birds.

The FCR achieved by the groups fed on T4 was superior to those achieved by the groups fed on T2 and T1 which might be due to the higher level of cactus fruit meal in the diet. However, the finding of Giachetto *et al*. (2003) showed a high energy diet results in a better feed conversion during post restriction period when compared to a lower energy level. Feed conversion expresses the individual's efficiency of feed utilization and is presented as the ratio of feed consumed to gain. The FCR obtained in this experiment ranged from 3.32 to 3.19 (for cactus fruit meal based diets) and 3.41 (control diet) over the 42 days feeding trial. These figures are closer to the ones reported by Aberra *et al*. (2015) which ranged between 3.34 and 3.65 at 42 days of age. The results of this study confirmed that inclusion of 6.75% cactus fruit meal into broilers ration could bring economically acceptable feed conversion efficiency when fed to Cobb 500 broiler chickens.

Carcass Characteristics of Cobb 500 Broiler Chickens

The evaluation of carcass quality of broiler chickens is a very important segment in production and marketing of poultry products (Nikolova and Bogosavljević-Bošković, 2011). Carcass characteristics are the main tool to evaluate the quality of carcass. The results of this study showed that Broilers fed on different levels of cactus fruit meal had higher carcass quality as measured in terms thigh, drumstick and breast muscle. Thighs and drumsticks weight obtained by the groups fed on T4 were

areas where maize is not available CFM could be used as a source of energy especially under small scale production system.

The similarity in gizzard weight in the current experiment indicates that birds got adequate energy level from all the dietary treatments. This result is not in agreement with the finding of Onwudike (1983) who stated that broiler fed with low energy diet had high gizzard weight. In broilers, the liver is the main site of lipid production, whereas fatty tissue, especially in the abdomen, is the main site for fat storage. Moreover, deep yellow coloration of shank, beak, smooth skin and fat and whitish color of meat were observed on the carcass produced from the groups fed on T3 and T4 than those fed on T1. This might be attributed to the presence of natural sources of xanthophyll in diets containing cactus fruit meal. This is the most important part in poultry nutrition. According to NCR (1994) carotenoid pigments are responsible for the yellow-orange coloration of egg yolks, fat, skin, shanks, feet and beak.

In the current study male chickens had heavier breast muscle than female chickens. It indicated that the heavier final body weight of modern broiler chicken is mainly attributed to the relatively higher yield of breast, because heavier chicks produce a greater portion of breast (Brake et al 1993). Other workers stated that energy content and protein quantity of feed influenced the breast meat quantity (Marcu *et al*.,2013). Aberra *et al*. (2013) reported that female's breast is developed faster than the male chickens of the same age and produce higher breast yield than the males which is not consistent with the current experiment. Melkamu (2013) reported similar effects on breasts and other carcass parts in chickens reared on different nutrition systems.

Most of the edible commercial carcass in the current experiment is similar among all the treatments groups, which is consistent with the study of Raji *et al*. 2014) who found similar result in finisher broiler chickens fed African yam bean. Dressing percentage observed in the group fed T3 was comparable with those fed on T1 which showed that inclusion of 4.75% of cactus fruit meal could bring comparable dressing percentage. Isikwenu and Udomah (2015) reported general reduction in abdominal fat content of broilers fed on cactus fruit meal, which might be attributed to its hypocholesteromic activities which may give a better lean meat. In the current experiment, abdominal fat was similar for all the treatment groups. High body fat deposition in broiler represents economical loss to the producers. The report of Nikolova *et al.* (2007) stated that abdominal fat is affected by genotype, sex, age and nutrition of the broiler chicken. Rabie *et al*. (2010) and Marcu *et al*. (2013) showed that accumulation of abdominal fat is caused by low protein and energy diet in the ration.

CONCLUSION

The overall result of this study showed that cactus fruit meal could substitute up to 6.75% of maize in broiler ration without any negative effect. The substitution of maize by CFM improved average daily body weight gain, feed intake, feed conversion ratio and most common carcass parameters like thigh, wing and drumstick weight. The use of maize in poultry feeding in developing countries is limited by high market price, seasonal availability and highly affected by climate change than cactus fruit. Cactus fruit meal could safely and economically be used to replace up to 6.75% of maize in broilers diet in urban, peri-urban and commercial poultry production systems.

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