Effects of Replacing Maize with Enset (*Ensete ventricosum*) Corm on Growth, Carcass, Blood Heamatology, and Biochemistry of Broiler Chicken

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Abstract: A total of 192 day-old unsexed broiler chicks were randomly and equally distributed in to 12 pens and used to evaluate the effects of replacing maize with enset corm on feed intake, body weight gain, carcass characteristics, blood hematology and biochemistry. Treatments were dietary levels of enset corm at 0% (T1), 15% (T2), 30% (T3) and 45% (T4) to replace maize by weight. Isocaloric and isonitrogenous starter and finisher rations were prepared and used for 42 days trial at Haramaya University. Four broilers (2 from each sex) were randomly taken from each pen and slaughtered for carcass evaluation. Daily dry matter intake during the entire period of the study ranged from 86.9 to 90 g/bird and was significantly ($p<0.05$) higher for T4. Average daily gain during the finisher phase was similar for T1 and T2 but higher ($p<0.05$) than T3 and T4. Better ($p<0.05$) feed conversion ratio was obtained from broilers fed T2 diet during the finisher and entire period of the study. Replacement of maize by enset corm at T4 level lowered ($p<0.05$) dressed and eviscerated weight. Blood hematology and serum biochemistry indices were not differ significantly ($p>0.05$) among the treatments except alkaline phosphatase (ALP) which was significantly higher ($p<0.05$) for birds fed T4 diet. The highest net return was obtained from broilers consumed T2 treatment diet. In conclusion, enset corm can replace maize as an energy source ingredient up to 30% without affecting broiler performance even though the 15% inclusion of enset corm was more profitable.

Keywords: *Blood haematology, Broilers, Carcass, Dry matter, Enset corm, Growth*

Introduction

Poultry farming is an important part of agricultural production and it provides cash income and high quality animal protein within the shortest possible time to meet the demand posed by the rapidly increasing human population across the world. However, feed scarcity and consequent high price of the conventional protein and energy sources has been the major constraint that limits the productivity of the sector regardless of the production system. Grains of good quality are known to constitute 60-70% of the commercial poultry feed which are also used as human food (Jahan *et al*., 2006). This put the sector in a direct competition for grains causing increased cost of poultry production especially at small scale and household levels (Gura, 2008). Therefore, the use of non-conventional feed ingredients which could be available at household level to formulate poultry ration is currently receiving attention. One of such crop is enset (*Ensete ventricosum*).

Enset (*Ensete ventricosum* (Welw) Cheesman, Musaceae), false banana, is a monocarpic short-lived perennial plant which is cultivated in Ethiopia since the ancient times. It tolerates drought that seriously affect other cereals (Mohammed *et al*., 2013). Cultivated enset grows in a wider area of home gardens comprising the central, south, and south-western parts of Ethiopia and it is estimated that about 35% of the total population in Ethiopia live in areas where enset is an important food crop and enset products are staple foods (CSA, 2014). Enset is usually harvested at onset of flowering, 5 to 8 years after planting, and is grown with generations of plants mixed, thus being a reliable food source across time (Dalbato, 2000). The pseudo-stem, corm and the stalk of inflorescence constitute the most important components of enset used for human food as a carbohydrate source (Adugna, 2008).

Over 70% of the enset plant is composed of pseudostem and corm (Ajebu *et al*., 2008). Enset corm has the highest concentration of most soluble carbohydrates and starch, and least fibre and cellulose (Mohammed *et al*., 2013). The corm, botanically the underground stem of enset, is used for vegetative propagation of enset. It is also cooked and eaten like potato. It is a sustainable food source, which can be uprooted and used any time during the life span of the plant, especially during extended droughts when cultivation of annual cereals failed. Mohammed *et al*. (2013) reported that enset corm contained 17 of the 20 amino acids in concentrations ranging between 1.2 and 8.7 g per 100 g of protein and the amounts of most amino acids are higher than that of potato. Ajebu and Eik (2014) indicated that enset corm can be used as an alternative energy source to improve the productivity of sheep. Nigussu *et al*. (2016) reported that inclusion of enset corm up to 30% as a substitution for maize in poultry diet formulation is safe, economical, and an advantage for enset growing areas since it is available year round. However, there is lack of information on the effect of feeding enset corm on performance of

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broiler chicks. Therefore, the present experiment was designed to evaluate the effect of replacing enset corm for maize on growth performance, carcass characteristics, blood hematology and biochemistry, and profitability in feeding of broiler chicks.

Materials and Methods

Experimental Feed Preparation and Treatments

The experiment was conducted at Haramaya University Poultry Farm, which is located at 505 km east of Addis Ababa, the capital city of Ethiopia. Enset plants of age 4 to 6 years of 'Ashakti' variety was bought from a farmer in south west Shoa Zone, Oromia Regional State. Fresh enset corm was dug out after removing the aerial part of enset plant. Whole fresh enset corm was washed, cleaned and sifted, peeled and knife chopped into small manageable slices and then spread over plastic sheet under direct sunlight to dry within five days. The slices were turned regularly to prevent uneven drying and possible decay. Feed ingredients purchased from the nearby market, used to formulate the rations for the study were maize grain, enset corn, wheat short, noug seed cake, soybean meal, vitamin premix, salt, lime-stone, methionine, lysine and dicalcium phosphate. Dried enset corm, maize grain, noug seed cake, salt, and lime-stone were ground to pass through 5 mm sieve size. Chemical composition of major feed ingredients was determined from representative samples (Table 1).

Based on the chemical analysis result treatment rations containing enset corm were prepared at the level of 0% (T1), 15% (T2), 30% (T3) and 45% (T4) replacing maize by weight in the total ration (Table 2). Treatment rations were formulated to be nearly isocaloric and isonitrogenous to meet the nutrient requirements of starter (1-21 days) and finisher (22-42 days of age) broiler chickens.

Table 1. Chemical composition (% DM basis) of the feed ingredients

Ingredients and treatments	DM (%)	Ash	CP	EE	CF	ME	NFE	Ca	P
Enset corm	86.3	5.4	3.2	3.2	2.1	3719	72.4	0.41	0.02
Maize	92.4	3.2	9.3	3.9	3.8	3696	72.2	0.14	0.30
Wheat short	91.8	4.6	15.7	3.3	7.8	2664	60.4	0.13	0.30
Noug seed cake	92.7	13.0	31.8	8.2	15.2	2519	24.5	0.31	0.60
Soyabean meal	91.9	6.1	44.7	1.4	12.6	2661	23.6	0.32	0.70

DM= Dry matter; CP= Crude protein; EE= Ether extract; CF= Crude fibre; Ca= Calcium; P= Phosphorous; ME= Metabolizable energy (kcal/kg DM); NFE= Nitrogen free extract.

Table 2. Proportion of the feed ingredients used in formulating broiler starter and finisher rations

Ingredients	Starter				Finisher			
	T1	**T2**	**T3**	**T4**	**T1**	**T2**	**T3**	**T4**
Maize grain	48	40.8	33.6	26.4	55	46.8	38.5	30.3
Enset corm	0	7.2	14.4	21.6	0	8.25	16.5	24.8
Wheat short	6	7	5	5	7	6	5	6
Noug seed cake	12	11	11	11	6	7	6	5
Soybean meal	30	30	32	32	28	28	30	30
Vitamin premix*	1	1	1	1	1	1	1	1
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Limestone	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
L-Lysine	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
DL-Methionine	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Dicalcium phosphate	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100	100	100	100
DM (%)	94.8	94.3	93.8	93.4	92.9	93.5	93.0	92.5
Ash	10.2	10.3	10.4	10.6	8.1	9.3	7.4	9.6
EE	4.4	4.3	4.2	3.8	4.2	4.1	4.2	3.2
CF	7.7	7.6	7.4	7.4	7.1	7.1	6.9	5.9
CP	22.37	21.84	22.04	22	20.5	20.4	20.3	20.0
ME	3066	3069	3071	3073	3220	3206	3266	3211
Calcium	1.05	1.04	1.03	1.10	0.89	0.90	0.91	0.88
Phosphorus	0.44	0.43	0.43	0.42	0.42	0.41	0.43	0.41

*T1= 0% enset corm replacing maize; T2= 15% enset corm replacing maize; T3= 30% enset corm replacing maize; T4= 45% enset corm replacing maize; *Vitamin premix 50 kg contains, Vit A= 2000000iu, Vit D3= 400000 iu, Vit E= 10000 mg, Vit K3= 300 mg, Vit B1= 150 mg, Vit B2= 1000 mg, Vit B3= 2000 mg, Vit B6= 500 mg, Vit B12= 4 mg, Vitpp= 60000 mg, Folic acid= 160 mg, Choline chloride= 30000 mg, Anti-oxidant= 500 gm, Manganese= 10000 mg, Zinc= 14000 mg, Iron= 9000 mg, Copper= 1000 mg, Iodium= 200 mg, Selenium= 80 mg, Calcium= 28.2%.*

Management of Experimental Birds

A total of 192 day-old unsexed Cobb 500 broiler chicks were purchased from Alema private limited company, Debrezeit, Ehiopia. The experimental house and pens, watering and feeding troughs were thoroughly cleaned, disinfected, and sprayed against external parasites. Chicks with initial body weight (BW) of 46.8 ± 1.4g (Mean ± SD) were randomly divided in to the four dietary treatments, each with three replication of 16 chicks placed in an experimental pen partitioned with wire mesh. The chicks were given commercial anti stress (vitalyte) in drinking water during the first three days to lessen stress due to transportation. Birds were vaccinated against Newcastle disease (HB1 at day 7 and Lasota a booster dose at day 21) and Infectious Bursal Disease (Gumboro disease) at the age of 10 days, all given through an eye drop. The chicks were brooded using 250W infrared electric bulbs with gradual height adjustment as a source of heat and light. Wood shaving was used as a litter material. Feed and clean tap water were offered *ad libitum* throughout the experiment.

Measurements

The study lasted for 42 days for which the amount of feed offered and refused per pen was recorded daily and feed consumed determined by the difference. Feed offered was sampled once per treatment from the bulk prepared for each phase and the leftover was sampled daily per pen and pooled per treatment for the entire experimental period for chemical analysis. Birds were weighed weekly in a group per pen and pen average was calculated as total weight divided by number of birds. Body weight change was calculated as the difference of the final and initial body weight (BW). Average daily gain (ADG) was calculated as BW change divided by the number of experimental days. Feed conversion ratio (FCR) was computed as the ratio of daily dry matter (DM) intake per ADG. Mortality was registered as it occurred and viability rate was computed as number of chicks survived during the period devided by total housed chicks multiplied by 100.

For carcass evaluation, 4 randomly selected birds, 2 males and 2 females from each were feed deprived for 12 hours, weighed, and slaughtered. The bodies were dry de-feathered by hand plucking, eviscerated, and carcass cuts and non-edible offal components were determined as described by Kubena *et al.* (1974). Dressed carcass weight was measured after the removal of blood and feather and the dressing percentage was calculated as the proportion of dressed carcass weight to slaughter weight multiplied by 100. Eviscerated carcass weight was determined after removing lower leg (shank), head, kidney, lungs, pancreas, crop, proventriculus, small intestine, large intestine, caeca, and urogenital tracts from dressed carcass. The eviscerated percentage was determined as the proportion of the eviscerated weight to slaughter weight. From eviscerated carcass weight drumstick, thigh, and breast meat were separated and weighed, and their weight were also determined as percentage weights of each component to the slaughter weight. Fat around the proventriculus, gizzard, against the abdominal wall, and cloacae were removed and weighed and fat percentage was calculated as the proportion of slaughter weight. The edible offal (heart, gizzard, and liver) were weighed and expressed in relation to the slaughter weight. Weight of gastrointestinal tracts (GIT) crop, proventriculus, small intestine, caeca, and large intestine were weighed each without their contents. The relative weight was calculated as the proportion of weight of GIT parts to slaughter BW. The length of the parts was measured using measuring tape.

For the analysis of blood hematology and biochemical components, samples of blood were collected from the jugular veins of the 4 birds used for carcass evaluation into a 5 ml sterile syringe using a 23-gauge needle. The blood samples were immediately transferred into a tube containing ethylene diamine tetra-acetic acid (EDTA) as an anticoagulant for the determination of hematology. The red blood cell (RBC) and white blood cell (WBC) were counted using haemocytometer (Irizaary-Rovira, 2004). The hemoglobin (Hb) concentration was determined by matching acid hematin solution against a standard colored solution found in Sahlis hemoglobinometer. Packed cell volume (PCV) was measured by microhaematocrit method. Mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC) and mean corpuscular hemoglobin (MCH) were computed as described by Irizaary-Rovira (2004).

Another batch of 5ml blood sample was collected into a plain tube for the analysis of blood bio-chemicals from the same birds from which sample for hematological analysis was taken. Serum was separated after centrifugation at 3,000 rpm x g for 15min and stored at -20^{0}C until used. Serum alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP) activities, cholesterol, glucose and triglycerides concentrations were measured following a standard laboratory procedures. Total serum protein was determined by refractometer (George, 2001).

Economic efficiency of growth for different levels of enset corm used in broilers diet was evaluated through the calculation of European Broiler Index (EBI) and Production Efficiency Factor (PEF) (Marcu *et al.*, 2013).

$$\text{EBI} = \frac{Viability\ (\%) * ADG\ g/chick/day}{FCR * 10}$$

$$\text{PEF} = \frac{Viability\ (\%) * BW\ (kg)}{age\ (d) * FCR} * 100$$

Where: Viability (%) = chicks remaining at the end of the period (%); Age (day) = the age of the chick at slaughter (42 days); BW= final BW of the birds; ADG= Average daily BW gain; FCR= feed conversion ratio.

The economic benefit was estimated by the partial budget analysis (Upton, 1979). Variable costs were determined as the difference between feed expense to formulate each treatment diet and prices of carcass. The net income (NI) was calculated as the amount of money which is left when total variable costs (TVC) are subtracted from total returns (TR). The marginal rate of return (MRR) was calculated by dividing net income to variable cost.

Chemical Analysis of Feed

Samples of feed ingredients, feed offered, and refusals from the respective treatments were analyzed for DM, ether extract (EE), crude fiber (CF), ash, and Kjeldahl Nitrogen (N) (AOAC, 1990); and the crude protein (CP) was determined as Nx6.25. Calcium and total phosphorus content were analyzed by atomic absorption and vanado-molybdate methods, respectively (AOAC, 1998). Metabolisable energy (ME) content of the experimental diets was calculated by indirect method from the equation proposed by Wiseman (1987) as ME (Kcal/kg DM) = 3951 + 54.4EE - 88.7CF - 40.8 ash.

Statistical Analysis

Data were analyzed using the general linear model procedures of Statistical Analysis Systems (SAS, 2009) with the model containing treatments except carcass characteristics that was analyzed with a model containing treatments and sex. Differences between treatment means were separated using Tukey Kramer test. The means were considered significant at $P < 0.05$.

Results

The CP content of enset corm was lower compared with other feed ingredients (Table 1). The calculated ME content of enset corm was higher than the other ingredients, except maize grain which has almost similar value. The calcium content of enset corm was relatively higher while the phosphorus was lower than the other ingredients.

Dry matter intake during the starter phase and entire period of the study was significantly ($p<0.05$) higher for birds consumed T4 diet as compared with the rest of the groups (Table 3). Average daily body weight gain during the starter phase and the entire experiment was high ($p<0.05$) for T2 and the value for T4 was low compared to the other treatment rations for the entire experiment.

On the other hand, best ($p<0.05$) feed conversion ratio (FCR) was obtained from broilers fed with T2 followed by T1 and T3 and the least being for T4 for the entire period of the study. There was no significant difference in viability rate throughout the experimental period.

Table 3. Performances of broilers fed ration containing different levels of enset corm

Parameters	Treatments				SEM	P value
	T1	**T2**	**T3**	**T4**		
Starter Phase (1-21 days)						
DMI (g/bird)	48.8^{b}	48.6^{b}	49.3^{b}	52.3^{a}	0.74	0.001
IBW (g/bird)	45.6	45.7	46.3	46.1	0.29	0.877
FBW (g/bird)	504.3^{b}	578.7^{a}	532.8^{b}	494.8^{b}	3.31	0.008
BW change (g/bird)	458.7^{c}	533^{a}	486.5^{b}	448.7^{c}	0.92	0.015
ADG (g/day)	21.8^{c}	25.4^{a}	23.2^{b}	21.4^{c}	0.04	0.015
FCR	2.2^{a}	1.9^{b}	2.1^{a}	2.4^{a}	0.04	0.005
Viability (%)	96.9	96.9	96.8	96.6	0.85	0.385
Finisher phase (21-42 days)						
DMI (g/bird)	126.8^{ab}	125.1^{b}	125.6^{ab}	127.7^{a}	0.38	0.041
BW change (g/bird)	1125^{b}	1171.7^{a}	1042.6^{b}	1053^{c}	19.07	0.007
ADG (g/day)	53.6^{a}	55.8^{a}	49.6^{b}	50.1^{b}	0.09	0.007
FCR	2.4^{a}	2.2^{c}	2.5^{a}	2.5^{a}	0.04	0.000
Viability (%)	100	100	100	100	-	-
Entire Experiment (1-42 days)						
DMI (g/bird)	87.8^{b}	86.9^{b}	87.5^{b}	90.0^{a}	0.52	0.002
FBW (g/bird)	1629.3^{b}	1750.4^{a}	1575.4^{b}	1487.8^{c}	15.24	0.000
BW change (g/bird)	1583.7^{b}	1704.7^{a}	1529.1^{b}	1441.7^{c}	21.79	0.006
ADG (g/day)	37.7^{b}	40.6^{a}	36.4^{b}	34.3^{c}	0.45	0.006
FCR	2.3^{b}	2.1^{c}	2.4^{b}	2.4^{a}	0.05	0.001
Viability (%)	98.5	98.5	98.4	98.3	0.43	0.385

^{a,b,c}Means within a row with different superscripts differ (p<0.05); T1= 0% enset corm replacing maize; T2= 15% enset corm replacing maize; T3= 30% enset corm replacing maize; T4= 45% enset corm replacing maize; SEM= Standard error of the mean; IBW= Initial body weight; BW= Body weight; FBW= Final body weight; DMI=Dry matter intake; ADG= Average daily gain; FCR= Feed conversion ratio.

Slaughter weight, dressing weight, and eviscerated weight were lower ($P<0.05$) for T4 than the remaining treatments that had similar values (Table 4). Dressing and evicerated percentage, drumstick weight and percentage, gizzard and fat percentage were not significantly ($p>0.05$) different among treatments.

Lower (P<0.05) breast weight and percentage and thigh weight were recorded for T4 than T1 and T2. Percentages of liver and heart were higher (p<0.05) for T3 and T4 as compared to the other treatments. Slaughter weight, dressed weight, eviscerated weight, and drumstick weight were higher (p<0.05) in males as compared to females, but the rest carcass parameters were not different (p>0.05) between sexes. The weight and length of gastrointestinal tract did not differ (p>0.05) among treatments, except that the small intestine for T1and T3 was small in weight and short in length than broilers fed T2 and T4 (Table 5). Sex did not affect (P>0.05) the weight and length of gastrointestinal tract parts.

Hematological indices were not (p>0.05) affected by inclusion of enset corm in the broilers ration (Table 6). Except for the alkaline phosphatase (ALP) which showed higher (p<0.05) value in birds fed T4 diet, blood biochemical parameters were also similar (p>0.05) among the treatments (Table 7).

Production efficiency factor (PEF) and European broiler index (EBI) values recorded during the starter phase and entire experiment were higher (p<0.05) for birds fed T1 and T2, intermediate for T3 and lower for T4 diets (Table 8). The net profit was high from broilers fed T2 while the least profit was earned from T4. The overall result of production efficiency measure and partial budget indicated that feeding 15% enset corm ration as a replacement for maize provided the highest net profits.

Table 4. Carcass components of broilers fed ration containing different levels of enset corm as a replacement for maize

	Treatments				SEM	P value	Sex		SEM	P value
	T1	**T2**	**T3**	**T4**			Male	Female		
Slaughter weight (g)	1580ᵃ	1622ᵃ	1539ᵃ	1432ᵇ	15.82	0.001	1631ᵃ	1458ᵇ	35.4	0.012
Dressed weight (g)	1442ᵃ	1471ᵃ	1446ᵃ	1363ᵇ	22.66	0.024	1492ᵃ	1292ᵇ	33.9	0.034
Dressing (%)	91.3	90.7	90.9	91.9	1.20	0.990	91.5	89.0	1.14	0.442
Eviscerated weight (g)	1113ᵃ	1143ᵃ	1090ᵃ	1032ᵇ	14.85	0.028	1167ᵃ	1014ᵇ	27.9	0.012
Eviscerated (%)	70.5	70.4	68.8	69.6	0.58	0.701	71.5	69.9	1.21	0.326
Breast weight (g)	441ᵃ	443ᵃ	406ᵃᵇ	362ᵇ	6.33	0.001	438	403	14.1	0.375
Breast (%)	27.9ᵃ	27.3ᵃ	26.4ᵃᵇ	25.3ᵇ	0.27	0.001	26.8	27.6	0.67	0.997
Thigh weight (g)	157ᵃ	163.6ᵃ	149ᵇ	144ᵇ	2.31	0.001	159	147	13.9	0.177
Thigh (%)	9.9	10.1	9.7	10.1	0.08	0.051	9.8	10.13	0.18	0.987
Drumstick weight (g)	139	145	138	134	3.45	0.561	147ᵃ	129ᵇ	3.46	0.042
Drum stick (%)	8.8	8.9	8.7	8.8	0.19	0.982	9.0	8.9	0.15	0.998
Gizzard (%)	2.33	2.38	2.53	2.94	0.10	0.151	2.54	2.78	0.08	0.154
Liver (%)	1.97ᵇ	2.08ᵇ	2.42ᵃ	3.03ᵃ	0.15	0.035	2.37	2.36	0.07	0.636
Heart (%)	0.50ᵇ	0.51ᵇ	0.60ᵃ	0.71ᵃ	0.03	0.001	0.57	0.61	0.02	0.762
Fat (%)	0.19	0.16	0.16	0.17	0.00	0.160	0.2	0.3	0.08	0.289

[a,b,c] Means within a row with different superscripts differ (p<0.05); T1= 0% enset corm replacing maize; T2= 15% enset corm replacing maize; T3= 30% enset corm replacing maize; T4= 45% enset corm replacing maize; SEM= Standard error of the mean; IBW= Initial body weight; BW= Body weight; SEM= Standard error of the mean.

Discussion

Crude protein and CF contents of enset corm used in the present study were comparable with the previously reported values of 3.3 and 2.1% by Mohammed *et al.* (2013), respectively. A higher value of CP was recorded in the present study (3.2%) than values (2.2%) reported by Ajebu and Eik (2014). The CP content of enset corm is in general low and indicates the need for incorporation of feed with higher CP content in diets used enset as one of its ingredient. The crude fat concentration was higher than the value (0.41%) reported by Mohammed *et al.* (2013), which could be due to differences in stages of harvesting, agronomic practices, and plant variety (Maphosa *et al.*, 2003). The ME content (3718 kcal/kg DM) of enset corm noted in the current study is indicative of its potential as energy source feed to replace maize. The ME value in the current study was higher than value of 3330 kcal/kg DM reported by Tadessa and Shigeta (2016). Variety and age of enset plant might have been contributed to the variation in ME content of enset corm (Melesse, 2013). Generally, the treatment diets contained CP, ME, Ca, and P levels nearly within the recommended values for broilers (NRC, 1994).

The higher DM intake of broilers fed 45% enset corm as a substitution for maize diet during the starter phase and entire period of the study indicates that enset corm inclusion in the ration did not limit the intake of broilers. This indicates that enset corm has a good palatability by broilers. The present study was in agreement with the findings of Seyoum (2013) who observed higher feed intake for broilers fed 67% and 100% furfurame, which is an intermediate product in *kocho* processing from enset, when substituted for maize. However, it was in disagreement with the findings of Ajebu *et al.* (2015) who noted a non-significant difference among the treatments in terms of intake when broiler chicks were fed with 0%, 33%, 67% and 100% *kocho* diets substituting maize.

Table 5. Weight and length of gut parts of broilers fed ration containing different levels of enset corm as a replacement for maize

Parameter	Treatments				SEM	P value	Sex		SEM	P value
	T1	**T2**	**T3**	**T4**			Male	Female		
Esophagus wt (g)	2.9	2.5	2.4	2.3	0.09	0.12	2.5	2.54	0.09	0.400
Crop weight (g)	9.7	9.3	9.2	9.6	0.14	0.597	9.1	9.65	0.23	0.968
Proventriculus wt (g)	7.8	8.6	9.1	9.7	0.52	0.069	9.9	9.54	0.42	0.708
Small intestine wt (g)	55.3[c]	80.7[b]	85.9[b]	92.1[a]	4.68	0.001	90.9	75.86	2.17	0.519
Large intestine wt (g)	4.2	6.3	6.3	6. 8	0.16	0.107	6.6	5.8	0.52	0.570
Caeca weight (g)	12.7	13.8	14.8	13.5	0.36	0.056	13.6	13.5	0.61	0.256
Esophagus length (cm)	13.0	12.5	13.0	13.2	0.11	0.168	12.8	13.04	0.12	0.629
Crop length (cm)	2.8	2.8	2.7	2.7	0.41	0.823	2.7	2.8	0.04	0.764
Proventriculus length (cm)	5.3	5.0	5.4	5.6	0.10	0.296	5.6	5.1	0.13	0.713
Small intestine length (cm)	165[b]	167[b]	162[b]	173[a]	1.21	0.005	170	165.7	34.6	0.577
Large intestine length (cm)	9.8	9.4	10.0	10.3	0.54	0.680	9.9	9.6	0.60	0.481
Caeca length (cm)	18.2	16.9	17.9	17.4	0.35	0.398	16.1	17.0	0.29	0.765

[a,b,c] Means within a row with different superscripts differ (p<0.05); T1= 0% enset corm replacing maize; T2= 15% enset corm replacing maize; T3= 30% enset corm replacing maize; T4= 45% enset corm replacing maize; SEM= Standard error of the mean; IBW= Initial body weight; BW= Body weight.

Table 6. Hematological parameters of broilers fed different levels of enset corm as a replacement for maize

Hematology parameters	Treatments				SEM	P value
	T1	**T2**	**T3**	**T4**		
RBC (10^6cells/mm^3)	2.6	2.4	2.6	2.6	0.15	0.932
WBC (10^3cells/mm^3)	3.4	4.0	4.2	3.6	0.29	0.523
Hb (g/dL)	13.5	13.9	13.1	12.6	0.14	0.605
PCV (%)	28.3	27.3	25.7	26.3	0.59	0.450
MCV (fL)	112.8	121.4	99.5	104.5	6.93	0.752
MCHC (%)	47.7	50.9	51.1	48.9	0.55	0.884
MCH (pg)	67.6	69.4	65.6	63.3	0.57	0.606

[a,b,c]Means in a row with different superscripts differ (p < 0.05); T1= 0% enset corm replacing maize; T2= 15% enset corm replacing maize; T3= 30% enset corm replacing maize; T4= 45% enset corm replacing maize; SEM= Standard error of the mean; Hb= Hemoglobin; PCV= Packed cell volume; RBC= Red blood cell; MCV= Mean corpuscular volume; MCH= Mean corpucular hemoglobin; MCHC= Mean corpuscular hemoglobin concentration; WBC= White blood cell.

Despite a higher DM intake, higher feed conversion ratio and lower ADG for birds fed 45% enset corm substituting maize compared to the control was noted. Although the reason for such result is difficult to justify, elevated ALP level for the highest enset corm inclusion level as compared to the other treatments suggests enset corm might have anti-nutritional factors that may limit its inclusion beyond a certain level in the diet of broilers. Similar to the current experiment, Seyoum (2013) observed a decrease in body weight gain with increasing levels of furfurame. However, Ajebu *et al.* (2015) noted no difference in average body weight gain for broiler chicks fed 0%, 33%, 67%, and 100% *kocho* diets.

The lower slaughter, dressed, and eviscerated weights at 45% enset corm substitution for maize is consistent with the lower growth performance of the broilers. However, Ajebu *et al.* (2015) noted no difference in slaughter weight for broilers fed 0%, 33%, 67%, and 100% *kocho* replacing maize. Lower carcass yield suggests lower energy and protein bioavailability for anabolic processes since the true muscle development is an accumulation of protein (Tegene and Asrat, 2010). A possible presence of anti-nutritional factor(s) in enset corm that might have an impact at the 45% level of substitution could have been limited the bioavailability of nutrients and negatively impacted growth and carcass yield (Sarwar *et al.*, 2012). This can be partly explained by the higher liver and heart weights of chicks fed diets with 30% and 45% enset corm as a substitution for maize. The variation in the weight of these organs among treatment diets indicates that enset corm might contain anti-nutritional factor (Adeyemo, 2010). According to Bone (1979) abnormalities in the weight of the internal organs arise from the increased metabolic rate of the organs in attempt to reduce toxic elements or anti-nutritional factors.

The absence of difference in abdominal fat weight in the current experiment could be attributed to the similarity of blood glucose levels, triglycerides, and cholostrol in birds fed diets with or without enset corm. Musa *et al.* (2007) showed that higher deposition of abdominal fat is associated with high serum concentrations of triglycerides, glucose, and total cholesterol. Moreover, Rondelli *et al.* (2003) indicated that female birds were fatter than males because female hormones stimulate fat deposition which is not in agreement with the current experiment. Fat amount, fat quality, and cholesterol content in food are important parameters to be considered when the relationship between fat and the risk of some cardiovascular diseases and cancer is evaluated (Cherian *et al*., 1996).

Table 7. Serum biochemical parameters of broilers fed different levels of enset corm as a replacement for maize

Biochemical parameters	Treatments				SEM	P value
	T1	**T2**	**T3**	**T4**		
AST (U/L)	15.9	19.5	17.8	16.7	2.21	0.962
ALT (U/L)	16.7	21.6	20.5	16.9	2.27	0.460
ALP (U/L)	2365.8^{c}	3013.3^{b}	3045.7^{b}	3491.3^{a}	196.3	0.001
Glucose (mg/dL)	246.8	235.3	237.2	237.5	13.05	0.787
Triglycerides (mg/dL)	62.7	52.05	60.6	53.1	15.27	0.219
Cholesterol (mg/dL)	119.6	130.1	117.5	133.8	8.93	0.384
Total protein (g/dL)	4.9	4.8	3.2	4.9	0.28	0.056

^{a,b,c} Means in a row with different superscripts differ ($p < 0.05$); T1= 0% enset corm replacing maize; T2= 15% enset corm replacing maize; T3= 30% enset corm replacing maize; T4= 45% enset corm replacing maize; SEM= Standard error of the mean; AST= Asparate aminotransferase; ALT= Alanine aminotrasferase; ALP= Alkaline phosphatase.

Table 8. Production efficiency and profitability of broiler ration containing different levels of enset corm as a replacement for maize

Parameters	Treatments				SEM	P value
	T1	**T2**	**T3**	**T4**		
Production efficiency						
Starter PEF	127.2^{a}	128.9^{a}	124.8^{b}	109.5^{c}	2.88	0.032
Starter EBI	117^{a}	118 ^{a}	114^{b}	100.4^{c}	2.63	0.027
Finisher EBI	195.6	194.8	177.7	176.3	16.8	0.116
Entire period PEF	148.5^{a}	148.9^{a}	138.2^{b}	121.5^{c}	4.27	0.042
Entire period EBI	144.3^{a}	144.7^{a}	134^{b}	117.7^{c}	4.19	0.042
Partial budget cost (Birr)						
Day old chick cost (Birr)	20	20	20	20		
Total feed consumed/bird (kg)	3.9	3.8	3.9	4.0		
Per unit feed cost (Birr)	6.0	5.8	5.6	5.4		
Total feed cost (birr/bird)	23.4	22.0	21.8	21.6		
Total variable cost (Birr)	23.4	22.0	21.8	21.6		
Revenue						
Average carcass weight (kg)	1.1	1.2	1.1	1.0		
Price/kg of carcass (supermarket)	80	80	80	80		
Total return (Birr)	88	96.0	88	80		
Net return/bird (birr)	64.6	74.0	66.2	58.4		
Marginal rate of return	-	3.36	3.03	2.70		

^{a,b,c} Means in a row with different superscripts differ ($p < 0.05$); T1= 0% enset corm replacing maize; T2= 15% enset corm replacing maize; T3= 30% enset corm replacing maize; T4= 45% enset corm replacing maize; SEM= Standard error of the mean; PEF= Production efficiency factor; EBI= Eropean broiler index.

The higher weight and length of small intestine at 45% enset corm substitution for maize could be due to lower amount of nutrients in the test diet (Bhuiyan and Iji, 2015). Chicks increase the size of their digestive tract in order to cope with the reduced amount of nutrients to be absorbed (Jorgensen *et al*., 1996). Moreover, Bradford (1976) noted that intestinal weight, length and absorptive area of gastrointestinal tract could be modified due to response of intestine to anti-nutritional factors in the diet.

Blood constituents assessed for hematological indices were not affected by replacing maize with enset corm and were within the normal hematologic values of 2.5-3.5 x 106 /μL red blood cells, 7-13 g/dL Hb, 22-35% PCV, 90-140 fl MCV for chickens reported by Wakenell (2010). The absence of significant difference in blood constituents assessed for hematological indices in the present study suggests that replacement of maize by enset corm diet did not predispose the birds to any health problems, as hematological variables can be used as an indicator of health in birds (Hrabcakova *et al*., 2014).

The reason for the higher ALP at 45% enset corm inclusion as a replacement for maize in broiler diet is not apparent, but could be attributed to a possible effect of anti-nutritional factors and hence more production of this enzyme by the liver to detoxify the anti-nutrition substances (Akinmutimi and Onen, 2008). According to Akpet *et al*. (2015) the hepatic marker enzymes such as ALP, ALT, and AST signal the health status of the liver, kidney, spleen, and pancreas and their increase in serum activity indicates marked injury and impairments of metabolic activities. The values of ALP for birds consumed the control diet, 15%, and 30% enset corm ration were in line with the value (2100-3300U/L) reported by Senanayake *et al.* (2015) for Cobb 500 broiler chicks under different feeding systems. In the present study, the level of blood glucose in broilers fed with enset corm is within the normal range of values (200 to 500 mg/dL) reported by Campbell (2012). The protein level of an animal has important diagnostic significance as proteins are involved in enzyme, hormones, and antibodies synthesis and to synthesize body tissues and muscle. McDonald (1991) reported that low total protein could reflect stress, chronic disease, parasitism, starvation or malnutrition while elevated values may induce dehydration, chronic infection or leukemia.

The economic efficiency assessment on PEF and EBI was positively influenced by the growth performances, FCR and recorded viability (Marcu *et al.*, 2013). Lower values of PEF and EBI at the 45% enset corm substitution for maize is the reflection of lower growth performances in broilers consumed this diet than the other treatments. The PEF obtained in all the treatments in the current study were lower than the accepted values (255-376) in Europe (Shane, 2013). The lower PEF values might be related to the environmental stress and feed quality variation (Kassa *et al.*, 2016).

The partial budget profitability analysis indicated that the highest net return was obtained from broilers consumed 15% enset corm substitution for maize and the least from broilers fed the 45%. The difference in the net return among treatments was mainly due to the low body weight gain of broilers at a higher level of inclusion. The MRR showed that each additional unit of 1 Birr cost increment resulted in 3.4, 3.0 and, 2.8 Birr profit for 15%, 30% and 45% enset corm inclusion in the broiler diet as a substitution for maize, respectively.

Conclusion

In conclusion, enset corm at 15% of replacing maize as an energy source ingredient resulted in a better growth performance and FCR. However, carcass cut parameters were not affected by up to 30% replacement of maize by enset corm. Moreover, up to 45% replacement did not affect blood hematology and blood biochemistry. Hence, replacement of maize by enset corm as energy feed staff at 15% could impart a profitable business in broiler chicks feeding.

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Conflict of Interests

The authors declare that they have no competing interests.

References

Adeyemo, G. O. (2010). Effects of exposure duration to cottonseed cake-based diets on broiler performance. *International Journal of Poultry Science*, 9 (2): 162-166.

Adugna Tolera (2008). Feed resource and feeding management. A manual for feed operators and development workers. Ethiopia sanitary and phyto-sanitary standards and livestock and meat marketing program (SPS-LMM). Addis Ababa, Ethiopia, pp: 38.

Ajebu Nurfeta and Eik, L. O. (2014). Assessment of different levels of enset (*Ensete ventricosum*) corm as an energy supplement in sheep fed a basal diet of Rhodes grass hay. *Tropical Animal Health and Production*, 46: 905-911.

Ajebu Nurfeta, Abebash Kebede & Aster Abebe (2015). Evaluation of replacement value of maize with *kocho* on the growth performance and carcass characteristics of broiler hubbard chickens. *Journal of Science and Development*, 3 (1): 35-43.

Ajebu Nurfeta, Adugna Tolera, Eik, L. O. & Sundstøl, F. (2008). Yield and mineral content of ten enset (*Ensete ventricosum*) varieties. *Tropical Animal Health and Production*, 40: 299-309.

Akinmutimi, A. H. & Onen, G. E. (2008). The response of broiler finisher birds fed graded levels of yam peel meal in place of maize-based diets. *International Journal of Poultry Science*, 7 (5): 474-479.

Akpet, S. O., Ibekwe, H. A. & Onyeama, H. P. (2015). Effects of *Moringa oleifera* serum activities of hepatic marker enzymes and lipid profile of Anak 2000 broiler chicks. *Merit Research Journal of Agricultural Science and Soil Sciences*, 3 (11): 168-172.

AOAC (1990). Association of Official Analytical Chemists, 16th ed. Official Methods of Analysis of AOAC International, Virginia. USA.

AOAC (Association of Official Analytical Chemist) (1998). Official Methods of Analysis, 16th ed., Washington, DC.

Bhuiyan, M. M. & Iji, P. A. (2015). Energy value of cassava products in broiler chicken diets with or without enzyme supplementation. *Asian-Australasian Journal of Animal Science*, 28 (9): 1317-1326.

Bone, F. J. (1979). Anatomy and Physiology of Farm Animals. Reston, USA.

Bradford, M. M. (1976). A rapid and sensitive method for the quantization of microgram quantities of protein utilizing the principle of protein-dye binding. *Analaytic Biochemistry*, 72: 248-254.

Campbell, T. W. (2012). Clinical chemistry of birds. In: M.A. Thrall, G. Weiser, R. W. Allison & T.W. Campbell (Eds.), Veterinary hematology and clinical chemistry, 2nd ed., Wiley-Blackwell, pp: 582-598.

Cherian, G., Wolfe, F. W. & Sim, J. S. (1996). Dietary oils with added tocopherols: Effects on eggs or tissue tocopherols, fatty acids, and oxidative stability. *Poultry Science*, 75: 423-431.

CSA (Central Statistical Agency) (2014). Agricultural sample survey Volume II. Statistical Bulletin No. 505. CSA, Addis Ababa, Ethiopia.

Dalbato, A. L. [published as: Lagibo, A.] (2000). An overview of population and food production situation in SNNPR. Population Newsletter, Awassa, Ethiopia, 4: 10-13.

George, J. W. (2001). The usefulness and limitations of hand-held refractometers in veterinary laboratory medicine: an historical and technical review. *Veterinary Clinical Pathology*, 30: 201-10.

Gura, S. (2008). Industrial livestock production and its impact on smallholders in developing countries: Consultancy report to the League for Pastoral Peoples and Endogenous Livestock Development, Germany, pp: 65. Retrived from http://www.pastoralpeoples.org/docs/gura_ind_livestock_prod.pdf

Hrabcakova, P., Voslálová, E., Bedáňová, I., Pištjková, V., Chloupek, J. & Večerek, V. (2014). Haematological and biochemical parameters during the laying period in common pheasant hens housed in enhanced cages. *The Scientific World Journal*, http://dx.doi.org/10.1155/2014/364602

Irizaary-Rovira, A. R. (2004). Avian and reptilian clinical pathology (avian hematology & biochemical analysis). In: R.L. Cowell (ed.), Veterinary clinical pathology secrets, Section XI, Elsevier Inc. St. Louis, MO, USA., pp: 282-313.

Jahan, M. S., Asaduzzaman, M. & Sarkar, A. K. (2006). Performance of broiler fed on mash, pellet and crumble. *International Journal of Poultry Science*, 5 (3): 265-270.

Jorgensen, H., Jensen, S. K. & Eggum, B. O. (1996). The influence of rapeseed oil on digestibility, energy metabolism and tissue fatty acid composition in pigs. *Acta Agriculturae Scandinavica Section-Animal Science*, 46: 65-75.

Kassa Shawle, Mengistu Urge & Getachew Animut (2016). Effect of different levels of lepidium sativum on growth performance, carcass characteristics, hematology and serum biochemical parameters of broilers. *Springer Plus*, 5: 1441.

Kubena, L., Wchen, F. J. & Reece, F. N. (1974). Factors influencing the quality of abdominal fat in broilers. III. Feed and dietary levels. *Journal of Poultry Science*, 53: 974-978.

Maphosa, T., Gunduza, K. T., Kusina, J. & Mutungamiri, A. (2003). Evaluation of sweet potato tuber (*Ipomea batatas l.*) as a feed ingredient in broiler chicken diets. *Livestock Research for Rural Development*, 15 (1).

Marcu, A., Vacaru-Opris, I., Dumitrescu, G., Ciochina, L. P., Marcu, A., Nicula, M., Pet, I., Dronca, D., Kelciov, B. & Maris, C. (2013). The influence of genetics on economic efficiency of broiler chickens growth. *Animal Science Biotechnology*, 46 (2): 339-346.

McDonald, P. (1991). Green-Halgh, Annual Nutrition 5, Addison Wesley Longman Ltd., Edinburgh, U.K., p: 606.

Melesse Temesgen (2013). Improving the indigenous processing of *kocho*, an Ethiopian traditional fermented food. *Nutrition and Food Science*, 3: 182.

Mohammed Beyan, Gabel, M. & Karlsson, L. M. (2013). Nutritive values of the drought tolerant food and fodder crop enset. *African Journal of Agricultural research*, 8 (20): 2327-2333.

Musa, H. H., Chen, G. H., Cheng, J. H. & Yousif, G. M. (2007). Relation between abdominal fat and serunn cholesterol, triglycerides, and lipoprotein concentrations in chicken breeds. *Turkish Journal of Veterinary and Animal Sciences*, 31: 375-379.

Nigussu Fekede, Mengistu Urge, Ajebu Nurfeta & Getachew Animut (2016). The effects of partial substitution of maize with enset (*Ensete ventricosum*) corm on production and reproduction performance of white leghorns layer. *Ethiopian Journal of Animal Production*, 16 (1): 79-94.

NRC (National Research Council) (1994). Nutrient Requirements of Poultry. In: S. Leeson & J. D. Summer (eds.), Nutrition of the Chicken 4th ed., University Books, Canada, p: 591.

Rondelli, S., Martinez, O. & Gracia, P. T. (2003). Sex effect on productive parameters, carcass and body fat composition of two commercial broilers lines. *Brazilian Journal of Poultry Science*, 5 (3): 169-173.

Sarwar, G., Wu, C. & Cockell, K. A. (2012). Impact of antinutritional factors in food proteins on the digestibility of protein and the bioavailability of amino acids and on protein quality. *British Journal of Nutrition*, 2: 315-32.

SAS (Statistical Software System) (2009). SAS User's Guide, Statistics. SAS Institute, Inc., Cary, NC. USA.

Senanayake, S., Ranasinghe, J., Waduge, R. Nizanantha, K. & Alexander, P. (2015). Changes in the serum enzyme levels and liver lesions of broiler birds reared under different management conditions. *Tropical Agricultural Research*, 26 (4): 584-595.

Seyoum Debebe (2013). Effect of feeding different levels of furfurame replacing maize on growth performance and carcass characteristics of Hubbard chickens, MSc Thesis, Hawassa University, Hawassa, Ethiopia.

Shane, S. (2013). What's your "PEF". Retrived from http://www.datapoul.co.uk/wp-content/uploads/ProductionEfficiencyFactor

Tadessa Dessie & Shigeta, M. (2016). Enset (*Ensete ventricosum*) production in Ethipia: Its natural and socio-Cultural values. *Agricultural and Food Sciences Research*, 3 (2): 66-74.

Tegene Negesse & Asrat Tera (2010). Effects of feeding different levels of cooked and sun dried fish offal on carcass traits of growing Rhode Island Red chicks. *Tropical Animal Health and Production*, 42: 45-54.

Upton, M. (1979). Farm Management in Africa, the principal of production and planning, Oxford University Press, p: 380.

Wakenell, P. S. (2010). Hematology of chickens and turkeys. In: D.J. Weiss & K.J. Wardrop (eds.), Schalem`s Veterinary hematology, 6^{th} ed., pp: 958-967.

Wiseman, J. (1987). Feeding of non-ruminant livestock, Butter worth and C. Ltd., p: 370.