The Effects of Partial Substitution of Maize with Enset (*Ensete ventricosum*) Corm on Production and Reproduction Performance of White Leghorn Layer

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Abstract

One hundred and eighty white leghorn layers were used to evaluate the effects of partial replacement of maize with enset (Ensete ventricosum) corm on production and reproduction performance. The layers were fed ration containing enset corm at levels of 0% (T1), 6.5% (T2), 13% (T3) and 20% (T4) to replace 0, 15, 30 and 45% of maize. The experiment was arranged in a completely randomized design with three replications and lasted 12 weeks. Hens were weighed at the start and end of the experiment. Data on dry matter intake, hen-day egg production, egg weight and egg mass were recorded daily. Egg quality parameters (egg shell weight and thickness, albumen weight and height, Haugh unit and egg yolk weight and color were determined at an interval of 7 days using 4 eggs per replicate. Enset corm contained 3.2% crude protein, 6.2% ether extract, 2.1% crude fibre and 1.18µg/100g beta-carotene. The mean daily DM intake of the group fed with T1 was significantly lower (P<0.05) compared with the groups fed with T2, T3 and T4, all of which had similar values. There was no significant difference (P>0.05) between all the treatment groups in average daily gain, hen-day egg production, egg mass, egg weight, feed conversion ratio, mortality rate, egg quality parameters, fertility, hatchability, embryonic mortality and chick quality characteristics. The net return gained from the inclusion of 13% enset corm to replace 30% of maize was more economical in terms of egg production and feed cost. Therefore, due to the year round availability and easy access by smallholder farmers in enset growing areas of Ethiopia, enset corm could safely and economically used in replacing 30% of maize in layers ration.

Keywords: *Egg quality, Enset corm, Hen-day egg production, Layers, Replacement*

Introduction

The demand for food of animal origin is expected to increase in developing countries because of escalation in human population, urbanization and income improvements especially in urban areas (Abdullah *et al*., 2011). The poultry sub-sector is one of the major protein sources that can meet the rising demand for protein of animal origin, attributed to the high rate of reproduction and feed conversion efficiency. Moreover, the sub-sector has the potential to create both rural and urban employment and generate income at various economic levels (Tekalign *et al*., 2017).

Eggs are endowed with high quality proteins and have been used as a standard of high biological value (Lakhotia, 2002). However, productivity per bird and the contribution of the sub-sector to the national economy is low in Ethiopia. Availability, quality and market price of the conventional energy and protein sources are factors that limit the productivity of poultry in the tropics, including Ethiopia (Atawodi, 2008). Moreover, commercial poultry production is largely dependent on high quality grains, used as human food, putting it in a direct competition with human population, which leads to increased cost of poultry production (Gura, 2008). This situation warrants the evaluation of locally available none conventional feeds for inclusion into poultry ration.

Ethiopia is endowed with diverse agro-climatic conditions favoring production of many different kinds of crops, providing a wide range of alternative feedstuffs suitable for poultry feeding (Tadelle *et al*., 2002). One of such crop is enset (*Ensete ventricosum*). *Ensete ventricosum* (Welw.) Cheesman, Musaceae] is a monocarpic short-lived perennial plant which is widely cultivated in the central, southern and south-western parts of Ethiopia. It is estimated that about 35% of the total population in Ethiopia live in areas where enset is a very important food crop, indicating that enset products are staple foods in Ethiopia (CSA, 2014). The pseudo-stem, corm and the stalk of the inflorescence constitute the most important components of enset (Adugna, 2008). Over 70% of the enset plant is composed of pseudo-stem and corm (Ajebu *et al*., 2008). The major food products obtained from the enset plant are *kocho, bulla* and *amicho*

Enset corm has the high concentration of highly soluble carbohydrates and starch, but very low in fibre and cellulose (Mohammed *et al*., 2013). The corm, botanically the underground stem of enset, is used for vegetative propagation of enset. The corm can be processed with pseudo-stem to produce *kocho*. 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, particularly during an extended drought. 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 between 25.6 and 186.6 mg per 100 g of corm and the amounts of most amino acids are higher than that of potato.

Ajebu and Eik (2014) indicated that corm could be used as an alternative energy source in the diet of sheep. However, there is lack of information on the effect of feeding enset corm on performance and egg quality of layer chickens. Therefore, the present experiment was planned to evaluate the effect of partial substitution of maize grains with enset corm on the production and reproduction performance of White Leghorn layers.

Materials and Methods

Description of the study area

The experiment was conducted at Haramaya University poultry farm, located at 42°3' east longitude, 9°26'north latitude, at an altitude of 1980 meter above sea level 505 km east of Addis Ababa. The mean annual rainfall of the area was reported to be 780 mm and the average minimum and maximum temperature is 8 and 24°C, respectively (Samuel, 2008).

Treatment ration preparation

Enset plants of age 4-6years of "Ashakti" variety were bought from farmers in south west Shewa zone, *Daryan* Kebele, Oromia Regional State, Ethiopia. Fresh enset corm was dug out after removing the aerial part of enset plant. Whole fresh enset corm was washed, cleaned and sifted, peeled, chopped into small slices and sun dried over plastic sheet for five days. It was regularly turned to prevent uneven drying and decaying. The other feed ingredients i.e maize grain, wheat short, soybean meal, noug seed cake, salt, vitamin premix and dicalcium phosphate were purchased from the local market. Dried enset corm, maize grain, noug seed cake and salt were ground to pass through 5mm sieve before mixing. Finally the four treatment rations (Table 1) were formulated based on the results of the laboratory chemical analysis. The treatment rations were formulated to meet the nutrient requirements of layers (Leeson and Summers, 2005). Enset corm was included into the treatment ration to replace 0, 15, 30, and 45% of maize by weight in T_1, T_2, T_3 and T_4, respectively.

Management of the experimental animals

A total of 180 White Leghorn layers of 26 weeks of age were obtained from Haramaya university poultry farm. Before the commencement of the experiment, layers were managed under feed containing 20% CP and ME content 2800kcal/kg DM during starter phase and 16% CP and ME content of 2700kcal/kg DM during the grower stage. They were randomly divided into 12 groups of 15 birds each with equally mean group weight. Each group was housed in an individual pen covered with sawdust and equipped with all the necessary layers house equipment's. Before the commencement of the actual experiment, all the experimental pens were thoroughly cleaned, disinfected and sprayed against external parasites. The pullets were vaccinated against Newcastle, Gumburo and Fowl Typhoid diseases. Vitamins were given as vitamin premix mixed in the diet. The wet litter was changed with dry, disinfected and clean sawdust whenever necessary. Twenty four cocks were randomly distributed to each group of layers (2cock/group). The treatment rations were randomly allocated to the experimental layers in Completely Randomized Design with 3 replications and lasted 12 weeks.

Table 1: Treatment ration used in the experiment

Ingredients	Treatments			
	T1	T2	T3	T4
Maize	43.5	37	30.5	24
Enset corm	0	6.5	13	20
Wheat short	17	17	17	17
Noug seed cake	17	16	17	16.5
Soybean meal	14	15	14	14
Vitamin premix*	1	1	1	1
Salt	0.5	0.5	0.5	0.5
Lime stone	6.5	6.5	6.5	6.5
Dicalcium phosphate	0.5	0.5	0.5	0.5
Total	100	100	100	100

T1 = 0% enset corm; T2 = 6.5% enset corm ; T3 = 13% enset corm ; T4 = 20% enset corm as partial replacement to 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, Iodine= 200 mg, Selenium = 80 mg, Calcium = 28.2%

Feed was offered twice per day on an *ad libitum* base and refusal was removed the next day. Clean water was made available all the times. Feed offered and refused were sampled daily per pen and pooled per treatment for the entire experimental period for chemical analysis. Hens were weighed at the start and end of the experiment. Eggs were collected three times a day and weighed immediately. The mean daily feed intake, body weight change, feed conversion ratio, hen-day egg production and egg weight, egg quality parameters, fertility and hatchability, chick quality and economic analysis were used as treatment evaluation parameters.

Egg production and quality parameters

Egg mass per hen was calculated as total egg weight divided by number of hens and hen-day egg production was determined according to Hunton (1995). Egg quality characteristics were determined at an interval of 7 days using freshly laid eggs. Egg shell, albumen and yolk weights were measured using sensitive balance. Albumen and yolk height were measured with a tripod micrometer. Egg shell thickness was measured by micrometer gauge. Yolk color was determined by comparing the egg color with Roche Color Fan measurement. Haugh unit was calculated from the egg weight and albumen height using the formula suggested by Haugh (1937). Egg and yolk shape indexes were computed according to Penda (1996).

Fertility, hatchability and chick quality

Adequate eggs stored for ≤7 days at a temperature of 10-14^{o}C and selected against undesirable size, shape and shell characteristics were incubated. The eggs were candled on the 9th day of incubation for the determination of percentage fertility. Average percentage hatchability of the fertile eggs was computed by dividing the number of chicks hatched by the number of fertile eggs. Early, mid, late and pipe embryonic mortalities were determined on the 9th, 14th, 18th and the last days of incubation using the method of Bonnier and Kasper (1990).Chick quality was determined according to Molenaar *et al.*(2009) and chick length was determined according to the method of Meijerhof (2005). Chick weight at hatching was determined by weighing the chick after 12 hours of hatching (Molenaar *et al*., 2009). Yield percentage was calculated as the percentage of average chick weight to average initial egg set weight (Molenaar *et al*., 2009).

Economic consideration

The procedure of partial budget analysis developed by Upton (1979) was applied to estimate the economic benefits of each treatment ration, the market price of each feed ingredients were registered at the time of purchase. Total Return (TR) was calculated as a total egg produced multiplied by price of egg at Haramaya University during the experimental period. Net return (NR) was calculated as TR (Total return)-TVC (Total Variable Cost) (in this case feed cost). Change in total variable cost (ΔTVC) was calculated as total feed cost of the treatments containing enset corm (termed as experimental ration) minus total feed cost of treatments without enset corm (control). The change in total return (ΔTR) was calculated as the difference between total incomes from the respective experimental treatments minus total income of the control. Change in net return (ΔNR) was calculated as net return of the respective experimental treatments minus net return of the control experiment. The marginal rate of return (MRR) measures increases in net return (ΔNR) associated with each additional units of expenditure (ΔTVC). It is calculated as: $MRR = \Delta NR / \Delta TVC$.

Chemical analysis of feeds

Dried feed samples were milled to pass through 1 mm screen for chemical analysis. Samples were analyzed for dry matter, crude protein, ether extract, crude fibre and ash according to

AOAC (2000). Calcium and total phosphorus content of enset corm was analyzed by atomic absorption and vanado-molybdate methods, respectively (AOAC, 1998) and beta-carotene content of enset corm was determined by spectrophotometer (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

The data were analyzed using the general linear model procedure of SAS (SAS, 9.1) using the model $Y_{ij} = \mu + T_i + e_{ij}$, Where: Y_{ij} = the j^{th} observation in the i^{th} treatment level, μ = over all mean, T_i = treatment effect and e_{ij} = random error. Differences between treatment means were separated using Tukey Kuramer Test (SAS, 9.1). The means were considered significant at $P < 0.05$.

Results and Discussion

Chemical composition of feeds

The CP content (3.20%) of enset corm is similar to the value (3.33%) reported by Mohammed *et al*. (2013) (Table 2).

Table 2. Chemical composition (% dry matter unless specified) of the feed ingredients

Item	Ingredients				
	Enset corm	Maize	Wheat short	Noug seed cake	Soya bean meal
Dry matter (%)	86.3	92.4	91.8	92.7	91.9
Ash	5.4	3.2	4.6	13.0	6.1
Crude Protein	3.2	9.3	15.7	31.8	40.8
Ether Extract	3.2	3.5	5.8	9.8	1.4
Crude Fibre	2.1	2.6	7.1	14.7	4.1
ME (kcal/kg DM)	3718	3657	2664	2518	2660
Ca	0.41	0.14	0.13	0.31	0.32
P	0.02	0.3	0.3	0.6	0.70

ME =Metabolizable energy, Kcal= kilo calories, Metabolizable energy (Kcal/Kg DM) = 3951+ 54.40 Crude fat – 88.70 Crude fiber – 40.80 Ash (Wiseman, 1987)

Table 3: Chemical composition (% DM, unless specified) of experimental diets

Nutrient contents	Treatments			
	T1	T2	T3	T4
Dry matter (%)	92.85	92.44	92.05	91.65
Crude fiber	7.05	6.96	6.90	6.83
Ether extract	3.64	3.68	3.80	3.88
Nitrogen free extract	49.4	48.7	48.2	47.6
Ash	15.83	15.89	16.32	16.82
Calcium	2.91	2.92	2.92	2.93
Total Phosphorus	0.54	0.54	0.53	0.53
Crude protein	17.46	17.25	16.86	16.56
ME (kcal/kg DM)	2877	2885	2880	2870

T1 = 0% enset corm; T2 = 6.5% enset corm; T3 = 13% enset corm; T4 = 20% enset corm as partial replacement to maize

A lower value of CP (2.2%) was reported by Ajebu and Eik (2014). The CP content of enset corm is low in general indicating the need for supplementation with feeds sources high in CP such as noug cake and soyabean meal. However, the ME content of enset corm was higher than the other feed ingredients used in this experiment except that of maize grain which has comparable value. The ME content of 3718 kcal/kg of DM reported for enset corm in the current study was higher than value of 3378 kcal/kg of DM reported by Mohammed *et al.* (2013). Variety and age of enset plant may have contributed to the variation in ME content of enset corm. The ME value of enset corm obtained in this study justifies its potential in substituting energy value of cereals such as maize in the diets of layers. The phosphorus content of enset corm was lower than that of the other feed ingredients used in this study. The calcium and phosphorous contents of the treatment diets are shown to be within the recommended values for layers.

Production performance

The mean daily DM intake of the group placed on T1 was significantly lower ($P<0.05$) than the group placed on T2, T3 and T4. On the contrary, there was no significant difference ($P>0.05$) between the groups fed with the latter three treatments (Table 4). The higher mean daily DM intake of groups of layers fed T2, T3 and T4 indicates that the inclusion of 6.5%, 13% and 20% of enset corm to replace maize in layers ration is acceptable and palatable. Consistent to the current result, Ngiki *et al.* (2014) reported increasing trends of feed intake with increasing levels of cassava root meal as substitute for maize. A linear increase of DM intake was observed in sheep consumed supplement containing graded levels of enset corm as a replacement to maize in the ration (Ajebu and Eik, 2014). Afolaya *et al*. (2013) reported significantly lower feed intake for layers fed with ration consisting up to 20% sweet potato diet as a replacement for maize. On the other hand, Ajebu *et al*. (2015) noted similar feed intake for broiler chicks fed with 0%, 33%, 67% and 100% *kocho* diets substituting maize. Raphael *et al*. (2013) also reported that replacement of maize with cassava root meal has similar effect on DM intake in laying hens.

Table 4: Feed intake, body weight change and egg laying performance of white leghorn hens fed graded levels of enset corm

Variables	Treatments				
	T1	T2	T3	T4	SEM
DM intake (g/hen/d)	119.1[b]	124.9[a]	126.1[a]	124.4[a]	1.31
Initial body weight (kg)	1.11	1.10	1.11	1.12	0.01
Final body weight (kg)	1.71	1.68	1.67	1.65	0.01
Average daily gain (g/head)	7.14	6.90	6.67	6.31	1.31
Hen-day egg production (%)	42.50	43.40	44.40	42.20	0.65
Egg mass (g/hen/day)	20.90	21.70	20.30	19.60	0.81
Egg weight (g)	49.50	50.70	49.60	51.90	0.67
FCR (g of feed DM/g of eggs)	2.60	2.70	2.50	2.70	0.03
Mortality rate (%)	5.10	6.70	6.70	5.10	1.85

[a,b] Means within a row with different superscripts differ (p<0.05);T1 = 0% enset corm; T2 = 6.5% enset corm; T3 = 13% enset corm; T4 = 20% enset corm as a partial replacement to maize; SEM = Standard Error of the Mean; FCE= Feed conversion efficiency

Average daily gain, HDEP, egg mass, egg weight, feed conversion efficiency and mortality rate were not different (P > 0.05) among treatments. Absence of significant variation in hen-day egg production in the present study indicates that inclusion of enset corm diet up to 20% as a partial replacement for maize could be used to support the nutrient requirements of layers. Similarly, Smith (2003) observed up to 50% replacement of maize in the ration by cassava root meal show similar effect on egg laying performance. Saentaweesuk *et al.* (2000) noted that total substitution of maize by cassava in layers ration did not affect production performances. However, Anaeto and Adighibe (2015) observed decreasing trends in HDEP of layer fed with an increasing level (0%, 25%, 50%, 75% and 100%) of cassava root meal diets replacing maize. Senkoylu *et al*. (2005**)** noted that cassava tuber meal inclusion above 50% reduced egg production and egg quality as compared to maize based ration. On the other hand, Akinola and Oruwari (2007) noted increased egg production as the level of cassava tuber meal substituted 100% of the maize. Ladokun *et al*. (2007) also showed higher HDEP for layers that consumed 50% sweet potato meal rations compared with diets containing only maize. Mortality rate was similar for hens fed diets with or without enset corm. This justifies that mortality noted in the present study is not related to inclusion of enset corm. Afolayan *et al*. (2013) showed that replacing maize with sweet potato meal did not affect the health status of the layers.

Egg quality characteristics

Egg quality parameters were similar (P>0.05) for all the treatment groups (Table 5). The similarity of egg quality characteristics indicates that maize can be replaced with enset corm in white leghorn layers ration without affecting egg quality parameters. Aderemi *et al*. (2012) also reported similar effect for substitution of maize with whole cassava meal on both internal and external egg quality parameters. Aina and Fanimo (1997) noted similar effect on egg weight, shell thickness and Haugh unit with complete substitution of maize by cassava tuber and sweet potato meals in layers ration. However, Anaeto and Adighibe (2015) reported significant decrease in shell thickness, albumen weight and yolk weight as the level of cassava tuber meal increased beyond 50%. Fafiolu *et al.* (2006) also recorded a slightly higher yolk color on 30% malted sorghum grain replacing maize. The similarity of yolk color recorded in the current result for feed with and without enset corm justifies that enset corm can replace maize without affecting yolk color. Wu *et al.* (2007) observed lack of effect of energy levels on yolk color. Egg yolk color is a very important factor in consumer satisfaction and influence human appetite (Amerine *et al.*, 1995).

Fertility, hatchability and chick quality

The values of fertility, hatchability, embryonic mortality and chick quality characteristics were not different (P>0.05) among treatment groups (Table 6). Similar values of fertility and hatchability among treatment groups justify that maize can be replaced with enset corm in layers ration. Haftu *et al*. (2014) reported similar fertility and hatchability levels of eggs collected from white leghorn layers fed different levels (0%, 10%, 20% and 30%) malted barley diets replacing maize. Zebib and Mengistu (2012) also noted similar fertility and hatchability percentages from layers fed with varying levels (0%, 25%, 50%, 75% and 100%) of sorghum diets as a substitute for maize. Etalem *et al*. (2013) observed higher hatchability of fertile eggs collected from birds fed with 50% cassava meal compared with 100% maize. Odunsi *et al*. (2002) indicated inadequacy of nutrients in the breeder diets to result in poor hatchability of fertile eggs. Thus, the present result indicated that replacing enset corm for maize up to 20% could supply nutrients similar to maize for fertility and hatchability.

Table 5: Egg quality characteristics of white leghorn hens fed graded levels of enset corm

	Treatments				
Egg quality parameters	T1	T2	T3	T4	SEM
Sample egg weight (g)	52.25	51.81	51.78	50.43	0.33
Egg length (mm)	55.3	57.5	54.3	55.5	1.32
Egg width (mm)	40.6	40.4	40.2	40.5	0.01
Egg shape index	73.17	70.87	73.4	72.99	1.46
Egg shell weight (g)	5.59	5.56	5.71	6.07	0.06
Egg shell thickness (mm)	0.31	0.31	0.32	0.33	0.002
Egg albumen weight (g)	31.09	30.33	30.20	30.07	0.24
Albumen height (mm)	7.84	7.31	7.36	7.92	0.17
Haugh unit	89.48	87.46	91.70	89.80	1.15
Egg yolk weight (g)	15.47	15.43	15.38	14.98	0.24
Egg yolk height (mm)	15.35	15.16	15.40	14.8	0.17
Egg yolk diameter (mm)	49.2	47.7	48.0	49.2	0.05
Egg yolk index	0.31	0.32	0.32	0.30	0.03
Yolk color (RSF*)	3.4	3.3	2.83	2.9	0.13

Means within a row with different superscripts differ ($p<0.05$); T1 = 0% enset corm; T2 = 6.5% enset corm; T3 = 13% enset corm; T4 = 20% enset corm as a partial replacement to maize; *RSP = Roche scale points; SEM = Standard error of the mean

The absence of statistically significant difference in embryonic mortalities between treatment groups justifies that enset corm could replace maize without affecting embryonic development. Zebib and Mengistu (2012) observed similar levels of embryonic mortality for birds fed with different levels (0%, 25%, 50%, 75% and 100%) of sorghum diets replacing maize in white leghorn layers ration. Similarly, Mihret and Mengistu (2012) noted lack of effect on embryonic mortalities in layers fed varying levels (0%, 25%, 50%, 75% and 100%) of dried cassava tuber meal diets replacing maize. On the other hand, Etalem *et al*. (2013) reported lower early and mid-embryonic mortalities for layers fed with 50% cassava root chips as a substitute for maize as compared to the group fed ration based on maize as a major energy diet.

Abiola *et al. (*2008) documented positive correlation between egg size and chick weight at hatching. Similarly, Mihret and Mengistu (2012) reported positive correlation of chick weight and length for birds fed with cassava tuber meal as a substitute for maize. Accordingly, the similarity in chick weight between all the treatment groups could be attributed to the similarity of egg weight among the treatment groups. Moreover, it may show that replacing maize with enset corm does not affect chick development and all ration consisted sufficient amount of nutrients to support embryonic development. This observation is in agreement with the finding of Etalem *et al*. (2013) who reported similar chick weight for birds fed with cassava root chips as a substitute for maize. Zebib and Mengistu (2012) also reported similar chick weight for birds fed with sorghum grain as a substitute for maize. On the other hand, Haftu *et al*. (2014) showed higher chick weight for birds fed with 20% and 30% malted barley grain replacing maize in the white leghorn layers ration. Absence of difference in chick length in the present study is in agreement to previous studies that evaluated effects of replacing malted barley grain (0%, 10%, 20% and 30%) with maize (Haftu *et al*., 2014). Chicks with better yolk utilization could have developed more body mass during the incubation period, and therefore grew longer (Meijerhof, 2006).

Table 6: Fertility, hatchability and chick quality characteristics of white leghorn layers fed different proportion of enset corm as a partial replacement for maize

Chick quality Parameters	Treatment				
	T1	T2	T3	T4	SEM
Fertility (%)	98.00	96.67	96.0	98.0	0.36
Hatchability on fertile egg bases (%)	76.22	75.97	73.78	76.19	2.65
Early Embryonic mortality (%)	4.78	4.85	5.6	4.75	0.36
Mid Embryonic mortality (%)	3.38	2.75	2.78	2.74	0.45
Late Embryonic mortality (%)	5.43	5.50	5.55	6.12	0.50
Pipe Embryonic mortality (%)	8.17	7.59	8.33	8.19	0.56
Chick weight (g)	33.10	32.87	32.81	32.04	0.53
Chick length(cm)	15.42	15.29	15.22	15.20	0.08
Yield percentage	45.21	47.07	44.83	46.91	1.49

Means within a row with different superscripts differ ($p<0.05$); T1 = 0% enset corm; T2 = 6.5% enset corm; T3 = 13% enset corm; T4 = 20% enset corm as a partial replacement to maize; SEM = standard error of mean

Economic consideration

The result obtained from partial budget analysis indicated that replacement of maize with 13% enset corm gave higher NR while the remaining treatments were ranked T2>T1>T4 (Table 7). The change in total variable cost in all the treatment groups was positive but the change in net return was negative for T4. The highest net return from 13% *enset* corm diet is because of the higher egg production and lower cost of the enset corm as compared to maize. This means that the cost of egg production decrease with increasing enset corm as an energy ingredient up to 13% level of replacement of maize. Medegu *et al*. (2011) also reported highest cost per kg feed in maize-based diet compared to sorghum based diets.

Table 7: Economics of feeding graded levels of *enset* corm

	Treatments			
Total cost	T1	T2	T3	T4
Total feed consumed/ head (kg)	10.4	11.0	10.9	11.1
Total feed cost/head (birr)	62.6	67.5	68.4	70.7
Total Variable Cost(feed cost) (birr)	62.6	67.5	68.4	70.7
∆TVC (birr)	-	4.9	5.8	8.6
Total revenue				
Total number of egg produced/hen	38.0	43.0	44.0	38.0
Total Return (TR)(birr)	95.0	107.5	110.0	95.0
∆TR (birr)	-	12.5	15	0
Net Return(NR) (birr)	32.4	40.0	41.6	24.3
∆NR (birr)	-	7.6	9.2	-8.1
MRR (%)	-	1.55	1.58	-0.94

∆TVC = Change in Total Variable Cost; TR= Total Return; ∆TR= Change in Total Return; NR=Net Return; ∆NR=Change in Net Return; MRR = Marginal Rate of Return; Birr= Ethiopia's unit of currency: US $ 1.00= Birr 22.00; Egg sale = 2.5 birr/egg; T1 = 0% enset corm; T2 = 6.5% enset corm; T3 = 13% enset corm; T4 = 20% enset corm as a partial replacement to maize

Conclusion

The dry matter intake was the highest for layers fed with the treatment ration containing 20% enset corm diet. However, egg quality parameters, fertility, hatchability and chick quality were similar for layers fed with the treatment ration containing 0%, 6.5%, 13% and 20% enset corm as a substitute for maize in layers diet. The net return gained from the inclusion of 13% enset corm to replace 30% of maize was more economical in terms of egg production and feed cost. Therefore, due to the year round availability and easy access by smallholder farmers in enset growing areas of Ethiopia, enset corm could safely and economically used in replacing about 30% of maize in layers ration.

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