Effects of Replacing Maize with *Kocho* in White Leghorn Layers Ration on Egg Production, Egg and Chick Quality, Fertility and Hatchability

Nigussu Fekade[1*], Mengistu Urge[2], Ajebu Nurfeta[3], and Getachew Animut[4]

[1]Department of Animal Sciences, Assosa University, P. O. Box 18, Assosa, Ethiopia
[2]School of Animal and Range Sciences, Haramaya University, P.O. Box 138, Dire-Dawa, Ethiopia
[3]School of Animal and Range Sciences, Hawassa University, P.O. Box 5, Hawassa, Ethiopia
[4]Agricultural Transformation Agency, P.O.Box 708, Addis Ababa, Ethiopia

Abstract: One hundred and eighty 26-week old white leghorn layers were used to evaluate the effect of replacing maize with *kocho* on egg production, egg and chick quality as well as fertility and hatchability. The layers were fed with ration containing *kocho* at the levels of 0% (T1), 33% (T2), 67% (T3) and 100% (T4) replacing white maize grain in the ration. The experiment was arranged in a completely randomized design with four treatments, each replicated three times with 15 birds each. The experiment lasted 12 weeks. Hens were weighed at the start and end of the experiment. Data on dry matter intake, hen day egg production (HDEP), egg weight and egg mass were recorded daily. Egg quality parameters (egg shell weight and thickness, albumen weight and height, Haugh unit and yolk weight as well as color) were determined at the interval of 7 days on 4 eggs per replicate. *Kocho* contained 3663 kcal/kg DM, 3.8% CP, 2.5% ether extract, 2.3% crude fiber and 1.5µg/100g beta-carotene. Highly significant ($P<0.05$) dry matter intake (140.2, 136.9, 133.4 and 152.4 g for T1, T2, T3 and T4). Respectively, and average daily gains (1.93, 2.02, 1.91, 1.96 g) were recorded for T4. Egg mass, egg weight and feed conversion ratios were statistically similar ($P>0.05$) among treatments. HDEP for T3 (53.83 %) and T4 (53.62%) was similar and significantly ($P < 0.05$) higher than T1 (40.54%) and T2 (43.19%). Egg quality characteristics, except yolk color were similar ($P > 0.05$) among treatments. Yolk color was higher ($P < 0.05$) for T1 compared with T3 and T4. Percent hatchability on fertile egg bases for T4 was significantly ($P<0.05$) lower than the remaining treatments while T2 and T3 were similar. Mid embryonic mortality was significantly ($P < 0.05$) higher for T4 compared to the rest of the treatments but T2 and T3 had similar values. The lowest ($P < 0.05$) late embryonic mortality was recorded for T1. Fertility, early and pipe embryonic mortalities, chick weight, chick length and yield percentage were similar ($P > 0.05$) among treatments. The partial budget analysis indicated that replacement of maize with 67% (T3) *kocho* gave a higher net return. Therefore, *kocho* can replace maize in layers ration when there is scarcity of maize in enset growing areas of Ethiopia.

Keywords: Egg production; Fertility; Hatchability; *Kocho,* Layers

1. Introduction

Poultry production plays an important role in Ethiopia's economy. It renders a significant contribution to household income and food security particularly in providing animal protein to the people (Gondwe, 2004). However, the productivity per unit of bird and the contribution of this sector to the national economy is relatively low in Ethiopia. Feed scarcity and consequent high price of conventional energy and protein sources are factors that limit the productivity of poultry in Ethiopia (Aberra *et al*., 2011). Compared to other animals, feed resources for commercial poultry production are grains of good quality, which also are used as human food. This put the sector in a direct competition for grains which leads to increased cost of poultry production (Gura, 2008).

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 cultivated in the central, south and south-western parts of Ethiopia, where an estimated 35% of the total population of Ethiopia lives and the plant is used as one of the staple food in these areas (CSA, 2014). The pseudo-stem, corm and the stalk of inflorescence constitute the most important components of enset (Adugna, 2008). Over 70% of the enset plant is composed of pseudostem and corm (Ajebu *et al*., 2008). The major food products obtained from the enset plant are *kocho, bulla* and *amicho*.

Kocho is bulky, fermented starch, made from a mixture of the decorticated pseudostem and grated root fermented with yeast, in a traditionally dug out pit (Admasu, 2002). As indicated by Tsegaye (2001) *kocho* has high carbohydrate (96%) the content even more than maize (83%). According to Admasu (2002) *kocho* yield of enset per unit of space and time, in terms of edible dry weight and energy was much higher than the yields of any other crops cultivated in Ethiopia. *Kocho* could be produced throughout the year and hence is available year round unlike that of maize and it can be stored for a long period of time without spoiling.

Earlier work shows that substitution of maize with *kocho* up to 100% resulted in similar dry matter intake, average daily gain, and carcass yield of Hubbard broiler chicks (Ajebu *et al*., 2015) and could be used as an alternative ingredient to replace maize in the diet of sheep (Ajebu *et al*., 2012). However, there is scarcity of information regarding the effect of feeding *kocho*

*Corresponding Author. E-mail: ngusufekade@gmail.com

ISSN 1993-8195 (Online), ISSN 1992-0407(Print)

on performance and egg quality of layer chickens. Therefore, the present experiment was conducted to evaluate the effect of replacing *kocho* for maize on egg production, egg and chick quality, fertility and hatchability of white leghorn layers.

2. Materials and Methods

2.1. 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 2006 meters above sea level. The mean annual rainfall of the area was reported to be 780 mm and the average minimum and maximum temperature are 8 and 24°C, respectively (Samuel, 2008).

2.2. Experimental Feeds Preparation

Enset plants of age 4-6 years of "Ashakti" variety were bought from farmers in *Daryan* kebele, South west Shewa zone, Oromia Regional State, Ethiopia. The pseudo-stem and corm were pulverized with a long wooden (bamboo) pestle and pound into a pulp from which the fibers were removed. The remaining scrapings, the pulp, and the inner core were kneaded together, rolled into balls, and wrapped in a fresh enset leaves. The leaf packages with fresh enset mash were packed into a pit in the ground that has been completely lined with leaves and left to ferment for fifteen days (Asres and Omprakash, 2014). The fibre of wet *kocho* was separated by hand. Then the wet *kocho* was spread over plastic sheet to sundry until it becomes safe for storage. Feed ingredients used to formulate the rations for the study were *kocho,* maize grain, wheat short, soybean meal, noug seed cake, salt, vitamin premix and dicalcium phosphate (Table 1).

Maize, noug seed cake and salt were ground at Haramaya University feed mill to pass through 5mm sieve before mixing to formulate the rations. The feed ingredients used for the experiment (except *kocho*) were purchased from local market. The treatment rations used in the present study were formulated to be nearly isocaloric and isonitrogenous with 2800 kcal ME/kg DM and 16.0% CP to meet the nutrient requirements of layers (Leeson and Summers, 2005). *Kocho* was included into the treatment ration to replace 0, 33, 67, and 100% of maize for T_1, T_2, T_3 and T_4, respectively.

Table 1. Proportion of the feed ingredients used in formulating layers rations.

Ingredients	Treatments			
	T1	T2	T3	T4
Maize	43.5	29	14.5	0
Kocho	0	14.5	29	43.5
Wheat short	17	17	13	10
Noug cake	17	17	17	17
Soybean meal	14	14	18	21
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

Note: T1 = 0% *kocho*; T2 = 33% *kocho*; T3 = 67% *kocho*; T4 = 100% *kocho* as 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%.

2.3. Experimental Animals Management and Experimental Design

A total of 180 white leg horn pullets with body weight of 1.13±0.06kg (Mean±SD) and age of 26 weeks were used for the experiment. Pullets used in the study were obtained from Haramaya University poultry farm. Pullets were grown with feed containing 20% CP and 2800kcal/kg DM ME during starter phase and 16% CP and 2700kcal/kg DM ME during the grower phase. Before placing the pullets into the experiment house, the experimental pens, watering and feeding troughs and laying nests were thoroughly cleaned, disinfected and sprayed against external parasites. The floor of the pens was covered with disinfected sawdust. The pullets were vaccinated against Newcastle, Gumburo and Fowl Typhoid diseases using appropriate vaccine according to the manufacturer's recommendation. Vitamins were given as vitamin premix mixed in the diet. Each pen was equipped with individual laying nests, covered with saw dust. The wet litter was changed with dry, disinfected and clean sawdust whenever required.

The birds were randomly allocated to four dietary treatment groups in a CRD design. Each treatment has three replicates comprising 15 pullets and 2 cocks per replicate. Each pen has a 2 x 2.4m wire mesh partitioned pens. Twenty four cocks were randomly and equally distributed to each replication. During the twelve weeks period of the study, the birds were subjected to similar managerial and sanitary conditions.

2.4. Feed intake and Laying Performance of Hens

Feed was offered *ad libitum* with 10% refusal twice per day at 0800 and 1700hours and clean tap water was available all the time. The amount of feed offered and refused per pen was recorded daily, and the amount consumed was determined as the difference between the two. Feed offered and refused were sampled daily per pen and pooled per treatment for the entire experimental period for chemical analysis. Hens were individually weighed at the start and end of the experiment and body weight change was calculated as the difference of the two weights. Eggs laid in a pen were collected three times a day at 0800, 1300 and 1700hours. Eggs collected daily were weighed immediately after collection for each pen and average egg weight was computed by dividing the total egg weight to the number of eggs. Egg mass per hen was calculated as total egg weight divided by number of hens. Hen-day egg production was determined according to Hunton (1995). Feed conversion ratio was calculated as gram of eggs produced per gram of feed consumed.

2.5. Egg Quality Characteristics

Egg quality parameters, such as egg shell weight, egg shell thickness, albumen weight, albumen height, egg yolk weight and egg yolk color were determined at an interval of 7 days on freshly laid 4 eggs per replicate after breaking and separating each of the components. 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 eggshell thickness micrometer gauge. Measurements of egg shell thickness were taken from three regions (large end, small end and on the equator region of the eggshell) and the average value was taken. Yolk color was determined by comparing the color of properly mixed yolk sample placed on white paper with the color strips of Roche fan measurement, which consist 1-15 strips ranging from pale to orange yellow color. 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).

2.6. Fertility, hatchability and chick quality

The eggs for incubation were collected towards the end of the study and stored for 7 days at a 10-14^{o}C. Good shape, clean shell, no cracks, medium or average sized eggs (50 eggs for each replication) were selected and used for incubation. 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 from the incubated eggs at 9th, 14th, 18th and on the last days of incubation, respectively by breaking all unhatched eggs with respective replicate 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 evaluates the weight loss during incubation and was calculated as the percentage of average chick weight to average initial weight of egg set (Molenaar *et al.*, 2009).

2.7. Economic Evaluation

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

2.8. Feed Chemical Analysis

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 following the proximate method of analysis (AOAC, 1990). Calcium and total phosphorus content was analyzed by atomic absorption and vanado-molybdate method, respectively (AOAC, 1990) and beta-carotene content of *kocho* 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 follows: ME (Kcal/kg DM) = 3951 + 54.4EE - 88.7CF - 40.8 ash.

2.9. Statistical Analysis

Data was analyzed using the general linear model procedure of Statistical Analysis Systems software (SAS, 2009). Differences between treatment means were separated using Tukey Kuramer Test. The following model was used for data analysis. $Y_{ij} = \mu + T_i + e_{ij}$, Where: Y_{ij} = represents the jth observation in the ith treatment level, μ = over all mean, Ti = treatment effect and e_{ij} = random error. The effect was considered significant at $P < 0.05$.

3. Results

3.1. Chemical composition of the feeds

The CP content of *kocho* was the lowest compared with other ingredients (Table 2). The ME content of *kocho* was higher than other ingredients, except maize grain which had almost similar value. Phosphorus content of *kocho* was lower than any other ingredients used to formulate treatment diets.

Table 2. Chemical composition (% DM) of the feed ingredients and treatment diets.

Ingredients and treatments	DM (%)	Ash	CP	EE	CF	ME	Ca	P	Beta-carotene (μg/100 g)
Kocho	86.3	5.8	3.8	2.5	2.3	3647	0.5	0.06	1.5
Maize	92.4	3.2	9.3	3.9	3.8	3657	0.1	0.30	ND
Wheat short	91.8	4.6	15.7	3.3	7.8	2664	0.1	0.30	ND
Noug cake	92.7	13.0	31.8	8.2	15.2	2518	0.3	0.60	ND
Soyabean meal	91.9	6.1	44.7	4.9	12.6	2660	0.3	0.70	ND
T1	92.8	15.8	16.5	3.6	6.9	2893	2.09	0.35	ND
T2	91.8	16.9	16.9	3.9	7.3	2827	2.12	0.33	ND
T3	91.7	17.0	16.9	4.0	7.4	2820	2.22	0.37	ND
T4	89.6	13.3	15.8	4.4	8.8	2868	2.23	0.31	ND

Note: DM= Dry matter; CP= Crude protein; EE= Ether extract; CF= Crude fibre; T1 = 0% *kocho*; T2 = 33% *kocho*; T3 = 67% *kocho*; T4 = 100% *kocho* as replacement to maize*; Ca = calcium; P = phosphorous;* ME =Metabolizable energy (kcal/kg DM); ND=Not Determined

Table 3. Dry matter intake, body weight change and egg laying performance of white leghorn hens fed *kocho* as a replacement to maize.

Variables	Treatments				SEM	P value
	T1	T2	T3	T4		
DM intake (g/hen/d)	130.1^{b}	125.7^{b}	122.3^{b}	136.5^{a}	3.49	0.001
Initial body weight (kg)	1.15	1.09	1.14	1.14	0.01	0.342
Final body weight (kg)	1.31	1.26	1.30	1.30	0.05	0.246
Body weight gain (g/hen/day)	1.93	2.02	1.91	1.96	0.10	0.640
Hen-day egg production (%)	40.54^{b}	43.19^{b}	53.83^{a}	53.62^{a}	1.88	0.027
Egg mass (g/hen/day)	15.15	15.65	20.73	22.21	0.74	0.054
Egg weight (g)	51.13	51.42	51.36	52.12	0.38	0.627
FCR (g feed DM/g egg)	3.04	2.76	2.71	2.72	0.04	0.442
Mortality rate (%)	7.89	-	-	-		

Note: ^{a,b} Means within a row with different superscripts differ (p<0.05); T1 = 0% *kocho*; T2 = 33% *kocho*; T3 = 67% *kocho*; T4 = 100% *kocho* as replacement to maize; DM=dry matter; SEM = Standard error of the mean; FCR= Feed conversion ratio replacement to maize.

Table 4: Egg quality characteristics of White leghorn hens fed *kocho* as a replacement to maize

Egg quality parameters	Treatment				SEM	P value
	T1	T2	T3	T4		
Sample egg weight (g)	51.1	51.8	51.42	51.12	0.41	0.558
Egg length (mm)	54.4	54.4	54.5	55.5	0.02	0.449
Egg width (mm)	41.7	40.7	40.4	40.1	0.61	0.099
Egg shape index	73.82	74.73	74.00	72.40	11.35	0.830
Egg shell weight (g)	6.04	5.92	5.95	5.63	0.07	0.235
Egg shell thickness (mm)	0.322	0.301	0.294	0.293	0.00	0.115
Egg albumen weight (g)	29.78	30.91	30.55	30.07	0.27	0.537
Albumen height (mm)	8.06	8.40	8.18	8.12	0.13	0.857
Haugh unit	91.50	93.02	92.14	92.01	0.74	0.932
Egg yolk weight (g)	15.31	15.03	14.92	14.42	0.15	0.178
Egg yolk height (µm)	15.23	15.10	15.04	13.99	0.22	0.165
Egg yolk diameter (mm)	4.79	4.81	4.84	4.92	0.31	0.321
Egg yolk index	0.32	0.32	0.31	0.30	0.22	0.345
Yolk color (RSP*)	3.97^{a}	3.75^{ab}	3.55^{b}	3.08^{c}	0.09	0.003

Note: ^{a,b,c} Means within a row with different superscripts differ (p<0.05); T1 = 0% *kocho*; T2 = 33% *kocho*; T3 = 67% *kocho*; T4 = 100% *kocho* as replacement to maize ; *RSP = Roche scale points; SEM = Standard error of mean

Table 5: Fertility, hatchability and chick quality characteristics of White leghorn hens fed *kocho* as a replacement for maize.

Parameters	Treatments				SEM	P value
	T1	T2	T3	T4		
Fertility (%)	99.73	99.35	97.93	97.98	0.43	0.674
Hatchability on fertile egg bases (%)	84.66^{a}	76.97^{b}	72.22^{b}	66.96^{c}	2.37	0.036
Early Embryonic mortality (%)	2.91	2.92	4.11	6.63	0.80	0.458
Mid Embryonic mortality (%)	3.46^{c}	5.22^{b}	5.51^{b}	7.47^{a}	0.53	0.030
Late Embryonic mortality (%)	4.21^{b}	4.62^{b}	9.71^{a}	11.51^{a}	1.10	0.008
Pipe Embryonic mortality (%)	5.63	9.53	8.89	7.97	1.10	0.678
Chick weight (gm)	33.70	33.87	32.56	33.60	0.34	0.571
Yield percentage	52.90	49.73	42.79	41.57	1.88	0.068
Chick length (cm)and	15.08	14.78	14.50	14.75	0.12	0.412

Note: ^{a,b,c} Means within a row with different superscripts differ (p<0.05); T1 = 0% *kocho*; T2= 33% *kocho*; T3 = 67% *kocho*; T4 = 100% *kocho* as replacement to maize; SEM = standard error of mean.

3.2. Feed intake and Laying Performance of Hens

The DM intake and body weight gain of hens fed T4 diets were higher (P<0.05) than other treatments while hens consumed T1, T2 and T3 diets did not differ in (P>0.05) DM intake and body weight gain (Table 3). Hen-day egg production for T3 and T4 was higher (P<0.05) than those fed T1 and T2 diets. Egg mass and egg weight were similar (P>0.05) among treatments. Lower feed conversion ratio was observed for layers on T3 and T4 than on control diet while layers fed T2 had similar value with T3 and T4 diets.

3.3. Egg Quality Characteristics

Egg quality characteristics, except yolk color were similar (p>0.05) among treatments (Table 4). Yolk color was in the order of T1 > T3 > T4 (p<0.05), while the value for T2 was similar with T1 and T3 but was higher than T4.

Table 6: Economics of feeding *kocho* to White leghorn as replacement to maize.

	Treatments			
Total cost	T1	T2	T3	T4
Total feed consumed/ head (kg)	11.7	11.5	11.2	12.8
Total feed cost/head (Birr)	66.5	69.1	67.8	73.0
Total Variable Cost (feed cost) (Birr)	66.5	69.1	67.8	73.0
ΔTVC (Birr)		2.6	1.3	6.5
Total revenue				
Total number of egg produced/hen	35.0	39.0	41.0	40.0
Total Return (TR)(Birr)	87.5	97.5	102.5	100.0
ΔTR (Birr)	-	10.0	15.0	12.5
Net Return(NR) (Birr)	21.0	28.4	34.7	27.0
ΔNR (Birr)	-	7.4	13.7	6.0
MRR (%)	-	2.8	10.5	0.9

Note: ΔTVC = Change in Total Variable Cost; ΔTR= Change in Total Return; NR=Net Return; ΔNR=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% *kocho*; T2 = 33% *kocho*; T3 = 67% *kocho*; T4 = 100% *kocho* as replacement to maize

4. Discussion

4.1. Chemical Composition of Feeds

The CP content of *kocho* (3.8%) in the present study was higher than the values (2.7%, 2.6%, 1.8% and 1.5%) reported by Ajebu *et al.* (2012) for different varieties of *kocho*. Higher CP (4.76%) content of *kocho* was reported by Melese (2013) compared with the current experiment. The pseudo stem of 3-selected enset varieties on average was reported to have 7.2 (%CP) (Fekadu and Ledin, 1997). The difference in CP content may be due to difference in enset varieties from which *kocho* is produced. Ajebu *et al.* (2008) observed varietal difference in CP content of unprocessed corm and pseudostem from which *kocho* is produced. Melese (2013) noted fermentation time as a factor to increase the CP content of *kocho*. The ME content for *kocho* noted in the present study is lower than the values of 3800 kcal/kg DM reported by Tsegaye (2001) but higher than the 2111kcal/kg DM reported by Tilahun *et al.* (2004). Mohammed *et al.* (2013) also reported 3437 and 3379kcal/kg DM for unprocessed corm and pseudostem, respectively.

The CF content (2.3%) of *kocho* is low as compared to the unprocessed corm (5.65%) and pseudostem (7.51%) reported by Mohammed *et al.* (2013) but within the range of 1.47-4.42% reported by Melese (2013) for different enset varieties. Method of processing might have been contributed to the relatively low CF content of *kocho*. The relatively low level of CF in *kocho* and high level of ME is indicative of its potential as a diary ingredient in layers ration. Beta-carotene content of *kocho* (1.5μg/100g) is lower as compared to feed ingredients known for good beta-carotene content such as golden whole kernel and yellow corn which contains about 15.7 and 52.22 μg/100 g, respectively (Scott and Eldridge, 2005). The CP contents of the treatment diets are within the recommended values (14-19%) suggested by NRC (1994) for high producing layer hens. The ME content of treatment diets were between 2820 to 2893 kcal/kg DM which were higher than the minimum values of ME requirement (2700 kcal/kg DM) recommended by NRC (1994) for white leghorn layer. The calcium (2.09-2.23g) and phosphorous (0.31-0.37g) contents of treatment diets were near to the recommended values (2.0 gCa and 0.32 gP) for white leghorn layers at first phase of laying (NRC, 1994).

4.2. Feed intake and Laying Performance of Hens

There is no information in literature on feed intake, egg production, egg and chick quality, fertility and hatchability in layers fed ration containing *kocho*. Therefore, most of the comparisons were made with other energy sources and root crops used in poultry ration as a replacement for maize. In the present experiment, 100% *kocho* inclusion in the ration significantly increased DM intake of white leg horn layers. In agreement with the present study, Hossain *et al.* (2013) and Ngiki *et al.* (2014) reported increased feed intake with increasing level of cassava root meal as a substitute for maize. However, Anaeto and Adighibe (2015) reported reduction in feed intake with complete replacement of maize with cassava root meal. On the other hand, similar dry matter intake was reported by Ajebu *et al.* (2015) for Hubbard broiler chickens fed 0%, 33%, 67% and 100% *kocho* diets and Seyoum (2013) for those fed 0%, 33.3%, 66.7% and 100% *furfurame*, a by-product of *kocho* processing produced from enset, as a replacement to maize. The higher feed intake of layers at 100% *kocho* diet in the current experiment may be attributed to the composition of the diet as the lysine content was relatively high because of increased levels of soyabean in the ration (Table 1).

The higher HDEP for layers fed on T3 and T4 in the current experiment could be due to the higher lysine content (5.5%) in *kocho* (Mohammed et al., 2013) than maize (0.2%) (Leeson and Summers, 2008). The positive effect of lysine in the diet on egg production has been reported (Wu, 2013). Enyenihi et al. (2009) reported a higher HDEP when 75% cassava tuber meal replaced the maize in the ration. Inclusion of sweet potato meal up to 20% as a replacement for maize increased HDEP as compared to 30% and 40% diets in white leghorn layers (Afolayan *et al*., 2013), which could be due to the effect of anti-nutritional factors at higher levels of potato diets (Ravindran, 1995). Uchegbu et al. (2010) noted lower HDEP when layers were fed 15% cassava root meal combined with brewery dried yeast and jack bean at dietary inclusion rates of 10 and 25%, respectively, as replacement for maize. The higher HDEP at higher level of *kocho* in the current experiment suggests use of *kocho* in formulating ration for smallholder poultry as a replacement for maize during its scarcity since *kocho* production is available throughout the year.

Kana et al. (2013) found no effect on egg weight and feed conversion from pullets fed 0%, 33%, 66%, 100% cassava root meal substituted for maize while, Anaeto and Adighibe (2015) found decreased egg weight when birds were fed diet containing cassava root meal beyond 50% as a replacement for maize. On the other hand, Aderemi *et al.* (2012) found that birds fed diet containing more than 25% cassava meal showed reduced feed conversion which is consistent with the current result.

4.3. Egg Quality Characteristics

Egg quality characteristics were not affected by the dietary inclusion levels of *kocho*, except the yolk color. This implies that *kocho* could be used in layers ration replacing maize without compromising the egg quality characteristics. The current result is in agreement with Mihret (2012) who observed similar egg quality parameters for birds fed diet containing cassava root meal replacing maize. Similarly, Rezaei (2006) indicated replacing rice bran with corn in layer diet had no effect on egg shell quality and Haugh unit score. The reason for reduction in egg yolk color with increasing level of *kocho* is presumably associated with the lower beta-carotene (Table 1) content of *kocho*. Consistent to the current finding, lower yolk color was reported by Kim *et al.* (2017) for birds fed 30% cassava tuber replacing maize. However, Fafiolu *et al.* (2006) observed higher yolk color for layers fed malted sorghum as a substitute for maize. Egg yolk color is a very important factor in consumer satisfaction and influences human appetite (Amerine *et al.,* 1995), with a preference for golden yellow to orange yolk color (Hasin *et al.,* 2006).

4.4. Fertility, Hatchability and Chick Quality

The similarity of fertility among treatments justifies that *kocho* can replace maize without affecting fertility. Etalem *et al.* (2013) reported lack of effect on fertility by the dietary inclusion of cassava root chips as a replacement for maize. Haftu *et al.* (2014) also reported similar fertility for white leghorn layers fed ration containing up to 30% dietary levels of malted barley replacing maize. Hatchability was reduced when *kocho* completely replaced maize in the diet. However, Zebib (2012) observed similar effect upon substitution of maize with 0%, 25%, 50%, 75% and 100% sorghum in layers diet. Ajebu *et al.* (2008) observed most fractions of enset to be rich in iron and manganese, but deficient in copper and zinc. The lower hatchability and higher embryonic mortality at higher level of *kocho* could be an attribute of insufficient availability of zinc and copper (Kienholz *et al*., 1961; Caskey *et al*., 1939). Breeder diets that are deficient in Zn can lead to a decrease in egg production, eggshell quality and hatchability. In breeder hens, Zn is important component of carbonic anhydrase, which is involved in the supply of carbonate ions during eggshell formation, carboxypeptidases and DNA polymerases, which are important in immune responses and hormone production (Nys *et al*., 1999). Moreover, Cu is closely associated with iron metabolism and plays an important role in eggshell membrane formation, which in turn influences eggshell structure, texture, and shape (Baumgartner *et al*., 1978). Zinc and Cu play important roles in embryo development as well as hatchability (Kidd, 2003), and a positive relationship has been established between egg Zn content and hatchability (Badawy *et al*., 1987). Thus, *kocho* has to be supplemented with Zn and Cu to enhance hatchability and minimize embryonic mortality.

Tona *et al.* (2003) reported positive correlation between eggs and chick weight. Zebib (2012) also reported positive correlation of egg size and chick weight for birds fed with sorghum ration as a substitute for maize. The similarity in chick weight observed in the current result is attributed to the non significant variation in egg weight (Table 4) as a result of replacing *kocho* for maize. This observation is in agreement with Mihret (2012) who reported similar chick weight for birds fed ration containing 0%, 25%, 50%, 75%, and 100% cassava root meals as a substitute for maize. Similarly, the non significant variation in chick length in the present study could be due to the comparable chick weight. Chicks with better yolk utilization could have developed more body mass during the incubation period, and therefore grew longer (Meijerhof, 2006).

4.5. Economic Evaluation

In the current study 34.7, 28.4, 27.0 and 21.0 birr net return was obtained from sale of eggs on 67%, 33%, 100% and control *kocho* diets, respectively, within 12 weeks of experimental period. The higher net return for T3 (67%) in the current study is due to higher egg production. Therefore, under the condition of the current experiment, *kocho* can replace maize economically up to 67%.

5. Conclusion

Egg weight, egg mass and egg quality characteristics except, yolk color, were not affected by dietary levels of *kocho* replacing maize. Yolk color and hatchability were the lowest when maize was completely substituted with *kocho*. Hen-day egg production was higher at 67% and 100% dietary level of *kocho*. *Kocho* can replace maize economically up to 67%. Therefore, *kocho* can replace maize in layers ration when there is scarcity of maize in enset growing areas of Ethiopia. However, dietary levels of *kocho* have to be supplemented with carotene rich ingredients to maintain normal yolk color.

6. Acknowledgements

The authors express their deepest sense gratitude to Haramaya University for providing research facilities and finance.

7. References

Aberra, M., Workinesh, T. and Tegene, N. 2011. Effect of feeding Moringa stenopetela leaf meal on nutrient intake and growth performance of Rhode Island Red chicks under tropical climate. *Tropical and Subtropical Agroecosystems*, 14: 485-492.

Aderemi, F.A., Adenowo, T.K. and Oguntunji, A.O. 2012. Effect of whole cassava meal on performance and egg quality characteristics of layers. *Journal of Agricultural Science*, 5(2): 195-200.

Admasu, T. 2002. Indigenous production, genetic diversity and crop ecology of enset (Ensete ventricosume (WelW.) cheesmen). PhD Dissertation, Wagening University, The Netherlands.

Adugna, T. 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.

Afolayan, S. B., Dafwang, I. I., Sekoni, A. and Jegede, J. O. 2013. Effect of Dietary Maize substitution with sweet potato meal on performance of growers (10-12 weeks) and subsequent egg production (23-35 weeks). *Asian Journal of Poultry Science*, 7(2): 55-64.

Ajebu, N., Abebash, K. and Aster, A. 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): 1-22

Ajebu, N., Adugna, T., Eik, L. O. and Sundstøl, F. 2008. Chemical composition and insacco dry matter degradability of different morphological fraction of 10 enset (Ensete ventricosume) varieties. *Animal Feed science Technology*, 146: 55-73.

Ajebu, N., Gashahun, B., and Girma, A. 2012. On-farm evaluation of enset (Ensete ventricousm) leaf supplementation on does' milk yield and composition and growth rates of their kids. *Ethiopian Journal Applied Science Technology*, 3 (2): 13-24.

Amerine, M.A., Pangborn, R.M. and Roessler, E. B. 1995. Principles of Sensory Evaluation of Food. Academic Press, New York.

Anaeto, M. and Adighibe, L. C. 2015. Cassava root meal as substitute for maize in layers ration. *Brazilian Journal of Poultry Science*, 13: 153-156.

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

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

Asres, A. and Omprakash, S. 2014. Extension of Enset Plant Product for Rural Development in Ethiopia. *Journal of Agricultural Economics, Extension and Rural Development*, 2(3): 31-40.

Badawy, E. M., Edrise, B. M. and Al-Wakeel, A. M. 1987. The relationship between quality, egg constituents and hatchability of the eggs of Hubbard broiler breeders: A field study. *Veterinary Medicine Journal*, 35:105–115.

Baumgartner, S., Brown, D., Salvsky, Jr. E. and Leach, Jr. R. 1978. Copper deficiency in the laying hen. *Journal of Nutrition*, 108: 804-811.

Bonnier, P. and Kasper, H. 1990. Hatching Eggs by Hens or in an Incubator. Agrodok No. 34. Agromisa, Wageningen, p 39.

Caskey, C., Gallup, W. and Norris, L. 1939. The need for manganese in the bone development of the chick. *Journal of Nutrition*, 17: 407-410.

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

Enyenihi, G. E., Udedibie, A. B. I., Akpan, M. J., Obasi, O. L. and Solomon, I. P. 2009. Effects of 5-hr wetting of un-dried cassava tuber meal on the HCN content and dietary value of the meal for laying hens. *Asian Journal of Animal and Veterinary Advances*, 4(6): 326-331.

Etalem, T., Getachew, A., Mengistu, U. and Tadelle, D. 2013. Cassava Root Chips and Moringa oleifera Leaf Meal as Alternative Feed Ingredients in Layers Ration. *International Journal of Poultry Science*, 12 (5): 298-306.

Fafiolu, A. O., Oduguwa, O. O., Ikeobi, C. O. N., and Onwuka, C. F. I. 2006. Utilization of malted sorghum sprouts in the diet of rearing pullets and laying hen. *Animal Archives*, (55)212: 361-371.

Fekadu Dereje and Ledin, I. 1997. Weight and chemical composition of plant parts of enset (Ensete ventricosum) and the intake and degradability of enset by cattle. *Livestock Production Science*, 49 (3), 249–257.

Gondwe, T. N. 2004. Characterization of local chicken in low input-low output production systems: is there scope for appropriate production and breeding strategies in Malawi. PhD Diss., Malawi University, Malawi.

Gura, S. 2008. Industrial livestock production and its impact on smallholders in developing countries. Consultancy Report to the League for Pastoral People and Endogenous Livestock Development, Germany, p65.

Haftu, K., Mengistu, U. and Kefelegn, K. 2014. Effect of replacing maize with malted barley grain on fertility, hatchability, embryonic mortality and chick quality of white leghorn layers. *Global Journal of Poultry Farming and Vaccination*, 2 (3): 121-125.

Hasin, B.M., Ferdaus, A.J.M., Islam, M.A., Uddin, M.J. and Islam, M.S. 2006. Morigold and orange skin as egg yolk colour promoting agents. *International Journal of Poultry Science*, 5(10): 979-987.

Haugh, R. R. 1937. The Haugh unit for measuring egg quality. U.S. Egg Poultry Magazine, 43: 552-553 and 572-573.

Hossain, M. A., Amin, J. R. and Hossain, M. E. 2013. Feasibility of cassava meal in broiler diets by partial replacing energy source (corn) in regard to gross response and carcass traits. *International Journal of Agricultural Research, Innovation and Technology*, 3(2): 59-65.

Hunton, P. 1995. Egg production, processing and marketing. *World Poultry Science*, 9: 457-480.

Kana, J. R., Kreman, K., Mube, K. H., Teguia, A. and Manjeli, Y. 2013. Effect of substituting maize with cassava root meal on laying performances of local barred-chicken under improved management conditions. *Livestock Research for Rural Development*, 25: 177.

Kidd, M. T. 2003. A treatise on chicken dam nutrition that impacts on progeny. World's Poultry Science Journal, 59: 475–494.

Kienholz, E. W., Turk, D. E., Sunde, M. L. and Hoekstra, W.G. 1961. Effects of zinc deficiency in the diets of hens. *Journal of Nutrition*, 75: 211–221.

Kim, IH., Lei, XJ., Park, JH., Hosseindoust, A. 2017. Effects of Cassava Root Meal in Diets Containing Corn Dried Distillers Grains with Soluble on Production Performance, Egg Quality, and Excreta Noxious Gas Emission in Laying Hens. Brazilian Journal of Poultry Science, 19 (2) 239-246.

Leeson, S. and Summers, J. D. 2005. Commercial Poultry Nutrition 3rd ed. Nottingham University Press: England. 398p.

Leeson, S. and Summers, J. D. 2008. Commercial Poultry Nutrition 3rd edition, Nottingham University Press, Nottingham, England, pp14

Mihret, A. 2012. Effect of substituting maize with sundried and ground Cassava tuber on egg production, quality, fertility and hatchability of white leghorn hens. MSc thesis, Haramaya University, Ethiopia.

Meijerhof, R. 2006. Chick size matters. *World Poultry Science*, 22: 30–31.

Meijerhof, R. 2005. What counts for chick quality? Hybro B.V P.O. Box 30, 5830 AA, Boxmeer, Netherlands.

Melese, T. 2013. Improving the indigenous processing of *kocho*, an Ethiopian traditional fermented food. *Nutrition and Food Science*, 3: 182.

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

Molenaar, R. Reijrink, I. Meijerhof, R. and Van Den Brand, H. 2009. Relationship between hatchling length and weight on later productive performance in broilers. Hatch Tech B. V., adaptation Physiology Group, Wageningen University, 6700 AH Wageningen, The Netherlands.

Ngiki, Y. U., Igwebuike, J. U. and Morupp, S. M. 2014. Effect of replacing maize with cassava root-leaf meal mixture on the performance of broiler chickens. *International Journal of Science and Technology*, 3(6): 352-362.

NRC (National Research Council). 1994. Nutrient requirements of poultry. 9th edition. National Academy Press, Washington. D.C., USA, p 167.

Nys, U., Hincke, M. T., Arias, J. L., Garcia-Ruiz, J. M. and Solomon, S. E. 1999. Avian egg shell mineralization. *Poultry Avian Biollogy and Revolution*, 10: 143–166.

Penda, P. C. 1996. Shape and texture. In: Text book on egg and poultry Technology, PP.57.

Ravindran, V. 1995.Biochemical and nutritional assessments of tubers from 16 cultivars of sweet potato. *Journal of agricultural and food chemistry*, 43: 2646-2651.

Rezaei, M. 2006. Utilization of mixed rice bran in layer hens diet. Pakistan Journal of Biological Science, 9 (8): 1420-1423.

Samuel, S. 2008. "The epidemiology and management options of chocolate spot disease (Botrytis fabae sard) on Faba bean (Vicia faba L.) in Northern Ethiopia." PhD Diss., Haramaya University, Ethiopia.

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

Scott, C.E. and Eldridge, A.L. 2005. Comparison of carotenoid content in fresh, frozen and canned corn. *Journal of Food Composition Analysis*, 18: 551-559.

Seyoum, D. 2013. Effect of feeding different levels of furfurame replacing maize on growth performance and carcass characterstics of hubbard chickens. MSc. Thesis, Hawasa University, Ethiopia.

Tadelle, D., Nigussie, D., Alemu, Y. and Peters, K.J. 2002. The feed resource base and its potentials for increased poultry production in Ethiopia. Regional report. *World Poultry Science Journal*, 58:1.

Tilahun, A., Stroud, A. and Aune, J. 2004. Advancing Human Nutrition without Degrading Land Resources through Modeling Cropping Systems in the Ethiopian Highlands. *Food and Nutrition Bulletin*, 25(4): 344-353.

Tona, K., Bamelis, F., De Ketelaere, B., Bruggeman, V., Moraes, V. M. B., Buyse, J., Onagbesan, O. and Decuypere, E. 2003. Effects of egg storage time on spread of hatch, chick quality and chick Juvenile growth. *Poultry Science,* 82: 736–741.

Tsegaye, Y. 2001. Coffee-enset-livestock interaction for sustainable livelihood in the Sidama area of Southern Ethiopia. *Journal of Agriculture in the Tropics and Subtropics,* 102: 119-131.

Uchegbu, M.C., Herbert, U., Ogbuewu, I.P., Nwaodu, C.H., Esonu, B.O. and Udedibie, A.B.I. 2010. Performance and egg quality characteristics of layers fed diets containing combinations of brewers dried grains, jack bean and cassava root meal. *Report and Opinion,* 11(1).

Upton, M. 1979. Farm Management in Africa, the Principal of Production and Planning, Oxford University Press, p380.

Wiseman, J. 1987. Feeding of Non-Ruminant Livestock. Butter worth and C. Ltd., p370.

Wu, G. 2013. Amino acids: biochemistry and nutrition. Boca Raton, Florida: CRC Press.

Zebib, A. 2012. Effects of substituting sorghum for maize on egg production, quality, fertility and hatchability of white leghorn layers. MSc. thesis, Haramaya University, Ethiopia.